Aid and terrorism: A dynamic contracts approach with interlinked moral hazard

Prabal Roy Chowdhury[a,*], Jaideep Roy[b]

[a]*Economics and Planning Unit, Indian Statistical Institute - Delhi Centre, 7 S.J.S.S. Marg, New Delhi 110 016; India, Tel: +91-11-4149 3930; E-mail: prabalrc@isid.ac.in*

[b]*Economics Unit, Murdoch University, 90 South Street, Perth, Western Australia; Tel +61 (0) 1483 68 3472; E-mail: j.roy@murdoch.ude.au*

Abstract

In a global environment where terrorist organizations based in a poor country target a rich nation, we study properties of a dynamically incentive compatible contract designed by the target nation that includes joint counter-terror tasks involving costly participation by each country. In order to provide incentives to this end the rich country supplies developmental aid under the snag that aid can be diverted to non-development projects, yielding an interlinked moral hazard problem in tasks and rewards. We argue that aid-tying leads to a novel and fruitful virtuous cycle whereby success in joint counter-terror operations help in the observability of aid delivery through an evocative and endogenous monitoring mechanism that is 'unrest-proof', and aid in its turn makes greater counter-terror possible. We characterize the optimal contract to spell out the exact sequence of counter-terror tasks and the amount of developmental aid that provides a new rational for the shock-and-awe military strategy. We then prove that it is not necessarily the case that a more hawkish (resp. altruistic) donor is less pro-development (resp. softer on terror). In addition we show that it may be easier to contract for higher counter-terror inputs when the recipient is more sympathetic to terrorists. We also discuss other problems faced by developing nations where our model can be readily adopted and our results can endorse appealing policy implications.

Keywords: Dynamic contracts, Interlinked Moral hazard, Developmental Aid, Terror, Aid-tying, Joint Counter-terror Operations.
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*Corresponding author
Email addresses: prabalrc1@gmail.com (Prabal Roy Chowdhury), j.roy@murdoch.edu.au (Jaideep Roy)

1. Introduction

This paper examines a dynamic multi-dimensional moral hazard problem in continuous time involving foreign aid and international terrorism. The framework involves two countries: one a target, and the other a source of terror.[1] Further, given the right incentives, the source country is in a position to help the target country take counter-terror measures on its soil. The target country, called the *donor*, provides aid (the *reward*) to the other country, called the *recipient*, in return for counter-terror measures (the *task*) that the recipient is supposed to undertake. In a departure from the standard framework under which dynamic incentives are studied in the literature, we assume, realistically, that the recipient can use the reward in more ways than one, either for development, or for funding corrupt activities. Moreover, the donor's preference over the end uses of the reward might be in conflict with that of the recipient. There is also limited liability in that the donor has little power to punish the recipient in case it either diverts the aid to corrupt uses, or stops delivering on the counter-terror front, the maximal punishment involving the withdrawal of aid (and counter-terror personnel).

Thus we study a novel environment where (a) both aid and counter-terror, i.e. the reward and the task, involve moral hazard, (b) there are severe limited liability constraints, and (c) the countries interact continuously over an interval of time. For this complex environment, we characterize the optimal scheme, showing that it involves something akin to *shock-and-awe* when it comes to counter-terror measures. The optimal contract turns out to have other non-obvious features. For example, we find that a more hawkish donor may provide relatively greater aid, while a more altruistic donor may spend relatively more on counter-terror measures. We also show that a recipient that is more sympathetic to terrorists can perform more demanding counter terror tasks in the optimal contract.

Since the events of 9/11, aid has been a critical element of counter-terror policy for many countries (see Azam and Thelen (2008, 2010, 2012)). For example, in 2009 President Obama asked for \$83 billion of additional funding from the Congress for counter-terror in Afganisthan and Iraq. Out of which, \$3 billion was for diplomatic programs and development aid. In a similar vein, Australia's *AusAID 2008-13 Strategy* argues that development aid to Indonesia is important in controlling terror threats and regional security (also see Brynen (2000), and Baird and Versegi (2005)). There is however much less of a consensus on the channel via which aid may help in the war against terror. One viewpoint emphasises the role of aid in generating jobs and growth in the recipient country, consequently making terror less attractive for its citizens.[2] This view has, however, been criticized on grounds that the terrorists are not necessarily recruited among the very poor (Krueger and Latin (2004), Krueger and Maleckova (2002), as well as Kruger's op-ed piece in New York Times (2003)). An alternative argument is that weak governments are vulnerable to terrorism. In this scenario the role of aid would be to help improve governance and welfare of the masses, thereby allowing the recipient to be more effective in counter-terror (op-ed in New York Times, September, 2002, by ex-President Bush). In this paper, we provide rigorous content to this second strand of argument and draw out some of the implications.

The model involves the donor and the recipient performing joint counter-terror operations, with the donor contributing personnel.[3] The central issue is an *ex post moral hazard* problem in counter-terror. While counter-terror can be made observable, the recipient may have little incentive to perform counter-terror tasks since there may be sympathy for the terror organization among the domestic population, and any counter-terror activity may lead to unrest in the recipient country.[4] In the event of the recipient reneging on its counter-terror requirements, we assume

[1] This is possibly because either there are terror camps located on its soil or it provides a recruiting ground for terror organizations. As to the proximate cause of terrorism, the literature has looked at the effect of, among other factors, poverty, economic powerlessness, marginalization, and fundamentalism (see for example, O'Kane, 2013).

[2] This viewpoint was articulated by, among others, ex-President Bush, "We fight against poverty because hope is an answer to terror" (Monterrey, March, 2002). The Millennium Challenge Account, meant for channeling aid to poor countries, sprang from this philosophy.

[3] The presence of military personnel from the donor country not only provides expertise to the recipient's army, but makes counter-terror operations by the recipient easier to monitor. Note that the United States has been arguing for the 'embedding' of its forces within the Pakistani operations for some time, but was only allowed to be so from September 2009 onwards (New York Times, on-line issue, December 10, 2010).

[4] In addition to sympathy for the terrorist objectives among the recipient population such unrest could be fuelled by a perception that counter-terror operations involve some loss of sovereignty. Mesquita and Dickson (2007), Figueiredo and Weingast (2001), Rosendorff and Sandler (2004) and Mesquita (2005) all explore related ideas. Further any collateral damage would harden such perceptions. The Sunday Times on November 08, 2008, for example, argued that the the Bush Administration's intervention in Somalia may have given

that the donor has no credible threat available to it. It is here that aid plays a critical role, first to keep unrest in check, thus improving governance (in line with the Bush (2002) argument), and second, to provide a credible punishment in case of deviation from counter-terror, since in that case the quality of aid may be severely degraded even though it can not be withdrawn.

Interestingly, aid itself is subject to moral hazard, in that it might be diverted to uses not preferred by the donor (e.g. to enhance the military capabilities of the recipient, or towards pork barrel politics[5]). The presence of counter-terror however ensures that in case aid is diverted, there is unrest, which the recipient dislikes. Thus aid and counter-terror together create a virtuous cycle, each keeping deviations from the other in check.

The formal structure therefore involves an ex post moral hazard problem in counter-terror, where the policy tool meant to resolve this issue, i.e. aid, is itself subject to ex ante moral hazard. This leads to a novel dynamic multi-dimensional moral hazard problem, which we call *interlinked moral hazard* where the objective is to design an aid-counter-terror package that is dynamically optimal from the point of view of the donor, and, furthermore, ensures that at each instant (a) aid is not diverted, and (b) counter-terror promises are kept.

The argument proceeds by first demonstrating that the optimal counter-terror scheme involves what we call *continuous and maximal engagement (CME)*. Under such a scheme, counter-terror operation starts as soon as the aid is delivered, and is uniform over time (at the maximal amount that still avoids unrest). The idea is to show that under a CME scheme the incentive to deviate is decreasing over time, so that one can replace the set of dynamic incentive constraints by a single one at the start of the game. This in turn allows one to show that any aid-counter terror package can be mimicked by one involving CME, and the same levels of aid and counter-terror as in the original scheme. Also, the CME property allows us to provide a closed form solution to the full problem, since using the CME property we can further show that the incentive constraint at the start is the hardest constraint to bind.

The closed-form characterization of the optimal contract then allows us to use standard comparative static methods with sharp conclusions to address some novel issues in the context of terror. Suppose that there is a political change in the donor country, so that the donor becomes either more hawkish, or more altruistic.[6] Popular wisdom suggests that an increase in hawkishness would be accompanied by an increase in counter-terror and a decrease in aid, whereas an increase in altruism would lead to an increase in aid and, perhaps, a decrease in counter-terror. The answers turn out to be much more nuanced though.

We find that while an increase in hawkishness always increases the magnitude of the war on terror, it may lead to an *increase* in developmental aid. This is possible only when either the donor is not too altruistic, or when the reach of development programs is severely restricted. Equally interestingly, while an increase in altruism always increases development aid, the magnitude of the war on terror may in fact *increase*, particularly when the donor is not too altruistic to begin with. As we suggest later in the paper, these findings have some resonance in reality, in particular in the United States' anti-terror policies in the past decade.

These results also highlight the importance of analyzing the moral hazard issues in this context. This is because these results are driven by the fact that in the constrained objective function of the donor (which incorporates the constraints the donor has to respect) the marginal productivity of aid depends on the level of personnel. Whereas if the analysis ignores these issues, then, in the unconstrained objective function, the marginal productivity of aid is independent of personnel. Consequently, none of the effects delineated in the preceding paragraph would arise.

We also examine some variations on the benchmark model that are motivated by geo-political realities. Among others, we examine a scenario where the donor, in addition to aid and personnel, supplies military equipment to the recipient. We show that an increase in the donor's altruism unambiguously leads to a decline in the supply of such equipment. However, the relation between military supply and donor's hawkishness turns out to be non-monotonic.

Finally, while we study the novel dynamic moral hazard problem in the context of terror and aid, the model can be

al-Qaeda a foothold in the Horn of Africa.

[5]Aid diversion for pork barrel politics has been studied by Bates (1981), Acemoglu et al. (2004), Boone (1996), Adam and O'Connell (1999), Lahiri and Raimondos-Moller (2004) and Overland et al. (2005). In The Daily Times, 18 August 2006, Syed Mohammad Ali argues that aid may even be diverted to terrorists, citing the example of serial bomb blasts in Bangladesh which were allegedly funded by Islamist NGOs.

[6]A hawkish donor's preferences are tilted more towards the size of counter-terror operations, than towards the recipient. Thus, for example, the United States government can be expected to become more hawkish if the neo-conservatives gain ascendency. The donor can become more hawkish even in response to a large scale terror attack on it.

adopted to study other applications. In Section 6 we spell out three such applications in the fields of rural education, infrastructure development and micro-finance that are currently amongst major government policy objectives and challenges in less developed countries across the world.

The rest of the paper is structured as follows. In Section 2 we describe the benchmark model. In Section 3 we provide a complete characterization of the optimal contract. In Section 4 we study the impact of donor preferences, in particular donor altruism and hawkishness, on the optimal contract. Section 5 is devoted to some variations of the benchmark model. Section 6 discusses some extensions of this framework to other problems. The paper concludes in Section 8, after a review of the related literature in Section 7.

2. The Model

There are two strategic actors, a donor country (henceforth donor) and a recipient country (henceforth recipient). The donor is concerned about the design of a foreign policy to tackle terror. Apart from supplying developmental aid, it also sends military personnel to actively supplement the anti-terror war waged jointly with the recipient.[7]

The planning horizon is the unit time interval $[0, 1]$, with time varying continuously, so that $t \in [0, 1]$. The sequence of activities is as follows:

- At $t = 0$, the donor announces and commits to a foreign policy program that consists of (i) development aid $k, 0 \leq k \leq 1$, and (ii) a force of military personnel $P \geq 0$, subject to the recipient adhering to a counter terror program that requires the recipient to invest an amount $C(t)$ at each $t \in [0, 1]$. Both k and P are delivered at $t = 0$.
- At any period $t > 0$ up to which the recipient has followed the program, it can opt to defect, either by diverting development aid to an alternative use, and/or by stopping counter-terror activities. In case the donor observes any deviation from the proposed counter-terror, or infers any aid diversion, the donor is committed to withdrawing its personnel P, as well as initiate liquidation of the development project. In that case there is immediate aid diversion, and the game ends. In case the recipient chooses not to defect, the game continues.
- At any $t > 0$, the donor can observe whether (i) the proposed counter-terror input $C(t)$ is being supplied or not, provided $P > 0$, and (ii) whether there is unrest in the recipient country. The donor cannot however observe if aid is being diverted or not.

Given the above time line, we now look at the details. A developmental aid of k yields an instantaneous return of ak to the recipient over the entire planning horizon ($a > 0$), provided it is not either liquidated by the donor, or diverted by the recipient. Thus a captures the productivity of the project (we shall later re-interpret a as a measure of the *reach* of the aid program). At any t therefore, the remaining aggregate yield from the development project is $ak(1 - t)$, yielding a utility of $ak(1 - t)$ to the recipient and $\beta ak(1 - t)$ to the donor, where $\beta \geq 0$ is the *altruism* parameter of the donor.

Delivery of aid involves an ex ante moral hazard problem in that the recipient nation can divert this aid, in a manner that is not only unobservable to the donor, but also to uses that are ideologically and/or politically unacceptable to the donor (in particular if the diverted amounts are used in activities inimical to the donor) creating an unacceptably large disutility for it. Such aid diversion at t generates a utility of $b(k(1 - t))$ for the recipient. Further, in case the donor initiates liquidation of aid, the recipient can and does divert the aid immediately, so that the recipient's payoff in case of liquidation is also $b(k(1 - t))$. Consequently, this acts as a limited liability constraint on the donor's ability to punish the recipient using aid liquidation as a tool. We maintain the following assumption on $b(\cdot)$:

Assumption 1. *$b(\cdot)$ is twice differentiable, increasing and strictly convex over the interval $[0, 1]$, with $b(0) = b'(0) = 0$, and $b(1) > a$.*

[7] We later consider a scenario where the donor supplies military equipment, but no personnel.

Clearly increasing returns, i.e. convexity of $b(k)$, makes it harder to sustain larger developmental projects. The motivation behind this assumption is that such diversions often operate via large networks (of politicians, bureaucrats, officials, the underworld and even the military). As a result higher amounts to divert, i.e. larger k, may make it easier to sustain larger corruption networks, and hence operate such aid diversion more efficiently. While convexity of $b(k)$ ensures that $ak - b(k)$ has a unique maximizer, our results go through qualitatively as long as a unique optimum obtains. In fact, if the return from the project takes the more general form $a(k)$, we can even allow for a concave $b(k)$, provided $a(k) - b(k)$ is concave.

The donor ties the aid to the recipient's performance on counter-terror measures. The effective counter-terror at any instant t depends on two elements, the cost $C(t)$ incurred by the recipient on counter-terror, as well as P, the personnel deployed by the donor, yielding an instantaneous counter-terror output of $f(P)C(t)$. Deployment of P addresses two aspects of the contractual environment. First, such personnel can guide, as well as provide advice and expertise to the recipient, thus making counter-terror more effective through the function $f(\cdot)$. Second, the deployment of personnel improves the observability of counter-terror activity, which is critical given that the recipient has strong incentives to shirk on counter-terror.[8] The counter-terror output $f(P)C(t)$ can be thought of as the number and size of successful attacks on terror organizations and their training camps in the recipient, that reduces terror attacks and so yields an instantaneous utility of $\alpha f(P)C(t)$ to the donor, where $\alpha > 0$ captures how *hawkish* the donor country is on counter-terror or how critical the terror threat is. For instance, α is likely to increase in response to either a terror strike, or to information gathered by the donor's intelligence agencies that such a strike is imminent.

Nevertheless, deploying personnel who face the threat of death and serious injury is costly for the donor, not just in terms of money, but more importantly in terms of the potential cost to valuable lives (and possibly the consequent dwindling of public support at home). This is captured by $\zeta(P)$.

We maintain that $f(P)$ and $\zeta(P)$ satisfy the following:

Assumption 2. *Both $f(P)$ and $\zeta(P)$ are twice differentiable. (i) $f(P)$ is increasing and strictly concave $\forall P > 0$, with $f(0) > 0$, $f(P) \leq 1$ and $f'(0) = +\infty$. (ii) $\zeta(P)$ is increasing and strictly convex $\forall P > 0$, and $\zeta(0) = \zeta'(0) = 0$.*

These assumptions are mostly standard. Note that the assumptions that $f(0) > 0$ and that $f(P) \leq 1$ together capture the notion that the involvement of donor personnel, while extremely important, is neither indispensable to, nor a panacea in the war against terror so long as $C(t) > 0$.

Counter-terror activities may, however, generate sympathy for the terrorist organization, leading to unrest, which is deeply disliked by the recipient (in particular if it can lead to a regime change). It is avoided if and only if at every instant the developmental aid is large enough so as to compensate the masses for any such sympathy for the terrorist organization. Thus in the rest of the paper we shall impose this evocative requirement that the war against terror is *unrest-proof*, so that we have,[9]

$$f(P)C(t) \leq ak, \ \forall t \in [0, 1]. \tag{1}$$

Note that the absence of unrest plays a valuable signalling role. Suppose the contract involves $ak \geq f(P)C(t)$ at t, and it is observed that counter-terror objectives are being met. Then the absence of unrest signals that aid is not being diverted. Thus unrestproofness links the incentives across the two otherwise independent dimensions.

An *aid-counterterror scheme* over the planning horizon $[0, 1]$ is a dynamic incentive contract $\mathcal{S} = \langle k, C(t), P \rangle$ between the donor and the recipient, specifying (i) the development fund k supplied at $t = 0$, (ii) the counter-terror task (or cost) schedule of the recipient at every $t \in [0, 1]$, and (iii) the personnel P deployed for the entire planning horizon, along with the commitment on part of the donor that defection leads to liquidation.

Let $C(\mathcal{S})$ be the total counter-terror cost of the recipient, $D(\mathcal{S})$ be the amount of total development output, and

[8] It is insightful to note that The New York Times on-line issue of December 10, 2010 suggests that the Pakistani Army approved the deployment of United States special operation elements to support Pakistani military operations. The first deployment occurred in September 2009. Previously, the Pakistani military leadership opposed such embedding in fear of opposition from the population.

[9] While this requirement may look somewhat ad hoc, there are no qualitative implications if the unrest-proof condition is instead framed as $f(P)C(t) \leq \tau ak$, for any $\tau > 0$. Clearly a larger τ reflects a society less prone to such unrest. Moreover, our results will hold qualitatively if we modelled the unrest as a smooth function of k and $C(t)$. See Remark 3 for more on this.

$B(\mathcal{S})$ be the total aid diversion activity under the scheme $\mathcal{S}$. Then the payoff of the recipient from $\mathcal{S}$ is

$$U_R(\mathcal{S}) = D(\mathcal{S}) + B(\mathcal{S}) - C(\mathcal{S}), \tag{2}$$

whereas the payoff of the donor from $\mathcal{S}$ is

$$U_D(\mathcal{S}) = \alpha f(P)C(\mathcal{S}) + \beta D(\mathcal{S}) - (k + \zeta(P) + B(\mathcal{S})) \tag{3}$$

Equation (3) states that the donor not only cares about counter-terror, but also about the recipient country, as captured by β. We should emphasize however that the analysis does include the case when the donor does not care about the recipient at all, i.e. $\beta = 0$. Further, the most interesting comparative statics results are actually for the case when $\beta = 0$ (see Remark 6). Further, any scheme $\mathcal{S}$ that leads to aid diversion is harmful to the donor.

Remark 1 (Commitment to aid liquidation). *Recall that the donor commits itself to liquidating the aid project in case of a detected defection in counter terror, which in turn causes the recipient to divert the entire remaining aid amount. Of course, this implies that aid liquidation is not dynamically consistent from the donor's point of view given that aid diversion yields a large disutility to the donor country. This commitment power helps the donor implement larger counter-terror and development though since, without this ability to commit, the recipient will always set $C(t) = 0$, irrespective of the levels of P or k, so that the donor will always have an incentive to renegotiate following a deviation. This makes long-term contracting an optimal mechanism in our environment. This is in line with Fudenberg et al. (1990) who shows that a long-term contract must be immune to renegotiation if one hopes to emulate it by a sequence of short-term contracts.*[10] *also, this commitment power allows us to ignore the disutility of $B(\mathcal{S})$ from the donor's objective function when we study the optimal contract.*

A scheme $\mathcal{S}$ satisfies *Individual Rationality* for the recipient if it yields an aggregate payoff that exceeds its reservation utility. Note that given our assumptions the outside option of the recipient can be normalized to 0, so that a scheme is Individually Rational iff $U_R(\mathcal{S}) \geq 0$.[11]

2.1. Feasibility, Incentive Compatibility and Optimal Schemes

Our task here is to solve for an optimal dynamic contract $\mathcal{S} = \langle k, C(t), P\rangle$ that maximizes the donor's utility i.e. $U_D(\mathcal{S})$, and is both dynamically incentive compatible for the recipient, as well as unrest proof over the planning horizon. We begin by recalling that in case the recipient diverts aid, while sticking to counter-terror targets, the unrest proof condition will be violated so that there will be unrest, which credibly signals that aid has been diverted. We next discuss the various constraints.

For the scheme under consideration, let $0 \leq \tilde{t} \leq 1$ be the last instant when counter-terror is positive. Hence, if at any $t \in [0, \tilde{t})$, the recipient follows the agreement from then on, then it enjoys a continuation utility of $ak(1-t)$ from development minus the counter-terror input cost of $\int_t^{\tilde{t}} C(t)dt$, yielding a net continuation utility of $ak(1-t) - \int_t^{\tilde{t}} C(t)dt$. Of course it has the option of (i) diverting currently available funds to the non-developmental projects and/or (ii) stopping counter-terror, thus obtaining a continuation payoff of $b(k(1-t))$ in both the cases.

Will the recipient ever deviate on one front, without deviating on the other? Suppose that there is aid diversion, whereas counter-terror objectives are being met. This would lead to unrest, when the donor withdraws personnel P. Thus aid diversion must be accompanied by the stopping of the counter-terror operations since doing so avoids the costs of doing counter-terror (which is anyway futile given that P has been withdrawn). Similarly, if the recipient deviates on counter-terror, it is observable and punished by the donor with a committed and credible liquidation plan, so that optimally the recipient should also divert the developmental aid to its alternative use. Thus without loss of generality we can restrict attention to deviation payoffs that involve deviation on both fronts, when the recipient has a continuation payoff of $b(k(1-t))$. Hence the incentive constraint can be formalized as (4) below. For $t > \tilde{t}$, a

[10]The commitment assumption is also standard in the dynamic moral hazard literature, e.g. Sannikov (2004) and Arie (2014), with very few exceptions, e.g. Battaglini (2007) or Strulovici (2011), who examines the implications of renegotiation.

[11]As we shall see below, nothing changes even if individual rationality is imposed dynamically at every instant.

similar argument holds, with the proviso that there are no further counter-terror operations at such an instant. The corresponding condition is formalized in constraint (5) below:

$$ak(1-t) - \int_t^{\tilde{t}} C(t)dt \geq b(k(1-t)), \forall t \in [0, \tilde{t}], \tag{4}$$

and

$$ak(1-t) \geq b(k(1-t)), \ \forall t > \tilde{t}. \tag{5}$$

Definition 1. *Any scheme $\mathcal{S}$ that satisfies conditions (1), (4) and (5) simultaneously is both unrest-proof and dynamically incentive compatible and is called* feasible.

The donor's problem is to maximise $U_D(\mathcal{S})$ subject to $\mathcal{S}$ being a feasible scheme and the commitment assumption holds. The rest of the paper is devoted in solving the donor's optimization problem and characterizing it.

3. Optimal Contract

We begin by introducing a class of aid counter-terror schemes that play a central role in the analysis.

Definition 2. *A scheme $\mathcal{S} = \langle k, C(t), P\rangle$ involves* Continuous and Maximal Engagement *(henceforth CME) if the associated counter-terror schedule satisfies $f(P)C(t) = ak$ for all $t \leq t'$ for some $t' > 0$, and $f(P)C(t) = 0$ otherwise.*

As we argue in Proposition 1 below, such schemes 'dominate' other schemes (in a sense made formal later; also see Remark 2). Therefore, in our search for the optimal contract we can, without loss of generality, restrict attention to such schemes which is analytically extremely convenient. Note that in this framework maximal engagement follows from purely dynamic incentive considerations.

Proposition 1. *Given any feasible scheme $\mathcal{S} = \langle k, C(t), P\rangle$, one can construct another feasible scheme $\mathcal{S}' = \langle k, C'(t), P\rangle$ such that (a) the associated counter-terror scheme involves continuous and maximal engagement (CME), and (b) it yields the same level of aid, as well as aggregate counter-terror input.*

Proof. Since $\mathcal{S} = \langle k, C(t), P\rangle$ is feasible, it is incentive compatible at $t = 0$ so that

$$ak - \int_0^1 C(t)dt \geq b(k).$$

Let $t(k)$ solve $\frac{akt}{f(P)} = \int_0^1 C(t)dt$. We construct a counter-terror scheme $C'(t)$ such that $C'(t) = \frac{ak}{f(P)}, \forall t \leq t(k)$ and zero otherwise.[12] Note that by construction this scheme is CME, and involves the same level of aggregate counter-terror as $\mathcal{S}$. Clearly, since $\int_0^1 C'(t)dt = \int_0^1 C(t)dt$, and $C(t)$ is incentive compatible at $t = 0$, the scheme $\mathcal{S}' = \langle k, C'(t), P\rangle$ is incentive compatible at $t = 0$ as well.

Next recall that the incentive constraint (5) at some t, $t > t(k)$, is $ak(1-t) \geq b(k(1-t))$. This holds since from the incentive constraint at $t = 0$, $ak \geq b(k) + \int_0^1 C(t)dt \geq b(k)$, implying that $ak' \geq b(k')$, for all $k' \leq k$, in particular $k' = k(1-t)$.

Next consider the incentive constraint (4) at t, $t < t(k)$. Using the fact that the scheme is a CME, so that $f(P)C(t) = ak, \forall t \leq t(k)$, the incentive constraint can be written as

$$ak(1-t) - \frac{ak}{f(P)}(t(k) - t) \geq b(k(1-t)).$$

Observe that at $t = 0$, the LHS exceeds the RHS since the incentive constraint for this scheme is the same as that for $\mathcal{S}$ at $t = 0$, which holds by assumption. Moreover, the LHS exceeds the RHS at $t = t(k)$, when the LHS simplifies to

[12] Notice that $t(k) \leq 1$, since $C'(t)$ has been constructed from $C(t)$ by shifting terror-input from later to strictly earlier instants.

$ak(1-t(k))$ and the RHS simplifies to $b(k(1-t(k))$. Thus the LHS exceeds the RHS from an argument analogous to that in the preceding paragraph. Finally, given that (a) while the LHS is either increasing, or decreases linearly in t, and the RHS is decreasing and convex in t, and (b) the LHS equals the RHS at $t=0$ and $t=t(k)$, the LHS cannot intersect the RHS at any $t<t(k)$. Thus the incentive constraint holds for all t over the planning horizon. $\square$

A CME scheme clearly has echoes of the well known 'shock-and-awe' strategy, initially discussed by the strategic military analysts Ullman and Wade (1996). This doctrine argues that a war should start with the largest and most decisive attack and then carry on at a lower scale, since by then the enemy would be psychologically defeated. We provide a new rationale behind this doctrine that focusses on dynamic socio-economic considerations in a long drawn war, rather than on any purely military-psychological ones.

Note that such maximal engagement is not an obvious feature of optimality in the dynamic context because while the project is at its most valuable phase initially, being worth ak at $t=0$, the payoff from deviation is also at its highest at $t=0$. As we demonstrate however, a CME scheme that is incentive compatible initially, will continue to do so subsequently. The key intuition is that the incentive of the recipient government to default should be uniformly distributed across time, so that it is not too large at any one single point. With continuous and maximal engagement, at every instant the donor asks for the maximal feasible amount of counter-terror, thus ensuring that default incentives are not too large at any instant and particularly during the end-tail of the contractual horizon.

Given Proposition 1, we shall henceforth restrict attention to CME schemes in the donor's optimization program. Proposition 2 below provides a complete and closed form characterization of the optimal scheme, thereby providing some critical insights regarding the linkages between counter-terror, aid and donor personnel.

We require the following notations:

- Let $\tilde{k}$ solve $ak-b(k)=0$ for $k>0$, so that the utility of the recipient government from diverting aid, exceeds its utility from the aid reaching its developmental target iff $k>\tilde{k}$.
- Let k^* solve $a=b'(k)$, so that the gap between ak and $b(k)$ is maximized when aid equals k^*.

As we shall see, k^* will play a crucial role in the ensuing analysis. Let (P_H,k_H) solve

$$max_{\{k,P\}}Z(P,k)=\alpha f(P)[ak-b(k)]-(1-\beta a)k-\zeta(P).$$

From Weirstrass's theorem a solution exists.[13] The necessary and sufficient conditions for an interior solution are given by

$$\alpha f'(P)[ak-b(k)]-\zeta'(P)=0, \tag{6}$$

and

$$\alpha f(P)(a-b'(k))+\beta a-1=0. \tag{7}$$

Further, define

$$\tilde{t}_H \equiv \frac{f(P_H)[ak_H-b(k_H)]}{ak_H},$$

where note that given $f(P)\leq 1$, it follows immediately that $\tilde{t}_H<1$.

Proposition 2. *The optimal counter-terror scheme prescribes continuous and maximal engagement and a personnel-aid vector of* (P_H,k_H).

1. *The counter-terror scheme involves*
   $$C(t)=\begin{cases}\frac{ak_H}{f(p_H)} & \textit{if } t\in[0,\tilde{t}_H],\\ 0 & \textit{thereafter.}\end{cases}$$

[13]Note that k is bounded above by $\tilde{k}$. Clearly, there exists $\tilde{P}$ such that $Z(P,k)<0$ for all $P\in[0,\tilde{P}]$ and for all $k\in[0,\tilde{k}]$ (given A2). Thus the maximisation problem has a solution.

2. *Aid is never too large in the sense that $k_H < \tilde{k}$. Moreover, aid is very small, in the sense that $k_H < k^*$, iff $1 - \beta a > 0$, which holds if either the donor is not too altruistic, or the productivity of aid is small.*

Proof. Given the commitment assumption highlighted in Remark 1, the equilibrium contract must imply $B(\mathcal{S}) = 0$ in the donor's objective function. Hence, the donor's problem simplifies to:

$$Max_{\{k,P,\tilde{t}\}} \alpha f(P) \int_0^{\tilde{t}} C(t)dt + \beta ak - k - \zeta(P),$$

subject to the no-unrest and incentive compatibility constraints conditions (1), (4) and (5) discussed earlier. Given that an optimal scheme is CME, we set equality in (1), and replace in (4), which then becomes

$$ak(1-t) - (\tilde{t} - t)\frac{ak}{f(P)} \geq b(k(1-t)).$$

At $t = 0$, this becomes $ak - \tilde{t}\frac{ak}{f(P)} \geq b(k)$. From Proposition 1 if the scheme is IC at $t = 0$, then it is IC at each $t \in [0, 1]$. Hence, the problem of the donor simplifies to

$$max_{\{k,P,\tilde{t}\}} \alpha\tilde{t}ak + \beta ak - k - \zeta(P),$$

subject to:

$$ak - b(k) \geq \tilde{t}\frac{ak}{f(P)}.$$

Observe that for any fixed value of k, the maximand is increasing in $\tilde{t}$. Thus, for every value of k, the constraint must hold with equality, so that the donor's problem then simplifies to

$$max_{\{k,P\}} Z(P, k) = \alpha f(P)[ak - b(k)] - (1 - \beta a)k - \zeta(P). \tag{8}$$

We call $Z(P, k)$ the constrained objective function of the donor in that it incorporates the various constraints that the donor operates under. Given our assumptions, one can use Weirstrass's theorem to show that a solution exists. Further, it is straightforward to argue that any solution must be interior.[14] Consequently, the solution (P_H, k_H) is characterized by the first order conditions (6) and (7). Further, counter-terror is positive over $[0, \tilde{t}_H]$.

It is then easy to see that $k_H < \tilde{k}$. If not, then the LHS of (6) becomes non-positive while by Assumption 2, the RHS is strictly positive. Next suppose $1 - \beta a > 0$. Then from (7) it follows that $a > b'(k)$, since under Assumption 2, $f(P) > 0$. Thus it must be that $k_H < k^*$. For $1 - \beta a < 0$, a similar argument establishes that $k_H > k^*$. □

As demonstrated in the proof of Proposition 2, the donor's constrained maximization problem can be written as an unconstrained maximization problem that involves a maximand $Z(P, k)$ that incorporates the various constraints that the donor operates under. Note that $Z(P, k)$ depends on $f(P)$, i.e. the contribution of donor personnel, times the recipient's utility from the aid, ak, minus its payoff from aid diversion $b(k)$). We shall find that many of the subsequent results will depend on whether $Z_{Pk} = \alpha f'(P)[a - b'(k)] < 0$ (respectively $Z_{Pk} > 0$). We shall say that the first case (viz. $Z_{Pk} < 0$) involves P and k being *instrumental substitutes*, and the second case (viz. $Z_{Pk} > 0$) involves these being *instrumental complements* in the design of the optimal dynamic contract. The following corollary will be helpful in having a clearer understanding of many of the results that follow.

Corollary 1. *Aid and personnel are instrumental substitutes if* $1 - \beta a < 0$ *and instrumental complements if* $1 - \beta a > 0$.

To see this, observe that if the level of aid is relatively high, then the *net* marginal productivity of aid is negative (i.e. $a - b'(k) < 0$), and hence aid and personnel are instrumental substitutes. By a similar logic, aid and personnel

[14] This follows from the Inada condition that $f'(0) = \infty$.

are strategic complements in case the level of aid is not that high. Further, let $1 - \beta a < 0$. Then it must be that $k_H > k^*$, since otherwise an increase in aid increases $Z(P, k)$. Consequently, $a < b'(k_H)$. Hence, given that $f'(P) > 0$, P and k are instrumental substitutes. By analogous arguments, whenever $1 - \beta a > 0$, P and k are instrumental complements.

While aid and donor personnel are instrumentally neutral in the unconstrained objective of the donor, once the various constraints are factored in this is no longer the case. The donor's unconstrained objective depends on the effective contribution of the donor personnel times the aggregate counter-terror input deployed by the recipient. Given the moral hazard problem on aid diversion, incentive compatibility demands that the aggregate counter-terror input depends on the *net* aid output (i.e. gross aid output minus the recipient's opportunity cost of not diverting aid on the equilibrium path of play). Consequently, the donor's 'constrained' objective depends on the product of two terms: the effective donor personnel and the net aid output. If the level of aid is relatively high, then the net marginal productivity of aid is negative, and hence aid and personnel are instrumental substitutes. By a similar logic, aid and personnel are instrumental complements in case the level of aid is not that high.

A few remarks are in order.

Remark 2 (Discounting)**.** *How does our analysis change if we allow for positive discounting for both the donor and the recipient? Consider the case where the donor does not care about the recipient's utility, so that $\beta = 0$. In that case the donor would prefer the counter-terror to occur sooner, rather than later. This ensures that Proposition 1 holds, i.e. the optimal scheme involves CME. Further, it can be shown that (i) the aggregate discounted counter-terror output must again equal $ak - b(k)$, and (ii) it is sufficient to consider the incentive constraint at $t = 0$. Consequently Proposition 2 goes through as well. Thus, as long as the donor is not too altruistic, the analysis goes through. We reiterate here that since the main objective of the donor is to tackle terror, too high a level of altruism is anyway not relevant to the problem we address.*

Remark 3 (Smooth unrest)**.** *Note that we have formalized unrest in a discrete manner. In particular, there is no unrest as long as $ak \geq f(P)C(t)$, and there is unrest otherwise. It is possible to model unrest in a more continuous fashion though, so that unrest varies continuously with $f(P)C(t) - ak$. In case the extent of unrest is observable, this formulation in fact makes it easier to track the extent of deviation and thus punish it, so that the results should go through qualitatively with the proviso that the equilibrium will involve some unrest.*

Remark 4 (Payoff-relevant unrest)**.** *It is also straightforward to allow for the fact that the recipient may dislike unrest, in particular if such unrest is potentially regime changing. This does not change the analysis in any respect since the donor designs the contract to prevent unrest anyway. In fact, if the recipient dislikes unrest strongly enough, the donor might design the contract in such a way such that the punishment is invoked only in case of deviation by counter-terror, and not in case of aid diversion. This is sufficient because the recipient is going to respect the unrest-proof constraint in its own interest, thus ensuring that aid is not diverted. Further, such contracts could be politically more acceptable as the punishment would be based only on observed deviations, and not inferences. In fact, in certain scenarios it is possible that the donor also dislikes such unrest, possibly because it might cause a regime change with the new regime being inimical to the donor's interests. Extending the analysis to allow for this possibility would not change the results in any way.*

3.1. Implications of Moral Hazard in Aid

The novelty of the dynamic incentive environment under study is that the reward scheme itself faces moral hazard constraints through aid diversion. The natural benchmark is therefore the case where this problem is absent. To this end we consider a *disciplined recipient* nation that has no intention to divert aid, so that $b(k) = 0$ for any k. The analysis confirms that the possibility of aid diversion has negative implications, not only for the level of aid itself, but also on the magnitude of counter-terror output.

Given (8) and the fact that $b(k) = 0$, the constrained maximization problem simplifies to

$$Max_{\{P,k\}} V(P, k) = \alpha f(P)ak + \beta ak - k - \zeta(P).$$

Let (P^d, k^d) be the solution to this problem. The following proposition compares the outcome in this case with Proposition 2.

Proposition 3. *Suppose that the $b(k) = 0$, $\forall k$, so that the recipient has no incentive for diverting the developmental aid. Then $P^d > P_H$ and $k^d > k_H$. Moreover, $k^d = 1$ if $1 - \beta a < 0$.*

Proof. Note that
$$V_P = \alpha a k f'(P) - \zeta'(P),$$
and
$$V_k = \alpha a f(P) - (1 - \beta a).$$
First observe that if $1 - \beta a < 0$, then $V_k > 0$ for all values of P, so that $k^d = 1 > k_H$. So suppose $1 - \beta a > 0$. Recall from Proposition 2 that in the benchmark model, we have

$$\alpha a f(P_H) - \alpha a f(P_H) b'(k_H) = (1 - \beta a).$$

Hence, it must follow that $\alpha a f(P_H) - (1 - \beta a) > 0$. Hence $k^d > k_H$.

We then argue that $P^d > P_H$. Suppose not. Then

$$\zeta'(P_H) \geq \zeta'(P^d) = \alpha f'(P^d) a k \geq \alpha f'(P_H) a k_H > \alpha f'(P_H)(a k_H - b(k_H)),$$

which is a contradiction. □

Consequently, in the absence of aid diversion, the level of aid is high, which is intuitive. Furthermore, in this case aid and personnel are necessarily instrumental complements, so that the level of personnel is also larger compared to the baseline model with multidimensional moral hazard. We also show that when $1 - \beta a < 0$, then the maximal amount of aid is supplied. This in turn allows the donor to employ the maximal possible personnel subject to there being no risk of unrest. Thus if the recipient nation has little corruption in aid delivery, both aid and personnel are high, as is the size of the war. It is also straightforward to show that the duration of the war is longer. These results pin down the exact inefficiency of having a reward scheme that itself suffers from moral hazard.

4. Hawks, Altruists and Geography

Given that the war on terror is a long drawn process, there can be several factors that impact the donor's objectives and priorities over time. Either because of domestic political changes, or perhaps because of pressures from world bodies, the donor can be forced to become more altruistic. Similarly, domestic politics can also drive the donor to become more hawkish, as can a terror attack on the donor country. It is therefore of some interest to examine the implications of such changes on the war on terror and the consequent optimal contract characterized in Proposition 2. We therefore ask if an increase in hawkishness necessarily imply that development funding will be negatively affected? Does the donor becoming more altruistic mean that the war on terror is diluted? What happens as the war on terror moves to more inaccessible terrains where aid delivery becomes more hazardous and therefore less effective?

To address these issues, we employ standard comparative statics techniques, examining the impact of α, β and a on (the unique) equilibrium values of P and k. Totally differentiating the first order conditions for an interior solution yield:
$$Z_{PP}\mathbf{d}P + Z_{Pk}\mathbf{d}k = -f'(P)[ak - b(k)]\mathbf{d}\alpha + 0\mathbf{d}\beta - \alpha f'(P) k \mathbf{d}a,$$
$$Z_{Pk}\mathbf{d}P + Z_{kk}\mathbf{d}k = -f(P)[a - b'(k)]\mathbf{d}\alpha - a\mathbf{d}\beta - [\alpha f(P) + \beta]\mathbf{d}a.$$
The second order conditions for optimality implies that $Z_{PP}, Z_{kk} < 0$ along with

$$D = Z_{PP}Z_{kk} - Z_{Pk}^2 > 0.$$

For any variable $x \in \{P_H, k_H\}$ and any parameter $y \in \{\alpha, \beta, a\}$, we have $\frac{\mathbf{d}x}{\mathbf{d}y} = \frac{D_{x,y}}{D}$, where

$$D_{P,\alpha} = -Z_{kk} f'(P)[ak - b(k)] + Z_{Pk} f(P)[a - b'(k)],$$

$$D_{k,\alpha} = -Z_{PP} f(P)[a - b'(k)] + f'(P) Z_{Pk}[ak - b(k)],$$
$$D_{P,\beta} = a Z_{Pk},$$
$$D_{k,\beta} = -a Z_{PP},$$
$$D_{P,a} = -Z_{kk} \alpha f'(P) k + Z_{Pk}[\alpha f(P) + \beta],$$
$$D_{k,a} = -Z_{PP}[\alpha f(P) + \beta] + Z_{Pk} \alpha f'(P) k.$$

4.1. Are More Hawkish Donors Less Pro-development?

The Bush administration's stance, post 9/11, was believed to be rather hawkish. The Bush Doctrine, perhaps drawing on neo-conservative ideas, held that the United States, along with other nations, was waging a global war against extremist forces seeking to destroy liberal values. Consequently, so the argument went, this was a war of ideology where the United States must take responsibility and show leadership by actively engaging the extremist forces.[15] Interestingly, the 'neo-conservatives' did not advocate increased aid in this war against terror. As Lynch (2008) writes, they believed strongly that "prosperity cannot be used as the solution ... and foreign aid is therefore broadly irrelevant in the war against terror." Somewhat paradoxically therefore, it was the Bush administration that was also instrumental in lifting many of the economic sanctions against nations believed to be harbouring terror organisations (e.g. Pakistan post 9/11), and increasing economic aid to levels never seen before.[16]

The dynamic framework we study helps us provide possible theoretical foundations for some of these policies. In particular, we examine the effect of an increase in hawkishness, i.e. in α, on the equilibrium outcome. We show that development aid may in fact increase with an increase in hawkishness. Interestingly, this happens whenever the donor is not too altruistic, which seems to be in line with Lynch (2008).

Proposition 4. *Suppose the donor becomes more hawkish, i.e. α increases. Then:*

1. *There is an unambiguous increase in personnel P_H.*
2. *Developmental aid k_H increases iff the donor is not too altruistic, i.e. $1 - \beta a > 0$.*
3. *There is an increase in both the aggregate counter-terror input $\int_0^1 C(t)dt$ from the recipient and aggregate joint counter-terror output $f(P)\int_0^1 C(t)dt$.*

Proof. The proof requires the use of Proposition 2 in the same way it was used to prove Proposition 3. It then follows that when $1 - \beta a > 0$, $Z_{Pk} > 0$ so that $D_{P,\alpha} > 0$ and $D_{k,\alpha} > 0$. On the other hand, when $1 - \beta a < 0$, $Z_{Pk} < 0$ so that $D_{P,\alpha} > 0$ and $D_{k,\alpha} < 0$. This proves parts 1 and 2 of the proposition. So consider aggregate counter terror input $I = [ak_H - b(k_H)]$. We have just shown that when $1 - \beta a > 0$, $k_H < k^*$ and k_H rises in α. Thus $\frac{\mathbf{d}I}{\mathbf{d}\alpha} > 0$. However, when $1 - \beta a < 0$, $k_H > k^*$ and k_H decreases in α. Thus $\frac{\mathbf{d}I}{\mathbf{d}\alpha} > 0$ as well. Hence we have shown that $\frac{\mathbf{d}I}{\mathbf{d}\alpha} > 0$ unambiguously. Since we have already shown that P_H increases unambiguously in α, it follows immediately that $\frac{\mathbf{d}A}{\mathbf{d}\alpha} > 0$ unambiguously as well. □

The intuition for this result hinges on the instrumental substitutability/complementarity between developmental aid and donor personnel (see Corollary 1). With an increase in α, the first order effect is an increase in personnel supplied by the donor country. If the donor is not too altruistic, then aid and personnel will be instrumental complements, so that there is a commensurate increase in aid. The opposite implication holds when the donor is relatively altruistic to begin with.[17]

[15] The then Vice president Dick Cheney, the Secretary of Defence Donald Rumsfeld and a number of influential Department of Defence policy makers (such as Paul Wolfowitz and Richard Perle), for example, argue that direct and unilateral United States military action was highly justified. For more on this, see Monten (2005).

[16] See Reuters, March 20, 2009: `http://www.reuters.com/article/latestCrisis/idUSN20525639`.

[17] One can easily show that if $1 - \beta a < 0$ then an increase in hawkishness necessarily increases the duration of the counter-terror phase, i.e. increases $\tilde{t}_H$. However, if $1 - \beta a > 0$, whether $\tilde{t}_H$ increases or decreases in response to a rise in hawkishness depends upon the elasticity of the return $b(\cdot)$ from aid diversion; if it is not too elastic (viz. < 1), then an increase in hawkishness increases $\tilde{t}_H$.

Remark 5. *Proposition 4 demonstrates that if hawkishness increases, in response to a terror strike say, then this may lead to an increase in aid. This suggests the interesting theoretical possibility that the recipient nation may have some incentive to suppress prior knowledge of possible terror attacks against the donor, knowing that such attacks would increase the quantum of aid. Analyzing this possibility in any greater depth is beyond the scope of the present paper though.*

4.2. Are More Altruistic Donors Softer on Terror?

Does an increase in altruism necessarily go hand in hand with a softer line on terror? When President Obama came into power, there was perhaps an expectation that this would usher in an era of greater altruism. However, this did not lead to any scaling back of the offensive against the Taliban (until very recently when it was believed that the problem of terror was largely solved in that country). Similarly, in the context of the counter-terror offensive in Colombia, there was in fact an increased militarization by the United States during Obama's first year in office. To address this issue, we examine a scenario where the donor becomes more altruistic, i.e. β increases.

Proposition 5. *Suppose the donor becomes more altruistic, i.e. β increases. Then:*

1. *Development aid k_H increases unambiguously.*
2. *Personnel P_H, the aggregate counter-terror input $\int_0^1 C(t)dt$ from the donor and the aggregate joint counter-terror output $f(P_H)\int_0^1 C(t)dt$, all increase iff the donor is not too altruistic, i.e. $1-\beta a > 0$.*

Proof. First suppose $1-\beta a > 0$. In this case, $Z_{Pk} > 0$ and equilibrium implies $a - b'(k) > 0$ and $ak - b(k) > 0$. Hence $D_{P,\beta} > 0$ and $D_{k,\beta} > 0$. Next suppose $1-\beta a < 0$. Then $Z_{Pk} < 0$ and equilibrium implies $a - b'(k) < 0$ and $ak - b(k) > 0$. Hence, $D_{P,\beta} < 0$ and $D_{k,\beta} > 0$. This proves parts 1 and 2 of the proposition.

From the reduced maximand, it follows that aggregate equilibrium counter terror input equals $I = [ak_H - b(k_H)]$ and output equals $A = f(P_H)I$.

Suppose $1-\beta a > 0$. From Proposition 2 it follows that $k_H < k^*$. Since we have shown that an increase in β in this case increases k_H and P_H, given our assumptions on the function $b(\cdot)$ it then follows that $\frac{\mathbf{d}I}{\mathbf{d}\beta} > 0$ and $\frac{\mathbf{d}A}{\mathbf{d}\beta} > 0$.

Now suppose $1-\beta a < 0$. From Proposition 2 it follows that $k_H > k^*$ while we have just shown that in this range an increase in β increases k_H but decreases P_H, it now follows that $\frac{\mathbf{d}I}{\mathbf{d}\beta} < 0$ and $\frac{\mathbf{d}A}{\mathbf{d}\beta} < 0$. □

We find that with an increase in altruism, there is necessarily an increase in development aid. However, the size of the war on terror could either increase or decrease. In particular, and somewhat surprisingly, in case the donor is not too altruistic to begin with, the donor in fact comes down more heavily on terror with an increase in altruism. The intuition is as follows. The first order effect of an increase in donor altruism is an increase in aid. In case the donor is not too altruistic to begin with, the level of aid is large so that aid and personnel are instrumental complements. Consequently, there is a commensurate increase in personnel, and counter-terror output.

4.3. Productivity of Development Projects or Reach of Aid

As different LDCs may have different infrastructural and/or bureaucratic environments that affect aid delivery, we now study the impact of the productivity parameter a. A related interpretation is that a captures the productivity of aid in the terror-infested areas in particular, rather than in the recipient country as a whole. In that case a would also depend on whether the terror organization is based in geographically remote areas or not. The remoter the area, the harder it would be to deliver aid effectively to those areas, and all else equal, lower would be a. Under this interpretation a is a measure of the *reach* of the aid program. We have the following proposition.

Proposition 6. *Suppose the reach of the development aid, i.e. a, increases. Then:*

1. *As long as $1-\beta a > 0$, both aid k_H and personnel P_H increase monotonically in a; consequently, both aggregate counter terror input and output increase.*
2. *When $1-\beta a < 0$, the impacts of an increase in a on both aid and personnel are in general ambiguous. However, if the donor is minimally hawkish (so that α is positive but close to 0) then aid k_H increases monotonically in a, while personnel P_H falls monotonically in a; as a consequence, both aggregate counter terror input and output decrease.*

Proof. It is easy to check that when $1-\beta a>0$, we have $D_{k,a}>0$ and $D_{P,a}>0$. Also, we know that in this case $k_H<k^*$. Hence it must be that $\frac{\mathbf{d}I}{\mathbf{d}a}>0$ and $\frac{\mathbf{d}A}{\mathbf{d}a}>0$. So suppose $1-\beta a<0$. In this case $Z_{Pk}<0$ and so in general the signs of $D_{k,a}$ and $D_{P,a}$ are ambiguous. However, in the limit when $\alpha\to 0$, we have $D_{k,a}\to -Z_{PP}\beta>0$ and $D_{P,a}=Z_{Pk}\beta<0$. Hence by continuity, it follows that for α small enough, a rise in a increases k_H and decreases P_H. Since also we know that $k_H>k^*$, it must be that when α is small enough then $\frac{\mathbf{d}I}{\mathbf{d}a}<0$ and $\frac{\mathbf{d}A}{\mathbf{d}a}<0$. □

Suppose that the war is being fought in a remote area, so that a is already low to begin with and consequently $1-\beta a>0$. Then, as the existing war moves into even more inaccessible terrains, it is accompanied by lower amounts of aid and personnel, and as a consequence the size of the war decreases. On the other hand, if the donor is very altruistic (so that $1-\beta a<0$), but not too hawkish, then the donor may respond to the war moving into more inaccessible areas by reducing developmental aid, but increasing military personnel.

5. Other Geo-political Realities

In this section we examine some extensions of our baseline model that may be relevant for foreign policy analysis, as well as provide robustness checks for the preceding analysis.[18]

5.1. A Recipient who Supports Terrorists

In a situation where the recipient government sympathizes with terror organizations,[19] the development aid may, in fact, be diverted to the terror organization itself. For example, it has been alleged that British and American aid to Palestine has been used to pay salaries to jailed terrorists by the Palestine authorities.[20] How does this possibility affect the optimal contract and the policy mix? We argue that, somewhat paradoxically, in such a situation there may be an increase in counter-terror operations undertaken by the recipient country. Equally interestingly, we find that *it is not necessarily the case that recipients who show more direct involvement in the war against terror are less sympathetic to terrorists.*

To address these issues, we introduce two important modifications to our benchmark model. First, we now interpret $b(\cdot)$ as the utility that the recipient government obtains when it channels development aid directly towards terrorist organizations. Second, we need to incorporate the fact that now aggregate counter-terror itself is disliked by the recipient government (over and above any costs incurred by it in the process of the war). Hence, the utility of the recipient under a given scheme $\mathcal{S}$ changes to

$$U_R(\mathcal{S})=D(\mathcal{S})-f(P)C(\mathcal{S})-C(\mathcal{S})+B(\mathcal{S}). \tag{9}$$

It is straightforward to see that even in this case Proposition 1 holds so that we can restrict our analysis to contracts that are CME. Let $(\hat{P}_H,\hat{k}_H,\hat{t}_H)$ denote the solution to this adjusted problem of the donor. We find that the levels of both aid, as well as personnel deployed would be lower in this case, as would be the duration of the operations. Interestingly however, aggregate counter terror input and output falls only when either the donor is not very altruistic, or the productivity of aid delivery projects is very low, for example when the war is fought in remote areas. Otherwise, both counter-terror input, as well as output may rise or fall.

Proposition 7. *Suppose the recipient is sympathetic to the terrorists.*

1. *The optimal scheme involves supplying less development aid, as well as less military personnel compared to the case where the recipient has no sympathy for the terrorists. Also, counter-terror activities stop sooner. Thus* $\hat{P}_H<P_H$, $\hat{k}_H<k_H$ *and* $\hat{t}_H<\tilde{t}_H$.
2. *Moreover, (i) if* $1-\beta a>0$ *then both aggregate counter terror input and output is lower, and (ii) if* $1-\beta a<0$, *then aggregate counter terror input is higher (while output is ambiguous) compared to the case where the recipient is not sympathetic to the terror organization.*

[18] All proofs in this section are moved to the Appendix.

[19] See for example the United States State Department documents at `http://www.state.gov/s/ct/rls/crt/2008/122438.htm` for a list of nations believed to be falling under this category.

[20] E. Black, How British and American aid subsidises Palestinian terrorism, The Guardian, 11 November, 2013.

When a recipient government sympathizes with the terror organization, greater involvement by the donor, either in terms of aid, or personnel, backfires and gets diverted to the terrorists. Hence the donor has to manage with less personnel and less aid. Nevertheless, it is interesting that the actual involvement of the *recipient* in the war may be higher than in the case where the recipient nation was not supporting terrorists. For example, suppose aid and personnel are instrumental substitutes, so that $1 - \beta a < 0$, and the governance of the recipient changes so that the new rulers are terror sympathizers. While aid and personnel would be cut, a cut in aid reduces the returns from diversion much more than the returns from development. Hence, optimally the donor can now require the recipient to increase its own involvement in counter-terror.

5.2. Regional Hostility and Diplomacy

Although a digression from the main concerns in this paper, we note that many nations where terror organizations operate have neighboring countries that are either hostile to them or are perceived to be so. Does such hostility help or hinder the war on terror?

A simple way to capture such hostility is to let $b(k)$ represent the benefits from diverting aid for use against the hostile neighbor. An increase in such hostility, either real or perceived, can then be modeled as shifting the $b(k)$ function upwards to say $\hat{b}(k)$. In that case, the maximum amount of incentive compatible aid $\tilde{k}$ decreases unambiguously. If, in addition, we assume that for each $k \in (0, 1]$, we have $b'(k) < \hat{b}'(k)$, then optimally there is a decrease in both aid and personnel. Moreover, the time length of the war is also necessarily reduced.

The preceding discussion therefore suggests that regional hostility is not in the interest of the donor, thus creating a role for international diplomacy in managing this hostility. While a complete model of diplomacy is beyond the scope of this paper, in what follows we suggest a simple extension of our benchmark model.

Suppose the donor country can spend an amount d on diplomatic efforts aimed at reducing regional hostility. If it does so, then hostility is reduced so that the gain from aid diversion is $\Delta(d)b(k)$, where $\Delta(d)$is differentiable, with $\Delta'(d) < 0$. Mimicking arguments from Propositions 1 and 2, the constrained objective function can be written as

$$Z(P, k, d) = \alpha[ak - \Delta(d)b(k)] - (1 - \beta a)k - \zeta(P) - d.$$

It is easy to see that personnel and aid are both strategic complements with diplomatic effort d. This suggests that whenever aid and personnel are instrumental complements (i.e. $1 - \beta a > 0$), periods of diplomatic activity are likely to see large counter-terror activities and aid as well.[21]

The following remark is relevant for many of the results obtained thus far.

Remark 6 (Selfish donor)**.** *A donor may not care about development at all, so that $\beta = 0$. Clearly then aid and personnel are instrumental complements, since $1 - \beta a = 1 > 0$. While the analysis so far includes this as a special case, it may be useful to collect together some of the more interesting results.*

In this scenario the amount of aid supplied will be smaller compared to the case when he donor is altruistic (cf. Propositions 2 and 3). Moreover, if such a donor gets more hawkish (or if the reach of program, i.e. a, increases), then both personnel and aid would increase, as would aggregate counter terror input and output (see Propositions 4 and 6). Suppose now that the recipient is sympathetic to terror organizations. Proposition 7 then implies that aggregate counter terror input from the recipient and output from the joint operations would be low. Further in this case periods of regional diplomacy will be accompanied by large counter terror activities and high flows of development aid to the recipient.

5.3. Tackling Terror only with Aid

Given that involving donor personnel in a foreign nation may be politically and ideologically unacceptable in many cases, an alternative may be to use just aid in a bid to induce counter-terror. For example, the Indian ex-Prime Minister, Manmohan Singh, had announced a major 1 billion USD financial aid package for the Sheikh Hasina government in Bangladesh, aimed at ensuring continuing cooperation from Bangladesh in dealing with terrorism

[21] When $1 - \beta a < 0$, this may not necessarily be true though diplomacy will still help, and the details of how aid and personnel change in response to increased diplomacy can be easily worked out.

and insurgency targeted at India. Interestingly however, Bangladesh's top priority in its interactions with India is water management, which is a source of potential conflict. Consequently, any diversion of aid funds to this end may adversely affect Indian interests.[22]

How does this affect the amount of aid received by the recipient? A priori it would seem that with aid and personnel being alternative ways of helping the recipient, a donor country that is unable to contribute personnel, should be contributing a relatively greater amount of development aid. We show in fact that is not the case.

Consider a donor's problem when it is politically infeasible for the donor to send personnel to war. However, note that in the benchmark model we assume that counter terror measures taken by the recipient is not observable if $P = 0$. To get away with this problem, let us assume that (i) the cost of supplying personnel is such that $\zeta(P) = +\infty$ and (ii) to monitor counter terror it is sufficient to have a countable size of observers at insignificant costs.

Clearly, the effective counter-terror output at t from input $C(t)$ is $f(0)C(t)$. One can mimic the proof of Propositions 1 and 2 to argue that the optimal scheme must involve a CME and that the optimal problem reduces to maximizing

$$\alpha f(0)(ak - b(k)) + \beta ak - k.$$

Let $\underline{k}$ solve $\alpha f(0)[a - b'(k)] = 1 - \beta a$. Proposition 8 below shows that the optimal scheme necessarily involves less aid compared to the benchmark case, thereby highlighting the positive economic impact of foreign personnel.

Proposition 8. *Suppose the donor is unable to send military personnel freely (instead sends a handful of observers only who provide no productive input to counter terror output) but can provide developmental aid in a bid to induce counter-terror. Then, the optimal level of developmental aid involves* $\underline{k}$*, with* $\underline{k} < k_H$*.*

The comparative statics results are straightforward and hence we omit the derivations. They suggest that the volume of aid increases in case the donor becomes more altruistic (i.e. β increases), or the reach a of the aid increases. However, interestingly, an increase in hawkishness (i.e. a rise in α) increases the supply of aid if the donor is not too altruistic, i.e. $1 - \beta a > 0$. Otherwise, it decreases the supply of aid.

5.4. Aid and Military Equipment

In the financial year 2006, the US Congress had authorized the US Department of Defence to use 200 million USD from its Operation and Maintenance funds to equip foreign military forces with advanced technologies for counter-terrorism operations. Twenty-one countries where terrorist organizations were presumed to be flourishing received such funding in addition to what was already being provided through other military assistance programs. Since then, the Pentagon has budgeted more than 1 billion USD to equip foreign military forces through a program known as "Section 1206."[23] It is thus of some interest to analyze the case where the donor uses a combination of aid and military equipment in a bid to fight terror. As in Section 5.3, we will take a simplified stand that P is not a policy variable anymore but when the donor sends equipment, it also sends a handful of observers so that $C(t)$ becomes observable even if $P = 0$. Interestingly the analysis suggests that the comparative statics results for this case are somewhat different from the case where the donor could commit personnel.

We let M denote the size of military equipment by the donor. Further, let $m \geq 0$ denote the marginal cost for supplying an additional unit of equipment, where for ease of exposition, we simplify to the case $m = 0$. Such an assumption is also realistic if, for example, the donor country has an excess supply of military equipment. Such military support reduces the recipient's costs for waging the war. If C is the total counter-terror input, then, normalizing $f(0) = 1$ in the benchmark model, the terror output is C, while the recipient's counter-terror costs are $Max\{C - M, 0\}$. The important conceptual difference between personnel and equipment is that, unlike deployed personnel, military equipment can be diverted. We formalize this by saying that if military equipment amounting

[22] See for example, Times of India, January 12, 2010.

[23] Countries that received Section 1206 funding in the fiscal year 2009 include Bahrain, Bangladesh, Ethiopia, Kenya, Lebanon, Pakistan, Philippines and Yemen, among many others. Read more on this at `http://www.foxnews.com/politics/2010/01/04/war-terror-pentagon-looks-tap-foreign-aid-aq-fight/`. Further, during the latest round of U.S.-Pakistani strategic dialogue, the Secretary of State Hillary Clinton announced that the administration will ask the Congress for $2 billion for Pakistan to purchase U.S.-made arms, ammunition and accessories from 2012 to 2016 (Associated Press release on November 22, 2010).

to M and aid amounting to k are both diverted the recipient's payoff is $h(M)b(k)$, with $h(0) = 1$, $h'(M) > 0$ and $h''(M) > 0$.

In the following proposition we show that while the donor's level of altruism is negatively related to the amount of equipment sent, an increase in hawkishness does not necessarily imply more military equipment for the recipient.

Proposition 9. *Suppose the donor can costlessly supply military equipment, but supplying personnel is infeasible. Then:*

1. *A more altruistic donor unambiguously supplies less military equipment.*
2. *For low levels of hawkishness (so that $1 - \alpha\beta > 0$), a more hawkish donor supplies less military equipment. Otherwise, as hawkishness increases, so does the supply of military equipment.*

In contrast to the baseline model where an increase in altruism can either increase or decrease personnel, in this case increased altruism necessarily leads to a decrease in military equipment. The intuition follows from the fact that in this case development aid and military equipment are instrumental substitutes. Also, the monotonic relationship between personnel and hawkishness is overturned when we consider equipment. The non-monotonic relation between equipment (when the marginal cost of supplying this is zero) and the degree of hawkishness comes from the following observation. Consider a donor who is not too hawkish. With an increase in hawkishness, it wants the recipient to step up on counter-terror. But since it is not too hawkish, it reduces military supply and over-compensates it by aid. The trend gets reversed after a point when the donor becomes very hawkish.

6. Potential applications of this framework

While the present paper is framed in a specific context, namely that of counter-terror, its framework should be of broader interest. In particular, it should be applicable in all environments that share some of these key features: (i) an agent faces a dynamic ex post moral hazard problem in its primary task, (ii) the reward itself involves moral hazard in that the agent can use it in multiple ways, and (iii) the principal's preferences about the end uses of the reward are in conflict with those of the agent. Given the strong intuitive content of the analysis, our characterization of the optimal contract should be extendable to a more general framework, as well as other special applications that share these key features. We discuss here several potential applications of this framework that have recently taken the center stage in policy debates in less developed countries (LDCs).

First, consider the problem of teacher absenteeism faced by many LDC governments, which puts education, in particular in the rural sector, in jeopardy. The government wants teachers to exert costly effort $C(t)$ over a period of time and hence sends inspectors on random checks to schools so as to monitor such absenteeism, as well as enhance teacher quality. Alternatively, one can think of funding NGOs to select good teachers from urban areas and send them to rural schools.[24] These inspectors/good teachers can be interpreted as P in our notation. Further, in order to motivate poor parents to send their children to school, instead of working at home, the families are provided with livelihood boosts ak that the government supplies to the school authorities so that they can distribute among the students/student-families. One well known example of such schemes is the mid-day meal program initiated by the Indian government (see http://mdm.nic.in/). The school authorities derive an altruistic utility equal to ak from such help in case it is not diverted, and a private benefit of $b(\cdot)$ in case it is (see Khera (2006) on corruption in mid-day meal programs in India). Note that in this context, unrest translates to student absenteeism, which credibly signals that the midday meals, say, are being diverted! Further there is limited liability in that if the developmental fund is consumed privately, then neither can it be taken back, nor can the school authorities be credibly punished.

Even without explicitly solving this model, the lessons developed in this paper has some interesting insights that may be extended to this context. For example, our comparative statics results indicate that should education become more important for the Indian government, it would send more funds for mid-day meals! More interestingly, the government can implement higher teaching efforts from those schools which have less incentives to provide education in the first place.

[24] See a report by Deloitte for the Confederation of Indian Industry entitled, 'Urgent Needs of NGOs in the Education Sector'.

Second, consider the problem of building public infra-structure that may affect the immediate locality adversely. For example, one can think of building factories/power projects with potentially hazardous emissions, or of building a public highway in a tribal area, which may adversely affect the local lifestyle dependant on free access to forests. Suppose the project is being handled by some government agency. Thus potentially, the project not only faces moral hazard in construction, but also hostility from the local population. A resolution of this hostility may require the involvement of the local population in the effort, possibly in the construction process itself. The issue of course is that such participation has to be implemented by the same government agency operating the project, which may not want to do it. In line with the baseline model, the unrest proof condition provides a signal as to whether such local participation is being ensured or not.

Further, one can think of applications where some of the central features of our framework hold, though not necessarily all of them. For example, consider the problem of extending credit by a micro-finance institution (MFI). A loan, if granted, provides a flow income to the borrower over the lifetime of the project. Given that the borrowers are typically poor, the loans are often without collateral though. Thus in case a borrower diverts these loans to unproductive uses (when the MFI fails to recover its loan), the MFI has little penalty available to it, except to liquidate the project. In this context, clearly all three central premises of the framework discussed above applies. The departure being that there is nothing akin to unrest in this context. Even so, one can expect similar results to hold.

7. Related literature

This paper is related to several different strands of the literature, that on aid tying, counter-terror, as well as dynamic moral hazard.

7.1. Aid-tying

There is an important body of literature on tied aid, a contractual arrangement whereby the donor provides much needed aid but conditions that on certain actions to be taken by the recipient (see Koeberle (2003), Koeberle et al. (2005), Kanbur (2006), Collier (2007), Riddell (2007), and Temple (2010), among others). Our paper contributes to this literature by identifying the circular relationship between aid and counter-terror, each in turn enhancing the efficacy of the other. Further, it develops some of the ideas in this literature in a formal strategic and dynamic framework, namely that of aid 'fungibility', as well as the cooperation possibilities between the donor and the recipient, showing that doing so yields interesting insights into reality, in particular the implications of increased hawkishness and altruism.[25]

7.2. Counter-terror

The nascent literature on aid in the context of counter-terror includes Azam and Delacrix (2006) that demonstrates that there is a positive relationship between the amount of foreign aid received by a country and the number of terrorist attacks originating from it. While the knee jerk response to this result may be to conclude that aid is of no use in the war against terrorism, the present paper shows that such a conclusion may be too hasty. We demonstrate that such observations are not inconsistent with a scenario where there is too much aid (exceeding the level that is inter temporally incentive compatible), so that then aid gets diverted and the recipient country also backs out of the war on terror. The theoretical exercise in the present paper helps us understand the characteristics of the optimal aid-terror packages which, in turn, may help to avoid such hasty interpretations that may have potentially large policy implications. The issue of aid as an instrument to tackle terror has also been addressed from different perspectives in a few other papers. While Azam and Thelen (2008) analyze the effect of two kinds of aid, one geared towards fighting terrorism, and the other an educational one, in Azam and Thelen (2010) the target country chooses between aid and military intervention.

[25] Pack and Pack (1993), Feyzioglu et al. (1998), Mishra and Newhouse (2007) and van de Walle and Mu (2007) also discuss the issue of aid fungibility, though not in a game theoretic setup. The cooperation possibilities between the donor and the recipient is recognized in the 'partnership' models in the foreign aid literature, e.g. World Bank (2004) and Bourguignon and Leipziger (2006).

The present paper differs from this emerging literature, as well as contributes to it, in several different dimensions. First, this paper takes the issue of moral hazard in aid diversion, an ever-present reality in the LDCs where terror organizations are often based, very seriously. One of the central contributions of this paper is to show that aid and counter-terror work in unison to create a virtuous cycle, each enhancing the efficacy of the other, an argument that is critically dependent on the possibility of aid-diversion. Second, in contrast to this literature (which mostly adopts a static multi-stage approach) we use a dynamic model, that allows us to make the point that the optimal counter-terror policy looks very much like one of *shock-and-awe*. Third, while in the literature counter-terror is mostly delegated to the host country, we analyze a situation where counter-terror operations are *jointly* undertaken, arguing that such joint counter-terror operations are key to solving some of the agency and socio-political problems intrinsic to this setup. Finally, in terms of results, our framework allows us to address some issues hitherto not analyzed in the literature, e.g. the effects of increased hawkishness in the target nation, international diplomacy and other aspects of the such wars.

7.3. Dynamic moral hazard

The present paper also contributes to the extensive and growing literature on dynamic moral hazard. As in the present paper, Lambert (1983), Rogerson (1985), and Malcolmson and Spinnewyn (1988) all study dynamic incentive schemes without uncertainty regarding the agent's skills. In contrast to these papers however, we do not focus on risk sharing. Rather the present paper deals with task-sharing between the principal and the agent where this sharing helps the principal in increasing both the observability of outcomes, as well as the joint output. Bhaskar (2009) analyses dynamic moral hazard problems where, unlike in our case, the agent's talent is job specific and private information, and learning is allowed for (learning is also studied in DeMarzo and Sannikov (2008)). Contrary to the results in Holmstrom's (1999) career concerns model, Bhaskar (2009) finds that long term contracts can be inefficient since agents can defect early to generate favorable beliefs about their quality. Piskorzi and Westerfield (2012) examine a dynamic moral hazard model with an exogenous monitoring technology. Interestingly, in the present paper 'monitoring' in endogenous, and comes from two novel sources: an investment by the principal that also enhances productivity, and a socio-economic feature of the environment such that a defection in reward usage generates a signal (subject to the main task being adhered to). Mason and Valimaki (2008) study the issue of project completion under moral hazard although, unlike in our case, the reward is given only when the project is completed. They show that in order to provide incentives to complete the project early, rewards must be falling over time. In some sense this is similar to what we find in our optimal contract since the net rewards must equal $b(k(1-t))$ at each instant so that as t increases, the net reward falls in our case as well. However our result is not driven by incentives to complete the project in a short period but by the fact that optimality requires contracts that are front loaded with tasks.

Sannikov (2004) studies a continuous time principal agent model where output is stochastic, unlike ours, and conditional on an unobserved effort exerted by the agent. As in the present paper, the principal can commit to the contract at the start itself (see Remark 1 earlier). The main differences between Sannikov (2004) and our model are as follows. First, in the present paper the main task (viz. counter-terror) involves ex-post moral hazard, while in Sannikov (2004) moral hazard is ex-ante. Second, unlike in Sannikov (2004) as well as most papers in the dynamic moral hazard literature, in this paper the reward structure itself is subject to moral hazard. Third, given the deterministic formulation in this paper, one obtains a much simpler and intuitive closed form characterization of the optimal contract.

Sannikov (2006) studies a problem where a cash-constrained entrepreneur is financed through a credit line with a growing credit limit. There is a moral hazard problem in that the agent can manipulate cash flows through hidden savings, as well as adverse selection in that the quality of the project is private information. It is shown that despite involving incomplete contracts, such credit lines provide incentives to the agent in a way that is optimal for the principal. Even though the two environments are structurally different, one can possibly think of the aid program studied in this paper as a credit line. However in our framework, the principal can use a second instrument, i.e. personnel P, and is then aided by the unrest-proof constraint to ensure that in equilibrium the agent does not misrepresent.

Arie (2014) studies a model where the agent's effort costs are increasing and convex in past effort. As in our case, effort is unobserved and the principal can commit to a contract at the outset. He finds that the optimal contract looks like a dynamic quota, where initially rewards arrive only as a response to achievements that are beyond expectations, followed by a compensation stage where rewards are independent of achievements. It is of interest that the optimal contract in the present paper seems to have some similarities with these features even though there is no uncertainty in our framework. In the initial phase, the recipient gets rewarded only if it acts on the counter-terror, but a time comes when the donor does not demand further counter terror, and yet the recipient keeps reaping the reward for the rest of the horizon.

A common feature of most these papers, including the present one, is that the principal incurs some irreversible cost to reward the agent. Battaglini et al. (2014) study dynamic free-riding problems with irreversible contributions. They show that, contrary to the case when investments are reversible, if agents are sufficiently patient and the accumulated stock of private contributions do not depreciate too quickly, steady state contributions are almost efficient. Interestingly they also show that while irreversibility yields near efficiency, reaching these steady states takes too long. Although the problem addressed in that paper is very general and seemingly different, free-riding is indeed a moral hazard problem. Besides, one can view the problem we study as a free riding problem in a special way since there is an element of task-sharing where the principal incurs costs in terms of personnel while the agent incurs costs in terms of inputs towards a common goal of eradicating terror, even though the utilities from the task may not be perfectly aligned. Moreover, both parties like developmental aid and while the principal bears the supply cost of aid, the agent bears the opportunity cost of delivering it by giving up aid diversion. The contract we characterize helps parties to achieve a joint outcome that is individually rational for both.

In summary, the present paper adds to this burgeoning literature by analyzing a framework with dynamic ex post moral hazard (in counter-terror). In addition, the incentivising tool, namely aid, is not only itself subject to moral hazard, it is useful as an incentivising device only if there is no deviation from its intended use. As we argue earlier, we also provide an intuitive closed form solution with interesting properties, that should carry over to a more general framework.

8. Conclusion

The spectre of terrorism haunts countries all across the globe today.[26] So much so that the fight against terrorism constitutes an important element of the foreign policies of many countries, including the United Sates where President Obama made his commitment to counter-terror an explicit feature of his election campaign. Even earlier, the United States had been actively pursuing counter-terror objectives, with, for example, operation 'enduring freedom' being spread over several countries and continents, including Afghanistan, the Philippines, and the Trans-Sahara region.[27] The United Kingdom has a similar focus, with battling terrorism ranking amongst Britain's top foreign policy priorities.[28] In fact, not just developed countries but also many less developed and emerging nations (e.g. India, Sri Lanka and Malaysia, among many others), have to bear the brunt of terrorism.

In the simple set up studied here, we abstract away from many of the purely military and technological issues of counter-terror, and focus entirely upon the economic incentives of the parties involved and the social and political constraints that they face. In this paper we therefore focus on two policy tools, namely pre-emptive operations and development aid, and provide a simple rationale for aid-tying in this context, showing that such aid-tying leads to a virtuous cycle whereby joint counter-terror helps the observability of aid, and aid in its turn makes greater counter-terror possible.

The framework also allows us to develop several non-obvious results with interesting policy implications. Our first result has echoes of shock-and-awe, demonstrating that counter-terror operations must be the largest possible at the

[26] See, for example, Becker and Rubinstein (2005), Richman et al. (2008) and Abadie and Gardeazabal (2003, 2008), among others, for evidence on how terrorism can adversely affect economic and social conditions of target nations.

[27] In the context of South America, MSNBC reports that the Hezbollah has set up operations within the rural regions known as South America's Tri-Border Area. Other known terrorist organizations in the region include the Revolutionary Armed Forces of Colombia (FARC) and the National Liberation Army (ELN), who facilitate the trafficking of narcotics and the laundering of money derived from that enterprise. Further, many Western intelligence agencies report that Al Qaeda members, including nuclear 'whiz-kid' Adnan el Shukrijumah, have been spotted throughout South America.

[28] According to the ex-British foreign secretary David Miliband. See the report by Azhar Massod and Agencies, Islamabad, 27 July, 2007.

very beginning. It is however driven by dynamic incentive considerations, rather than purely military ones. Second, it is not necessarily the case that a more hawkish donor is less pro-development. Third, neither is it necessary that a more altruistic donor is softer on terror. Fourth, it is often the case that such wars move into more remote areas over time. Our analysis suggests that when this happens, aid and personnel deployed need not necessarily fall. All these results suggest that political changes in the donor country, or pressures from international agencies on the donor government, can have unanticipated consequences.

We also extend the analysis to allow for several interesting possibilities, e.g. controlling terror only with developmental aid or supplying military equipment (which itself can be misused). In the last case we show that while a more altruistic donor supplies less military equipment, the supply of military equipment is ambiguous with respect to an increase in hawkishness. Next allowing for the possibility that the recipient government supports the terrorists, we find that it is not necessarily the case that recipients who show more direct involvement in the war against terror are less sympathetic to terrorists. Finally, we argue that in the presence of neighbors hostile to the recipient country, periods of diplomatic initiatives by the donor country (aimed at reducing such hostilities) are likely to coincide with periods of large aid, as well as counter-terror activities.

Finally, we indicate some avenues for future research. Note that the unrest-proof condition did encapsulate the possibility, albeit in a reduced form, that counter-terror itself could generate some support for the terrorist organization. That this linkage is important is suggested, among other things, by the fact that terrorist organizations often target government funded aid delivery to the population, presumably in a bid to radicalize the population. It would therefore be of interest to endogenise this aspect, explicitly modeling the choices and constraints facing the domestic population, a task that we leave for future work. Finally, geo-political realities suggest that one allows for multiple donors. Our analysis then indicates that coordination among them may be crucial, so as to ensure that there is neither any unrest, nor aid diversion. Further, what if there are conflicts of interest between the various donors in terms of both aid and counter-terror? Global politics then becomes very important. Again we leave these ideas for future work.

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9. Appendix

Proof of Proposition 7. For the scheme $\mathcal{S} = \langle k, C(t), P\rangle$ to be incentive compatible and unrest-proof at each $t \in [0,1]$ we now require

$$(i) f(P)C(t) \leq ak, \forall t \in [0,1],$$

$$(ii)' ak(1-t) - \int_t^{\hat{t}} f(P)C(t)\mathbf{d}t - \int_t^{\hat{t}} C(t)\mathbf{d}t \geq b(k(1-t)), \forall t \in [0,\hat{t}],$$

and

$$(iii) ak(1-t) \geq b(k(1-t)) \forall t > \hat{t}.$$

As before, we set equality in (i) so that $C(t) = \frac{ak}{f(P)}$ and substitute this in $(ii)'$ to obtain

$$ak(1-t) - (\hat{t}-t)ak - (\hat{t}-t)\frac{ak}{f(P)} \geq b(k(-t)).$$

At $t = 0$, this reduces to

$$ak - \hat{t}ak\left(1 + \frac{ak}{f(P)}\right) \geq b(k).$$

It then follows that $ak \geq b(k)$ so that $ak(1-t) \geq b(k(1-t))$. Thus we can ignore (iii) as before. Hence the hard-line donor's problem is now

$$Max_{\{k,P,\hat{t}\}} \alpha \hat{t} ak + \beta ak - k - \zeta(P),$$

subject to:

$$\hat{t} \leq \left(\frac{ak - b(k)}{ak}\right)\left(\frac{f(P)}{1+f(P)}\right).$$

Setting equality into the above constraints, the problem reduces to

$$Max_{\{k,P\}} F(k,P) = \alpha[ak - b(k)]\left(\frac{f(P)}{1+f(P)}\right) + \beta ak - k - \zeta(P).$$

As our assumptions on $f(\cdot)$ guarantees an interior solution, consider the first order conditions:

$$F_P : \alpha\left(\frac{f'(P)}{(1+f(P))^2}\right)[ak - b(k)] = \zeta'(P),$$

and

$$F_k : \alpha\left(\frac{f(P)}{1+f(P)}\right)[a - b'(k)] = 1\beta a.$$

Since $P_H > 0$ and $f(P_H) > 0$ it follows that at (P_H, k_H), the LHS of the above two conditions become less than the corresponding RHS. Hence if $\hat{P}_H$ and $\hat{k}_H$ be the solution of the above maximization problem, then it must be that $\hat{P}_H < P_H$ and $\hat{k}_H < k_H$.

We then move to compare $\tilde{t}_H$ with $\hat{t}_H$. Recall, that

$$\tilde{t}_H = \frac{ak_H - b(k_H)}{ak_H} f(P_H),$$

while

$$\hat{t}_H = \frac{a\hat{k}_H - b(\hat{k}_H)}{a\hat{k}_H}\left(\frac{f(\hat{P}_H)}{1+f(\hat{P}_H)}\right).$$

Let $G(k) = \frac{ak-b(k)}{ak}$ and $J(P) = \frac{f(P)}{1+f(P)}$. Then,

$$J'(P) = \frac{f'(P)}{(1+f(P))^2} > 0.$$

Hence, since $f(P) > \frac{f(P)}{1+f(P)}$ and $P_H > \hat{P}_H$, it follows that

$$f(P_H) > \frac{f(\hat{P}_H)}{1+f(\hat{P}_H)}.$$

Also,

$$G'(k) = -\frac{1}{ak^2}[b(k) - kb'(k)].$$

Since $k_H > \hat{k}_H$, it follows that if $G'(k) > 0$ then $G(k_H) > G(\hat{k}_H)$. But $G'(k) > 0$ if and only if $b(k) - kb'(k) < 0$. Since $0 < \hat{k}_H < k_H$, it is sufficient for us to show that for all $k > 0$ we have $b(k) - kb'(k) < 0$, which we now show. Notice that as $k \to 0$, $L(k) = b(k) - kb'(k) = 0$. Now, $L'(k) = b'(k) - b'(k) - kb''(k) = -kb''(k) < 0$. Thus we have proved that $G'(k) > 0$ for all $k > 0$. This completes the proof of the proposition. □

Proof of Proposition 8. Let k_0 be the solution. The unconstrained FOC of this maximization problem yields

$$\alpha f(0)[a - b'(k)] = 1 - \beta a.$$

This gives the solution $k_0 = \underline{k}$. IC at each t implies that $k_O < \tilde{k}$.

In contrast, the solution (P_H, k_H) involves

$$\alpha f(P_H)[a - b'(k_H)] = 1 - \beta a,$$

where $P_H > 0$. Hence, it follows that

$$\frac{f(P_H)[a - b'(k_H)]}{f(0)[a - b'(k)]} = 1.$$

Since $f(P_H) > f(0)$ it follows that $a - b'(k_H) < a - b'(k_0)$ independent of the sign of $1 - \beta a$. Thus, $b'(k) < b'(k_H)$ so that $k < k_H$. □

Proof of Proposition 9. The problem faced by the donor is then as follows:

$$Max_{\{k,\tilde{t},M\}}\alpha \int_0^{\tilde{t}} C(t)dt + \beta \int_0^1 D(t)dt - k - mM$$

subject to:

$$(i) C(t) \leq ak, \forall t \in [0,1],$$

$$(ii) ak(1-t) - Max\left\{\left(\int_t^{\tilde{t}} C(t)dt - M\right), 0\right\} \geq h(M)b(k(1-t)), \forall t \in [0,\tilde{t}],$$

and

$$(iii) ak(1-t) \geq h(M)b(k(1-t)) \forall t > \tilde{t}.$$

We first impose CME so that from constraint (i) it follows that $C(t) = ak$ for all $0 \leq t \leq \tilde{t}$ and $C(t) = 0$ otherwise. Then constraint (ii) becomes

$$ak(1-t) - Max\left\{\left((\tilde{t}-t)ak - M\right), 0\right\} \geq h(M)b(k(1-t)).$$

Hence, for each $0 \leq t \leq \tilde{t}$, it must be that

$$ak(1-t) \geq h(M)b(k(1-t)).$$

For any $t > \tilde{t}$, the above inequality continues to hold. Thus we can ignore constraint (iii). Also, it is then necessary and sufficient to simply satisfy (ii) at $t = 0$. Hence the problem of the donor

$$Max_{\{k,M,\tilde{t}\}}\alpha\tilde{t}ak + \beta ak - k - mM$$

subject to:

$$\tilde{t}ak \leq ak + M - h(M)b(k).$$

Thus in the optimum it must be that

$$\tilde{t}(k,M) = 1 - \frac{h(M)b(k) - M}{ak} - mM.$$

Replacing this in the maximand reduces the problem to

$$Max_{\{k,M\}}\alpha[ak + M - h(M)b(k)] + \beta ak - k - mM.$$

The optimal solution for k and M is completely characterised by the following two first order conditions (these are sufficient as well under our assumptions on $b(\cdot)$ and $h(\cdot)$):

$$b'(k) = \frac{a(\alpha+\beta)-1}{\alpha h(M)},$$

and

$$h'(M)b(k) = 1 - \frac{m}{\alpha}.$$

We now proceed with the impact of changes in α and β on the above solution. Total differentiation of the above two equations yield the following:

$$\alpha h(M)b''(k)\mathbf{d}k + \alpha b'(k)h'(M)\mathbf{d}M = (a - h(M)b'(k))\mathbf{d}\alpha + a\mathbf{d}\beta,$$

and

$$h'(M)b'(k)\mathbf{d}k + b(k)h''(M)\mathbf{d}M = \frac{m}{\alpha^2}\mathbf{d}\alpha + 0\mathbf{d}\beta.$$

Hence,

$$D = \begin{vmatrix} \alpha h(M)b''(k) & \alpha b'(k)h'(M) \\ h'(M)b'(k) & b(k)h''(M) \end{vmatrix} > 0.$$

Next

$$D_{M,\alpha} = \begin{vmatrix} \alpha h(M)b''(k) & a - h(M)b'(k) \\ h'(M)b'(k) & \frac{m}{\alpha^2} \end{vmatrix}, D_{M,\beta} = \begin{vmatrix} \alpha h(M)b''(k) & a \\ h'(M)b'(k) & 0 \end{vmatrix}.$$

It is straightforward to check that $D_{M,\beta} < 0$. This proves part 1 of the proposition. To prove part 2, we have

$$D_{M,\alpha} = \frac{amh(M)b''(k)}{\alpha^2} - h'(M)b'(k)[a - h(M)b'(k)].$$

But using the first order condition, we obtain

$$D_{M,\alpha} = \frac{amh(M)b''(k)}{\alpha^2} - \left(\frac{1-\alpha\beta}{\alpha}\right)\left(\frac{\alpha-m}{\alpha}\right)\frac{b'(k)}{b(k)}.$$

Hence, $D_{M,\alpha} > (<)0$ if and only if

$$amh(M)b''(k) - (1-\alpha\beta)(\alpha-m)\frac{b'(k)}{b(k)} > (<)0.$$

The rest of the proof is now straightforward. $\square$

10. References

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