Title

Optimal Liability for Terrorism

Authors
Talley, Eric
Lakdawalla, Darius

Publication Date
2005-09-09

Optimal Liability for Terrorism*

Darius Lakdawalla[†] Eric Talley[‡]

June 2005

Abstract

This paper analyzes the appropriate role for civil liability in aligning terrorism precaution incentives when the perpetrators of terrorism are beyond the jurisdiction of courts or regulators. We consider the strategic interaction among the targets, subsidiary victims, and terrorists within a sequential, game theoretic model. Analysis of the model reveals that, while an 'optimal' liability regime indeed exists, its features appear somewhat peculiar when compared to conventional legal templates. For example, it frequently prescribes decoupled damages, and damages payments from seemingly unlikely defendants. As such, practical implementation of such a system may present a significant challenge. Consequently, we suggest that the provision of precaution incentives in the case of terrorism may be best solved through alternative policy mechanisms, such as a mutual public insurance pool for potential targets of terrorism, coupled with direct compensation to victims of terrorist attacks.

*PRELIMINARY DRAFT (do not cite or circulate without permission)

[†]Economist, RAND Corporation, 1700 Main Street, Santa Monica, CA 90407. darius@rand.org

[‡]Ivadelle & Theodore Johnson Professor of Law and Business, University of Southern California; Senior Economist, RAND Corporation. Email: etalley@law.usc.edu

1 Introduction

The terrorist attacks of September 11 shattered America's sense of well-being and profoundly reordered its substantive priorities on security, civil liberties, and the role of law. Indeed, the change in policy commitments that ensued set in motion a reshuffling of social and political institutions that are still taking shape in the post-9/11 environment.

Understandably, the early policy discussions centered on basic issues of safety and protection, particularly on the means for guaranteeing homeland security,[1] the degree to which civil liberties should be sacrificed for greater security,[2] and the proper role for government in insuring against the risk of terrorism.[3] However, as the immediate security and intelligence exigencies that followed September 11 were addressed, a new issue has predictably emerged: Private litigation. Hundreds of individual claimants have chosen to opt out of the victims compensation fund, and are currently pursuing liability claims in United States courts. A large portion of these actions fall under the jurisdiction of the Air Transportation Safety and System Stabilization Act, which specifically instructs courts to apply state common law principles to adjudicate the claims of those opting out.[4] Just how courts will adjudicate these claims is still a bit of a question mark. The liability landscape, then, and the overall policy tradeoffs that animate it, deserve immediate and reasoned consideration, if for no reason than the fact that it has now pressed itself upon us. Unfortunately, while the debates surrounding homeland security and insurance have been enriched by the contributions of numerous policymakers and academics, liability has received relatively little attention. This paper attempts to fill that void, exploring how and whether civil liability should play a role in allocating risks among those affected by large-scale acts of terrorism like that of 9/11.

When terrorists and/or their funders can be held accountable by courts, liability plays an obvious role by forcing terrorists to bear the social costs of their actions. However, in most circumstances, terrorists and/or their funders are beyond the reach of civil and criminal courts, because they may have committed suicide, fled, or successfully gone into hiding after an attack. Therefore, a more important and also more difficult question is whether and how liability can play a role when terrorists themselves cannot be brought to account. The pending 9/11 litigation demonstrates that this is no longer idle speculation, since litigation is being brought against many agents other than the terrorists themselves.

While the threat of liability may not deter terrorists directly, it can deter them indirectly, by shaping the incentives of those who can avoid harm. For example, the threat of legal liability may induce various types of 'targets' (such as bridges, buildings, public fora, and attractions) to take different levels (or types)

[1] E.g., the U.S. Patriot Act, H. R. 3162 (2001) (codified in scattered sections of Title 18 of the U.S. Code).

[2] Three recent (and important) Supreme Court cases from this year have centered on this question. See Rasul v. Bush, Hamdi v. Rumsfeld, and Rumsfeld v. Padilla [cites].

[3] See, e.g., the Terrorism Risk Insurance Act of 2002 [cite]

[4] See Pub. L. No. 107-42, 115 Stat. 230 (2001) (codified at 49 U.S.C. § 40101).

of precautions on behalf of licensees, permittees, and other bystanders. In addition, the implicit insurance afforded by legal liability can influence individual "passers-by" in their decisions about whether to venture out into public fora, and about protecting themselves once exposed. In addition, the credible threat of liability may affect the strategic interaction among targets that "compete" to avoid the attention of terrorists. All of these affect the costs and benefits of a terrorist attack and thus indirectly influence the behavior of terrorists, and the risk of terrorism.

In this paper, we ask whether and how—in light of the complex relationships among affected targets, unaffected targets, and victims—civil liability can improve welfare in a society threatened by terrorism. We show that there is a liability regime that improves welfare and achieves the first-best level of welfare (given that terrorists are unreachable). However, this regime does not fit within existing US legal templates. These institutional factors substantially reduce the value of liability as a policy approach to terrorism. Fortunately though, we also outline a more practical way to achieve the first-best: a social insurance scheme among targets and victims of terrorism.

From a doctrinal point of view, there are grounds for allowing no more than two types of tort claims. The most conventional and plausible claims would be brought by victims against a target of terrorism; for example, the residents or passers-by of the World Trade Center (WTC) may have grounds to sue the WTC itself for its failure to protect them. Much less likely, but still plausible, are suits by a damaged target against other high-profile buildings; the theory here would be that Building A protected itself so much that terrorists focused their attention on and ultimately attacked Building B.

The boundaries of legal possibility do not coincide well with the liability regime that is optimal from a welfare point of view. First, claims by victims against targets are *never* optimal; in some circumstances, it may even be optimal for targets to recover damages from victims. Second, it may sometimes be welfare-improving for a damaged target to recover from an undamaged one, but the opposite is also possible.

The welfare grounds for terrorism liability depart radically from conventional legal templates, because of the unique nature of terrorism risk. Unlike accidental harms, terrorism is perpetrated by a strategic adversary bent on maximizing damage. Since terrorists are likely to value inflicting casualties, they prefer (all else equal) to attack more heavily patronized targets. Therefore, increased patronage of a target "draws fire" onto that target. Since patrons will often fail to account for this effect, the result is over-patronage. Introducing liability payments from targets to victims would exacerbate this externality. In this way, the strategic behavior of terrorists undermines the usual rationale for compensating victims.

Moreover, strategic behavior by terrorists create incentive problems that require claims by one target against another. Rational terrorists will tend to focus their efforts on weaker, less well-defended targets and avoid harder ones. Therefore, the decision to erect a new building in a high-risk zone will "draw fire" away from existing structures, while hardening an existing target may shift fire onto other buildings. The latter possibility justifies a liability claim by a damaged target against an undamaged one, but the former justifies exactly the opposite. This leads to the necessity of flexible liability claims among potential targets of terrorism.

Our analysis proceeds as follows. In Section 2, we briefly explore the relevant legal issues surrounding terrorism litigation, and outline the circumstances under which private plaintiffs are likely to be able to raise at least plausible claims for recovery under common law tort doctrines. Against what is *possible*, we then juxtapose what is optimal, in Section 3. There, we characterize the socially efficient allocations of protection in this environment, and the optimal liability regime. We also delve into the sources of our optimal liability arrangement and show how this can be replicated (perhaps more efficiently) outside of the judicial system. Section 4 considers various caveats and extensions to our analysis, while Section 5 concludes. (An Appendix to this article contains the proofs of the various claims).

2 Terrorism and Tort Law

As noted in the introduction, the 9/11 litigation has constituted an open invitation for courts to play precedent-setting roles in determining how and whether to redistribute resources in the wake of a terrorist act, when the terrorists themselves are beyond the legal system's sphere of influence. This section briefly explores who the possible plaintiffs might be, and how successful their claims are likely to prove under the template of existing tort doctrine. We consider three types of civil litigation: (1) Suits brought by individual victims (such as bystanders) against affected targets (such as buildings); (2) Suits brought by targets against one another; and (3) Suits brought by targets against individual victims. We conclude that there may well be good precedential analogies for the first two types of legal actions, the third is more of a clumsy fit within modern tort law templates.

2.1 Liability Claims of Victims

Perhaps the most conventional form of liability claim comes from the victims described above. The kernel of each of their claims would be, in essence, a common law tort claim consisting of proving: that the target owed a duty to take reasonable steps to protect the safety and well-being of victims; that the target breached this duty; that this breach caused direct and foreseeable harm to the victims, which can be capitalized into provable damages.

Some of these elements of a common law tort claim are indisputable. Indeed, the degree of damage suffered by the various victims of the 9/11 attacks have been well-documented, and are estimated to be just under 10 billion dollars. Moreover, assuming terrorists can be effectively deterred by safety precautions undertaken by the target, it seems apparent that one could articulate a reasonable standard of care for those precautions, and make plausible inferences about whether a failure to undertake them constitutes a "but for" cause of victims' injuries.

One could imagine, however, that plaintiffs would face a more strenuous challenge in demonstrating that a target's "duty" would extend to terrorist acts (as opposed to general issues of building safety). Traditionally, courts have conceived of duty relatively loosely, with many courts positing that everyone owes everyone else a general duty of due care. In recent years, however, many courts have increasingly placed constraints upon the historically expansive contexts in which a defendant is deemed to have a duty of due care to potential victims. For example, a recent strand of cases has begun to limit the application of duty to risks that are not reasonably foreseeable.[5] Another strand of recent cases has eliminated the concept of duty from situations that involved inherently risky activities, in which a victim has been found to have assumed the risk of a harm occurring by placing him/herself in harm's way (such as spectators injured at baseball games or skiers injured on the slopes).[6]. Both of these trends might plausibly extended more generally, precluding liability for particularly unlikely or speculative causes of an injury (such as in terrorism claims). Showing a lack of a cognizable duty is perhaps one of the strongest weapons that defendants have available in disposing of litigation. Indeed, many courts are willing to allow cases to go forward in discovery and litigation once a duty is found to exist, since most of the remaining issues are factual in nature, and therefore appropriate for jury deliberations. However, the presence or absence of duty is a thorough-going issue of law for a court to decide. A finding of "no duty" effectively ends litigation in its tracks.

Another potential impediment that victims face in pursuing targets for tort liability is the doctrine of proximate cause. This doctrine limits liability exposure to situations where there is a reasonably foreseeable connection between the defendant's action and the resulting harm (See, e.g., *Palsgraff v. Long Island Railroad*[7]). A central issue that is likely to loom large within terrorist litigation contexts is the issue of intervening liability. Indeed, a significant body of case law holds a negligent defendant not liable if a subsequent actor's injurious actions interceded in the causal chain between the defendant's act and the plaintiff's injury.[8] In the terrorism context, intervening actors are likely to

[5] See, e.g., Washington v. City of Chicago, 720 NE2d 1030 (Ill. 1999).

[6] See generally, Keating, G. 2004, "Abusing Duty" (unpublished manuscript).

[7] 162 NE 99 (1928). In *Palsgraff,* the plaintiff's injury had been caused by an unlikely chain of events sparked by the defendant's negligent actions. Notwithstanding the factual conclusion that the defendant's breach of duty was the first proverbial domino in a clear causal chain, Justice Cardozo held that the case could not go forward, since it was not reasonably foreseeable that the type of harm suffered by the plaintiff would result from the defendant's alleged act of negligence.

[8] In a well-known products liability case, for example, a plaintiff sued an automobile manufacturer to recover on a manufacturing defect that caused the plaintiff's spare tire to fall off his SUV while driving on the freeway. Although initially unharmed, the plaintiff was injured when a third party's vehicle rear ended the plaintiff's vehicle while he was retrieving the tire. The New Jersey Court of Appeals reversed a trial court judgment for the plaintiff, holding that the intervening act of negligence (both of the victim and of the third party driver) was sufficient to break the chain of causation begun by the manufacturing defect. Yun v Ford

play a significant role. The instrumentality of injury in cases of terrorism is not a natural disaster or an inevitable chain of events, but rather a calculated decision by a strategic player to inflict deliberate harm on others. It is precisely these sorts of cases in which the proximate cause doctrine may have considerable limiting power. The proximate cause limitation is a distant conceptual cousin of the similar concept noted above that is working its way into "duty" cases.[9] However, unlike the doctrine of duty, the proximate cause inquiry is generally not one that courts determine at the onset of litigation. Consequently, plaintiffs would much rather be in a position to litigate foreseeability issues at the proximate cause stage as opposed to making such showings up front at the duty stage of a case.

In sum, it appears that potential "bypasser" victims would face a couple of significant challenges in pressing civil liability claims against affected targets. At the same time, however, assuming such claims could successfully withstand a "duty" determination, they would stand a reasonably good chance of surviving preliminary pleading and dismissal stages in most courts, which in turn makes them at least worthy of generating a settlement value.

2.2 Liability Claims against Other Potential Targets

A second plausible cause of action would involve suits by damaged targets against other targets. These causes of actions could take one of two forms. Under the first, a target that suffers "collateral" damage as a result of an act of terrorism might bring suit against the primary target to recover its losses. Under the second, a damaged target may attempt to recover from an *undamaged* target, alleging that the latter's precautionary acts imposed a harm by diverted a terrorists' focus to less protected targets.

The collateral target cases bear a close resemblance to the victim-on-target case described above. Indeed, in many respects, juxtaposing collateral targets are very much like individual victims who find themselves at the scene of an attack. Consequently, analysis of this sort of claim is likely to mirror much of the analysis in the previous section.

On the other hand, a case alleging the over-precautionary behavior of an unaffected target seems somewhat unconventional. Even here, however, a few templates within American tort law could provide a basis for such claims. One area of law in particular that analogizes reasonably well to this type of situation is the case law concerning liability after a natural disaster, such as a flash flood. This analogy is likely an apt one because, much like target hardening, protective measures by one property owner (such as the building of a dyke) may impose negative externalities on others by increasing their susceptibility to flood waters. The doctrinal analogy, moreover, is interesting because the law governing diffuse

---

Motor Co., Sup. 276 N.J. Super. 142, 647 A.2d 841 (1994); See also Brown v. United States Stove Co., 98 N.J. 155, 171-5, 484 A.2d 710 (1984) (manufacturer relieved of liability if superseding intervening cause).

[9] Indeed, Keeting (2003) criticizes the spillover of the foreseeability doctrine on exactly these grounds.

surface water is itself in a state of doctrinal flux, and the existing legal templates for dealing with such problems suggest a wide range of possible legal responses.

One approach that courts in around seventeen states have taken to the problem noted above is frequently referred to as the "common enemy" doctrine, under which a landowner is free to use any and all methods to dispose of surface runoff without fear of liability to her neighbors.[10] Other states, in contrast, follow what has become known as the "civil law" doctrine.[11] This rule is essentially the polar opposite of the common enemy doctrine, and in its pure form imposes *strict liability* to his neighbors when his actions to protect his land cause harm to his neighbors. These two approaches, sometimes in modified variations, appear to have been adopted in approximately twenty-two states each.[12]

In addition, a smaller number of courts have embraced a third doctrine that has become known as the "reasonable use" doctrine. This doctrine, which is somewhat younger than the other two described above,[13] lies between them substantively and is essentially a negligence rule: an owner may make reasonable use of his land and in so doing, to alter the drainage of surface water up to the point that the alteration causes unreasonable interference with his neighbors' use of their land.[14] In many respects, the reasonable use doctrine replicates the basic templates of nuisance law for surface water hazards,[15] and it is treated that way in the Restatement of Torts.[16] Although still a minority position among jurisdictions (embraced in about six jurisdictions), it is widely perceived to be growing quickly in its influence.[17] In these states, however, the duty and proximate cause hurdles noted above may well recur here also.

2.3 Liability Claims Against Victims

A final potential sort of claim involves a suit brought by a damaged target against individual victims who were also present (and possibly damaged) by the

[10] See, e.g., Keys v. Romley, 64 Cal.2d 396, 50 Cal.Rptr. 273, 412 P.2d 529 (1966); Yonadi v. Homestead Country Homes, Inc., 35 N.J.Super. 514, 114 A.2d 564 (App.Div.1955), petition denied 42 N.J. Super. 521, 127 A.2d 198 (1956); Butler v. Bruno, 115 R.I. 264, 341 A.2d 735 (1975); Carland v. Aurin, 103 Tenn. 555, 53 S.W. 940 (1899).

[11] The name emanates, apparently, from the fact that the only civil law jurisdiction in the US, Louisiana, is credited with being the first state to embrace it. See Orleans Navigation Company v. New Orleans, 1 La. (2 Mart. [O.S.]) 214 (1812).

[12] See Keys v. Romley, supra (counting jurisdictions); and Annot. 93 A.L.R.3d 1193, 1207-11 (1979).

[13] Though a relatively recent phenomenon nationally, the original seeds of the reasonable use doctrine can be found in New Hampshire during the 19th century. Swett v. Cutts, 50 N.H. 439 (1870); Bassett v. Salisbury Manufacturing Co., 43 N.H. 569 (1862).

[14] See Enderson v. Kelehan, 226 Minn. 163, 32 N.W.2d 286 (1948); Armstrong v. Francis Corp., 20 N.J. 320, 120 A.2d 4 (1956); Pendergrast v. Aiken, 293 N.C. 201, 236 S.E.2d 787 (1977); Butler v. Bruno, 115 R.I. 264, 341 A.2d 735 (1975); Annot. 93 A.L.R.3d 1193, 1216-21 (1979).

[15] Pendergrast v. Aiken, 293 N.C. 201, 236 S.E.2d 787 (1977).

[16] Restatement (Second) of Torts, § 833 (1979).

[17] It is also beginning to infiltrate the other two doctrines, which in some jurisdictions have begun to embrace some components of fault.

terrorist act. While certainly counterintuitive, it is possible to understand why such a claim might emerge: A large population of victims, the argument goes, presents a natural attraction for terrorist attention, since terrorists are likely to care, at least in part, about how many individuals are at a given site are vulnerable to attack (and perhaps the notoriety of the target as well). While individual victims recognize the fact that their presence at a site marginally increases the odds of a terrorist act, they do not fully internalize the additional cost that their presence imposes on the target itself, which is also subject to enhanced risk of attack. Consequently, the argument goes, affected targets may attempt to argue that the risk of attack was substantially caused (or at least increased) by the presence of victims at the site.

In theory, nothing prevents an affected target from asserting this type of claim against victims. It seems implausible that such actions would be successful in practice, for a number of reasons. First, at least some "victims" affected by a terrorist attack are actually contractual relationships with the target, and therefore it is possible for the target and victims to price out the risk of later harm. Rental/lease terms, capacity restrictions, conditions of occupancy, and other contractual mechanisms allow the target to regulate – directly or indirectly – the type, timing and frequency of patronage by victims in contractual privity. Thus, at least insofar as victims constitute *contracting parties* with the target, tort law may well recognize the parties' ability to price out risks, and deny relief on that basis.

But even for victims who are not in a contractual relationship with the target, target-on-victim claims seem unlikely to go forward. Indeed, to proceed against individual victims, it is necessary to file suit against each one, a process that imposes substantial fixed costs on the target plaintiff for each suit filed. Moreover, the extent of damages that the plaintiff has suffered as a result of each *individual* defendant's actions are likely to be both speculative and small in magnitude, since any individual victim imposes only incremental risks on a target. Putting these two factors together, it seems likely that the cost of filing suit against each bystander victim defendant would likely exceed (by orders of magnitude) the prospective damages that a plaintiff-target might reasonably expect in such a suit. Moreover, these problems become even more intractable under a negligence standard. Indeed, because all bystander victims act independently of one another in an uncoordinated fashion, it would be difficult to determine which sub-population of defendants was responsible for violating the negligence standard – i.e., that point at which the marginal social cost of an additional victim at a site exceeds the marginal social benefit. Finally, and perhaps most saliently, because of the human element of tragedy that attends death and injury of individual victims, it would almost certainly be politically unpalatable for a target-defendant to proceed against a population of sympathetic victims, regardless of what the contours of optimal deterrence theory may be.

2.4 Synthesis

Our analysis of existing templates in tort law has been necessarily brief, but it does generate a framework for thinking about the likely tort claims that victims and targets are likely to confront after a terrorist act. First, for most courts wading into this terrain, it is overwhelmingly likely that the terrorist actors themselves cannot be made to answer for their own activities, limiting the court's response to a type of "second-best" allocation of rights among the terrorists' victims and targets (actual or potential). Second, victim-on-target suits, along with collateral target suits, appear to be the most viable jurisprudentially, but they are likely to face stiff challenges on both duty and proximate cause grounds. Third, suits by damaged targets against unaffected targets for alleged excessive precautions are unorthodox, but find at least some plausible analogical templates within existing case law. Here too, though, duty and proximate cause arguments may present significant obstacles, depending on jurisdiction. And finally, it appears extremely unlikely (for both practical and economic reasons) that damaged targets can sue individual victims for "overpopulating" the site and drawing terrorists' fire.

How, then, are courts likely to resolve the uncertainty regarding duty and causation? Based on a doctrinal analysis alone, it is difficult to make predictions with absolute certainty. However, the doctrines discussed above are thought to rest heavily on policy considerations about the nature and effects of liability. And, one important set of policy considerations concerns how liability affects individual incentives, and in turn allows policymakers to navigate a large set of trade-offs between social costs and social benefits implicit in acts of terrorism. In the section that follows, then, we posit and analyze a formal model of behavior that makes these costs and benefits explicit.

3 An Incentive-Based Model of Terrorism, Precautions, and Liability

If liability is to play a role independent of public and private insurance provision, it must be by improving the incentives of actors who might otherwise externalize costs and benefits onto others. Therefore, the key rationale for liability must be in solving incentive problems, not insurance problems. For this reason, we build a model with risk-neutral agents, where incentive problems are shown in sharpest relief. Introducing risk-aversion might uncover an additional rationale for a liability regime, which always performs a risk-sharing function, but it would be a spurious one, better performed by an active private or public insurance market.

Another crucial feature of our model is the assumption that terrorists lie beyond the reach of courts or regulators. To be sure, there may be some situations where perpetrators of terrorism are subject to civil or criminal litigation, such as the convictions of Oklahoma City domestic terrorists Timothy McVeigh and Terry Nichols, or the recovery against the Libyan government for the PanAm bombing over Lockerbie, Scotland. However, the most central and salient characteristic of *most* terrorist acts is a lack of legal accountability for some or all of the key perpetrators. As a result, we analyze a second-best world in which terrorists themselves cannot reliably be brought to account, either because they sacrifice their own lives in the attack, or they effectively go into hiding. However, it is crucial to note that changes in target or victim behavior also alter the costs and benefits of terrorism, and thus the frequency of terrorism.

The legal discussion in Section 2 considered a number of different types of parties: Actual or potential targets hit by a terrorist attack; collateral targets (e.g., adjacent buildings) that are not directly targeted but nonetheless suffer damage when a targeted building is attacked; individual victims (such as vendors or employees) who are in contractual privity with targets; and victimized passers-by who are not in contractual privity with targets. Since several of these kinds of agents share common incentives and constraints, we simplify our set of actors as follows. First, we group a target with all potential victims and other agents in contractual privity with it; we assume they allocate their joint risks efficiently amongst themselves without need of a liability regime.[18] We refer to these agents collectively as "Targets". We also group collateral targets with bystanders, since their legal claims would be similar (see above), and since neither is likely to be in contractual privity with the targets. We refer to these groups generically as "Victims."[19]

Our formal analysis proceeds in three stages. First, we posit an economic environment in which terrorists, targets, and victims interact with one another. Second, we characterize equilibrium behavior within this framework in the absence of liability and describe its welfare properties. And finally, we ask whether a prudently designed liability system could improve welfare. In order to focus solely on incentives (rather than insurance), we assume that all players in our model are risk-neutral.

3.1 Framework

Consider a single terrorist group contemplating whether to attack one or more of N particular targets. The targets are assumed to be evenly spaced along a circle

[18] Thus, we define "targets" to include owners of buildings, landmarks, shopping centers, government offices, well-known businesses, and the like, that might be the locus of a terrorist's targeting activities, *plus* all groups or individuals who are in a direct and complete contractual relationship with a target, such as tenants, long-term employees, and so forth. As noted in the text, there is little to be gained by tort claims when complete contracts can be written by rational, welfare-maximizing agents.

[19] This definition abuses terminology somewhat, since *all* affected individuals/groups/entities can be appropriately thought of as 'victims'; we have used a narrower definition here to distinguish between primary victims ("Targets") and secondary victims (our use of "Victims" stated in the text). The key distinction is that targets can directly control the level of protection against terrorism, while victims cannot, save for relocating themselves away from high-risk areas. Consistent with the discussion in note 18, victims are assumed unable to write complete ex ante contracts with targets.

of (normalized) circumference 1 and have respective locations of $\left\{\frac{1}{N}, ..., \frac{N}{N}\right\}$.[20] Successful attacks depend on planning and preparation. Terrorists invest resources in preparation against each target i, denoted as r_i, where $i = 1, 2, ..., N$. The terrorist group has total resources R to allocate among attacking targets, as well as a non-violent activity (e.g., political rallies, bake sales, etc.) that yields an expected payoff of $\Gamma(A)$, where Γ is twice differentiable, increasing, and strictly concave.

In the event of a successful violent attack, a potential target is assumed to suffer a loss L, assumed (for simplicity) to be identical across targets. In addition, however, each target i may also have v_i victims present on site. From the attack, the terrorist group gains utility of $B(L, v_i)$ for each target i that is successfully attacked, where $B(.)$ is assumed to be increasing in both its arguments.[21] Terrorists maximize their expected utility, subject to the resources they have on hand.

Targets can reduce their probability of loss by investing in self-protection, but their decision problem is influenced by the behavior of terrorists and victims. The probability of a successful attack against target i is a function of terrorist preparation r_i and target protection s_i, as in $\rho(s_i, r_i)$, where we make the standard assumptions that $\rho_s < 0$, $\rho_r > 0$, $\rho_{ss} > 0$ and $\rho_{rr} < 0$. We also assume that self-protection measures thwart the marginal effectiveness of terror investments, so that $\rho_{rs} < 0$. Against a "harder" target, terrorists have to spend more resources to increase their probability of success by a given amount. Given the anticipated decisions of victims and terrorists, targets minimize the expected sum of protection costs, uncompensated losses, and damages (if any) that must be paid to victims and/or other potential targets.

Finally, "victims" also suffer in the event of an attack if they find themselves near (or inside) an affected target. In contrast to targets, however, victims have no control over the on-site protection decisions of targets. The only way victims can protect themselves is to locate in safer areas. Victims' initial locations are assumed to be distributed uniformly around the unit circle, and indexed by $k \in (0, 1]$. They can choose to "stay at home" or patronize one of the N targets. They derive utility $G_0 > 0$ from their outside option of staying home. The spatiality of the model reflects the fact that victims might have heterogeneous preferences across location, even holding terrorism risk constant. Patronizing any target i provides the payoff of $G > G_0$, but requires her to "travel" the distance $\left|k - \frac{i}{N}\right|$, and to bear travel costs of $\gamma\left(\left|k - \frac{i}{N}\right|\right)$. We assume that $\gamma(0) = 0, \gamma' > 0$, and $\gamma'' > 0$. Consequently, γ is invertible, and we therefore define the function $\theta(y) \equiv \gamma^{-1}(y)$.[22] Subsidiary victims maximize the net

[20] This distribution is not relevant to the terrorists, but is to the victims, as described below.

[21] The idea that terrorists value casualties has been advanced by the CIA, which observed before 9/11 that hardening government targets at home and abroad would encourage terrorists to substitute toward mass casualty attacks (Woo, 2002). Terrorists value body counts and have substituted toward them, instead of symbolic attacks, which have become more difficult.

[22] Note that $\theta(0) = 0, \theta' > 0$, and $\theta'' < 0$.

We also make a technical assumption that $G - G_0 < \gamma\left(\frac{1}{2N}\right)$, so that the victims who are furthest away from any target will simply choose to stay home, even in the absence of terrorist payoff from their patronage decision, taking account of both travel costs and uncompensated injury from possible terrorist attacks (described in more detail below).

Figure 1 below captures the sequence of the game. Because target decisions are most likely to be durable (e.g., building a skyscraper), we assume that primary targets move first, and that they each install their self-protection level s_i upon moving. After observing target self-protection, victims move second, setting aggregate patronage levels, v_i, for each target. After observing both self-protection measures and patronage at each target, terrorists are assumed to move last. We assume that the actions taken by each actor are observable to all involved.

Figure 1. Sequence of Moves

Note that this description fully defines a sequential game under complete information.

3.2 Equilibrium and Welfare in the Absence of Liability

We begin by characterizing predicted play in the benchmark case where no party can seek compensation through the tort system. This provides us with a baseline upon which to design the optimal liability regime, but it is also a plausible outcome in its own right, as pending terrorism litigation may ultimately prove unsuccessful. We employ standard backward induction techniques, beginning with the terrorists, then moving to the secondary victims, and then finally moving to primary targets.

risk. Relaxing this assumption, we conjecture, has little effect on our results.

3.2.1 Terrorists

Terrorists observe $\vec{s} = \{s_1, ..., s_N\}$ and $\vec{v} = \{v_1, ..., v_N\}$, and allocate their own resources $\vec{r} = \{r_1, ..., r_N\}$ to solve the following problem:

$$\begin{aligned} &\max_{\{\vec{r},A\}} \Gamma(A) + \sum_{i=1}^{N} \rho(s_i, r_i) B(L, v_i) \\ &s.t. \quad A + \sum_{i=1}^{N} r_i \leq R \end{aligned} \tag{3.1}$$

Given the concavity of ρ in r_i, for any given $\{\vec{s}, \vec{v}\}$ the first order conditions of this problem are both necessary and sufficient for a unique maximum, and are as follows:

$$\Gamma'(A) = \rho_r(s_i, r_i) B(L, v_i), \forall i \in \{1, .., N\} \tag{3.2}$$

The interpretation of these conditions is fairly standard. The terrorists allocate resources so that the expected marginal productivity investments is equal across all targets and the non-violent activity. Thus, for example, when one target increases its own protection, it becomes marginally less attractive to terrorists. Such a shock, then, induces terrorists to shift resources toward their other alternatives: attacking different targets and investing more in the nonviolent activity. Similarly, if a specific target is patronized by more victims, then that target becomes more attractive to the terrorist group, causing it to shift resources marginally away from other targets and the nonviolent activity, and toward the affected target.

Formally, these intuitions can be summarized in the following lemma.

Lemma 3.1. *Under an optimal allocation of resources by the terrorist group, and for a given* $\{\vec{s}, \vec{v}\}$, r_i *is uniquely defined, strictly decreasing in* s_i *and* v_{-i}, *and strictly increasing in* s_{-i} *and* v_i. *Moreover, for all* j, A *is strictly increasing in* s_j *and strictly decreasing in* v_j.

The uniqueness follows directly from the global concavity of the terrorists' decision problem, conditional on victim and target decisionmaking. The effect of the underlying parameters on terrorist behavior is proven in Lakdawalla and Zanjani (2004).[23] Perhaps the most important aspect of Lemma 3.1 is the fact that the resource allocation for a given location i can turn, in part, on actions taken by victims and targets at *different* locations ($-i$). For example, enhanced protection efforts by a remote target (s_{-i}) can shift risk *toward* target i as the terrorist group removes marginal resources from the better-protected target and reallocates them to others. Similarly, greater patronage at a remote target (v_{-i}) can shift risk *away from* target i as the increased patronage makes the remote target more attractive, and the terrorist group attempts to increase its resource expenditures there.

[23] Lakdawalla and Zanjani (2004) proves the result for s_i; the result for v_i is symmetric.

In what follows, we shall refer to these cross-target effects as "risk-shifting," since activities at one target tend to shift risk onto (or away from) other targets. In contrast, the changes that patronage/self-protection have in channelling terrorist efforts into (or away from) nonviolent activities we will call "deterrence," because it reduces the total level of investment in violent terrorism that society must bear. Both target protection and victim precaution have risk-shifting and deterrence effects. Target self-protection both enhances deterrence on the margin (a positive externality) and shifts some marginal risks onto other targets (a negative externality). Similarly, a reduction in victim patronage contributes to deterrence (a positive externality) and shifts risk onto other targets (a negative externality).

Analysis of the terrorist's first order conditions also yields the following result:

Lemma 3.2. *Under an optimal allocation of resources by the terrorist group, and for a given* $\{\vec{s},\vec{v}\}$, $\left|\frac{\partial r_i}{\partial s_i}\right| > \left|\sum_{-i}\frac{\partial r_{-i}}{\partial s_i}\right|$ *and* $\left|\frac{\partial r_i}{\partial v_i}\right| > \left|\sum_{-i}\frac{\partial r_{-i}}{\partial v_i}\right|$ $\forall i$.

Essentially, Lemma 3.2 states that deterrence and risk-shifting are generally always present simultaneously. Self-protection by a target reduces terrorist activity against that target by more than it increases it on other targets. Thus, while target hardening does shift risk, it has a deterrent effect in the aggregate. Similarly, victim patronage does transfer risk to other targets, but it also draws resources away from the non-violent activity, and thus erodes deterrence in the aggregate.

3.2.2 Subsidiary Victims

Having characterized the unique optimal choice for the terrorist group, we now consider how subsidiary victims behave in light of the terrorist's anticipated strategy profile. It is important to distinguish precisely between victims' internal costs, and the costs that they externalize onto targets. The latter externalities would form the basis for an optimal liability scheme, if one is to be formed.

Recalling the incentives and cost structure faced by each victim, each victim considers what target (if any) she will visit during the period, an action we denote by h. For each victim at location k, $h(k) = i$ denotes a decision by that victim to spend time at target i. In addition, victims can choose to spend time away from all targets (i.e., they "stay home"), an activity we denote by $h(k) = 0$. Thus, the action set for victims is given by $h(k) \in \{0, 1, ..., N\}$. It is easily verified that $v_i = \int_{h(k)=i} dk$ denotes the size of the sub-population patronizing target i, for $i \in \{1, ..., N\}$.

As noted above, victims receive payoff G from patronizing any target (rather than staying home), but must also bear travel costs of $\gamma\left(\left|k - \frac{i}{N}\right|\right)$, to patronize that location. In addition, however, all victims suffer personal losses should their patronized target be successfully attacked (in addition to any loss suffered by the target itself). In particular, each subsidiary victim spending time at that target suffers a negative shock D to her welfare. Consequently, the net payoff to victim k from patronizing target $i \in \{1, 2, ..., N\}$ is

$$G - \gamma \left(\left| k - \frac{i}{N} \right| \right) - \rho \left(s_i, r_i \right) D$$

while the net payoff for the outside (safe) activity remains constant at G_0. Note, however, that victims do not account for the losses of targets, even though they may be partly responsible for the risk that targets face.

Assuming that all targets have a positive number of victims (which will be confirmed in equilibrium), the identity of the "marginal" victim, k^*, who is indifferent between patronage at target i and staying at home, is given by the following expression:[24]

$$G - G_0 = \gamma \left(\left| k^* - \frac{i}{N} \right| \right) + \rho \left(s_i, r_i(v_1, ..., v_N) \right) D, \; i = 1, ..., N \tag{3.3}$$

This expression implies that victims located within the radius $\theta \left(G - G_0 - \rho \left(s_i, r_i(v_1, ..., v_N) \right) D \right)$ of target i will patronize it. Note that the right hand side of the above expression is strictly increasing in k^*, so the interval $[-k^*, k^*]$ is uniquely defined. Aggregate patronage of each target i is then given by[25]:

$$v_i = 2\theta \left(G - G_0 - \rho \left(s_i, r_i(\overrightarrow{s}, \overrightarrow{v}) \right) D \right) \tag{3.4}$$

All else equal, victims will tend to move toward more protected targets and avoid less protected ones. Moreover, since an increase in protection by any one target decreases aggregate risk, it will also increase the aggregate number of victims who patronize at-risk targets. Formally, we have:

Lemma 3.3. *Under an optimal allocation of resources by the terrorist group and optimal choices by victims, and for a fixed* $\{\vec{s}\}$, *the patronage of any target* i, v_i, *is uniquely defined, strictly increasing in* s_i *and* v_{-i}, *and strictly decreasing in* s_{-i}. *Moreover, for all* i, $\left| \frac{\partial v_i}{\partial s_i} \right| > \left| \sum_{-i} \frac{\partial v_i}{\partial s_{-i}} \right|$.

The results of Lemma 3.3 are analogous to the argument made by Lemma 3.2. An aggregate reduction in risk increases the aggregate number of victims choosing to venture out to targets. This reaction is likely to have a significant effect on target activities. While, as demonstrated above, targets can shift risk onto other targets by engaging in self protection, such expenditures come at

[24] The reader will note that this set of first order conditions leaves out the constraint that $\sum_{i=1}^{N} v_i \leq 1$. This constraint will tend not to be binding so long as victims find it optimal to spend at least some time in the outside activity. We will constrain our analysis to parametric contexts where this condition is satisfied in what follows.

[25] And consequently, the total number of potential victims who pursue the safe option is:

$$v_0 = 1 - \Sigma \cdot v_i = 1 - \sum_{i=1}^{N} 2 \cdot \theta \left(G - G_0 - \rho \left(s_i, r_i(\overrightarrow{s}, \overrightarrow{v}) \right) D \right)$$

some cost as well, since enhanced fortifications are likely to draw in subsidiary victims. On the margin, then, targets must weigh the private benefits they receive by shifting risks and effecting deterrence on the one hand, against attracting more victims (and thwarting their own precautions) on the other.

3.3 Targets

We now step back to the initial stage of the game, in which primary targets have the opportunity to make self-protection decisions. Recall that in the event of a successful attack, target i suffers losses L, but may invest resources s_i to dampen the probability of a successful attack. Like the other parties, primary targets behave strategically, and understand the nature of the subsequent structure of the game analyzed above: i.e., once targets' investments are sunk and observed, victims will then optimize across locational choices, and then the terrorists will optimize across investments in attacking targets and carrying out nonviolent political activity.

Consequently, each target i makes protection decisions that maximize its expected payoff, solving the following:

$$\min_{s_i} \rho(r_i(s_i, s_{-i}), s_i) \cdot L + s_i \tag{3.5}$$

This problem has the first order condition for each target i :

$$\underbrace{\rho_s\left(r_i, s_i\right) \cdot L}_{Direct\ Effect} + \underbrace{\rho_r\left(r_i, s_i\right) \cdot \frac{dr_i}{ds_i} \cdot L}_{Indirect\ Effect} + \underbrace{1}_{MC} = 0 \tag{3.6}$$

The intuition behind this condition is relatively straightforward. On the one hand, increasing s_i imposes a direct marginal cost of 1 on the target, reflected in the final term on the left hand side of (3.6). On the other hand, by enhancing self-protection, the target is able to affect the probability of an attack in both direct and indirect ways. A larger value of s_i *directly* reduces the probability of an attack by acting on the $\rho\left(.\right)$ function, represented by the first term on the left hand side of (3.6). In addition, however, a larger value of s_i has indirect effects by altering the strategies of victims and terrorists, and changing the equilibrium value of r_i in the continuation game, represented by the second term on the left hand side of (3.6) .

Note that the direct effect depicted in (3.6) is strictly negative, and thus there are always direct benefits to investing in precautions. However, the indirect effect is somewhat more complicated to sign, since the equilibrium partial derivative $\frac{dr_i}{ds_i}$ has multiple, countervailing effects. The decomposition of this derivative yields the following:

$$\frac{dr_i}{ds_i} = \overbrace{\frac{\partial r_i}{\partial s_i}}^{-} + \overbrace{\frac{\partial r_i}{\partial v_i}\frac{\partial v_i}{\partial s_i}}^{+} + \overbrace{\sum_{j \neq i} \frac{\partial r_i}{\partial v_j}\frac{\partial v_j}{\partial s_i}}^{+} \tag{3.7}$$

Equation (3.7) represents the equilibrium impact of target 1's own protection on its own risk. In general, the sign of this term is ambiguous: For, on the margin, a target's own protection may not make it safer, because it may draw in enough victims to offset the effect of protection. In any interior equilibrium, however, the marginal impact of self-protection on terror investments must be negative, or targets would not expend valuable resources on it. The external effects of protection on other targets though remain ambiguous in equilibrium.

[ERIC: I don't believe we need this set of conditions, as long as the second order conditions hold.] By placing on ρ sufficient technical regularity conditions,[26] one can show that, $\frac{dr_i}{ds_i} < 0$ for all values of s_i, $\lim_{s_i \to \infty} \frac{dr_i}{ds_i} = 0$; and $\lim_{s_i \to \infty} \frac{dr_i}{ds_i} = -\infty$. However, these conditions are merely sufficient for the optimal choice to be finite and strictly positive. They do not guarantee the global concavity of the target's problem. To guarantee concavity (and a unique local optimum), it is necessary to make one additional assumption:

Assumption A1: *The following condition holds everywhere:*

$$\rho_{ss}(r_i, s_i) + [2\rho_{rs}(r_i, s_i) + \rho_{rr}(r_i, s_i)] \cdot \frac{dr_i}{ds_i} + \rho_r(r_i, s_i) \cdot \frac{d^2 r_i}{ds_i^2} < 0 \quad \text{(A1)}$$

Condition (A1) is merely the second order condition for global concavity. It is possible to weaken this assumption, at the expense of complicating the analysis somewhat. In particular, violation of (A1) implies that there may be multiple local minima from which to choose, and it may be possible that the optimal protection choice might "jump" from one local minimum to another with a perturbation in the economic environment. Assumption A prevents such jumps from occurring.

3.4 Equilibrium and Welfare

By construction, we have shown that for a given $\vec{s}$, the optimal strategies of the subsidiary victims and targets are uniquely defined. Moreover, we have demonstrated that the optimal s_i for each target is almost always unique. We now show that, under the conditions described earlier, there is only one symmetric equilibrium, according to the following:

Proposition 3.4. *If Assumption A1 holds, there is a unique symmetric equilibrium of the no liability game, which is characterized by (3.6), (3.4), and (3.2).*

The symmetry comes from the even spacing of targets and victims, the equal value of each target, and the symmetric position of the targets in choosing their strategies simultaneously. Let the symmetric equilibrium described by the above system with no liability be denoted by $\{s^{NL}, v^{NL}, r^{NL}\}$. In what follows, we constrain our attention in all cases to this family of symmetric equilibria.

Intuitively, we can make a few general predictions about the efficiency characteristics of the symmetric equilibrium. First, in the absence of any liability

[26] Derivation available from the authors.

regime, there are likely to be too many victims at each target, since each victim does not internalize the cost of the risk she imposes on targets. Second, targets are likely to misallocate self-protection resources, since they do not account for external effects on other targets, and they do not fully internalize the welfare of on-site subsidiary victims. Hence, targets, may expend too much or too little on protection (depending on which of these effects dominates).[27]

Efficiency within our model most naturally reduces to maximizing the summed total expected payoffs of victims and targets (net of loss), conditional on the incentive compatibility constraints of the terrorists.[28] To simplify the notation, note that the number of victims at target i satisfies $\frac{v_i}{2} = k_i^* - \frac{1}{N}$, and thus target i is populated by victims over the interval $[-\frac{v_i}{2}, \frac{v_i}{2}]$. Therefore, total surplus of all victims in the neighborhood of target i (whether they patronize or not) consists of the sum of each victim's individual surplus:

$$VS(i) = \left(\frac{1}{N}\right) G_0 + 2 \cdot \int_0^{\frac{v_i}{2}} (G - G_0 - \gamma(x) - \rho(s_i, r_i) D)\, dx$$

Target surplus consists of expected losses net of protection:

$$-\sum_{i=1}^{N} (\rho(s_i, r_i)L + s_i)$$

A 'socially optimal' allocation of resources, then, would maximize the social surplus of victims and targets, taking as given the optimal responses of terrorists:[29]

$$\max_{s_i, v_i} \sum_{i=1}^{N} \left[2 \int_0^{\frac{v_i}{2}} (G - G_0 - \gamma(x) - \rho(s_i, r_i)D)\, dx - (\rho(s_i, r_i)L + s_i) \right]$$

subject to the incentive compatibility constraint:

$$\Gamma'(A) = \rho_r(s_i, r_i) B(L, v_i)$$

Constraining our analysis to a symmetric equilibrium, this problem simplifies to one of choosing $\{\hat{v}, \hat{s}, \hat{r}\}$ to maximize surplus for a representative target, so

[27] These intuitions will be important for our later analysis, since they suggest that the optimal liability regime involves forcing net *payments* by victims to the population of targets, and payments among targets that depend on the net externalities associated with protection.

[28] Note that this formulation does not include the welfare of terrorists, which seems most natural in this context. Conceivably, one could include $\Gamma(A)$, the payoff to nonviolent political activities, in social welfare. This would simply increase the social return to deterrence and have no qualitative impacts on our results. Our formulation also does not include any other social benefits of reducing terrorist behavior that are not visited on prospective victims or targets. We explore the relaxation of this latter possibility in Section 4.2.

[29] Recall that our definition of social optimality takes terrorists' actions / reactions a constraint (as they are assumed outside the regulatory structure). Thus, in reality, this is a type of constrained second best. Observe also that we are implicitly according equal weight to the welfare of targets and victims.

that the social welfare function becomes,

$$\Psi(\hat{r},\hat{s},\hat{v}) = 2\int_0^{\frac{\hat{v}}{2}} (G - G_0 - \gamma(x) - \rho(\hat{s},\hat{r})D)\,dx - \rho(\hat{s},\hat{r})L - \hat{s}$$

and the social planner's problem reduces to,

$$\max_{\hat{v},\hat{s}} \Psi(\hat{r},\hat{s},\hat{v})$$

subject to

$$\Gamma'(A) = \rho_r(\hat{s},\hat{r})B(L,\hat{v})$$

One way to conceive of the terrorist's incentive compatibility constraint is in reduced form, so that the planner chooses both $\hat{s}$ and $\hat{v}$ knowing that terrorists will react optimally, according to the functional $\hat{r}(\hat{s},\hat{v})$. The conditions for efficiency are:

$$\underbrace{-\left(\rho_s + \rho_r \frac{d\hat{r}}{d\hat{s}}\right)(\hat{v}D + L)}_{\text{Marginal social Benefit of } \hat{s}} = \underbrace{1}_{\text{MC of } \hat{s}} \tag{3.8}$$

$$\underbrace{\left(G - G_0 - \gamma(\frac{\hat{v}}{2}) - \rho(\hat{s},\hat{r})D\right)}_{\text{Marginal social Benefit of } \hat{v}} = \underbrace{\left(\rho_r \frac{d\hat{r}}{d\hat{v}}\right)(\hat{v}D + L)}_{\text{Marginal social Cost of } \hat{v}} > 0 \tag{3.9}$$

where

$$\frac{d\hat{r}}{d\hat{v}} = \left[\sum_j \frac{dr_i}{dv_j}\right]_{\substack{r_i=\hat{r} \\ v_i=\hat{v}}} > 0;$$

$$\frac{d\hat{r}}{d\hat{s}} = \left[\sum_j \frac{dr_i}{ds_j}\right]_{\substack{r_i=\hat{r} \\ s_i=\hat{s}}} < 0$$

The efficient protection decision accounts for the impact of protection on *total* social losses $(\hat{v}D + L)$, which includes both victim and target losses. The efficient allocation of victims in (3.9) results in strictly positive surplus for the marginal victim. Comparing (3.9) to the analogous condition (3.4) characterizing private decisionmaking in a symmetric equilibrium, we see immediately that the socially optimal level of victim patronage is strictly less than the privately optimal level. Indeed, when the marginal victim makes her patronage decision, she does not consider the effect their presence has on the risks of others. Analysis of the problem leads to the following proposition, where the symmetric equilibrium in the no-liability case is given by $\left\{s^{NL}, v^{NL}, r^{NL}\right\}$.

The efficiency properties of self-protection decisions by targets, on the other hand, are more complex. Protection may be inefficiently high or low, because it involves both *positive* externalities for potential victims, but *negative* externalities on other targets. Since the private marginal benefit of protection is $-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right) L$, the key comparison comes down to whether the social marginal benefit is less than the private marginal benefit (when evaluated at the social optimum), in which case the targets will engage in too much protection. This condition is equivalent to:

$$\frac{1}{L} < -\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)\bigg|_{\{\hat{r},\hat{s},\hat{v}\}}$$

On the other hand, should this strict inequality hold in the opposite direction, the targets engage in too little protection. Simplifying this condition, we have the following:

Proposition 3.5. *Absent a liability regime, and if assumption A1 holds, victims always over-patronize targets relative to the social optimum, so that $v^{NL} > \hat{v}$. Targets, on the other hand, may overprotect or underprotect, and in particular they over-protect ($s^{NL} > \hat{s}$) if and only if, at the social optimum $\{\hat{r}, \hat{s}, \hat{v}\}$:*

$$\frac{1}{L} < -\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)\bigg|_{\{\hat{r},\hat{s},\hat{v}\}} \tag{3.10}$$

The condition in the above proposition can be equivalently characterized as: the external marginal benefits of protection in equation 3.8 are negative.

3.5 Liability and Behavior

In order to consider the effects of liability, suppose that target i has been successfully attacked, and has suffered damages L. Moreover, the v_i victims at the target have also suffered damages D each. We now consider each of a family of compensation schemes. In each case, all targets but the attacked target must make a transfer payment to target i in the amount of $\tau_{-i}(s_i, s_{-i})$. Target i, in turn, is required to make a transfer payment $\theta_i(s_i, v_i)$ to the injured victims. (We do not consider systems under which targets bear liability for other targets' victims, because these are subsumed by the system we consider).[30]

Perhaps the simplest form of liability to consider is a form of strict liability – transfer payments that are mandatory upon proof of harm. We will consider a family of liability functions, in which each target bears some responsibility for liability of an attacked target, and each target bears some responsibility for damages incurred by its own victims. Thus, unaffected targets' liability to an affected target i would be given by:

$$\tau_{-i}(s_{-i}, s_i) = \alpha L$$

[30] A payment from target B to the victims at target A can be effected by a transfer from target B to target A, coupled with one from target A to its victims.

where the policy parameter α captures the fraction of a target's loss compensated by other targets. Under this formulation, the total amount received by i is therefore:

$$\sum_{j \neq i} \tau_{-i} = (N-1)\,\alpha L$$

The liability of the attacked target to its own subsidiary victims is:

$$\theta_i\,(s_i, v_i) = \beta D v_i$$

where the policy parameter β represents the fraction of an individual's damages compensated by the target. Note that both of these parameters can be either positive or negative, at least in theory (though, as noted above, there may be practical limitations on expecting that β would ever take on negative values – a possibility we address below).

The introduction of liability rules such as those above obviously distorts both targets' and victims' choices. In the presence of these transfers, and in the case of 2 targets, the representative target's strategic choice becomes:

$$\max_{s_i} - \left[\rho(r_i, s_i) \cdot ((1-(N-1)\,\alpha)\,L + \beta v_i D) + \sum_{j \neq i} \rho\,(r_j, s_j)\,\alpha L + s_i\right] \quad (3.11)$$

Consequently, the target's optimal choice has the following first order condition:[31]

$$-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)((1-(N-1)\,\alpha)\,L + \beta v_1 D) - \rho(r_i, s_i)\beta D \frac{dv_i}{ds_i} - \sum_{j \neq i}\left(\rho_r \frac{dr_j}{ds_i}\right)\alpha L - 1 = 0 \quad (3.12)$$

Similarly, with victims, the market clearing conditions also change to reflect the damage payments that victims might expect. Under the above liability regime, this market clearing condition now becomes:

$$\begin{aligned} G - G_0 - \gamma\left(\frac{v}{2}\right) - \rho\,(s_i, r_i)\,(1-\beta)\,D &= 0 \Leftrightarrow \quad (3.13) \\ G - G_0 - \gamma\left(\frac{v}{2}\right) - \rho\,(s_i, r_i)\,D &= -\rho\,(s_i, r_i)\,D\beta \end{aligned}$$

The terrorist's structural conditions for maximization remain unchanged, as terrorists are assumed to be beyond the reach of the tort system.

Under a liability regime, then, the social planner will now anticipate these distortions and solve the following:

$$\max_{\hat{v}, \hat{s}} \Psi\,(\hat{r}, \hat{s}, \hat{v})$$

[31] Note that in the case of $\alpha = \beta = 0$, this condition reduces to:

$$-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right) L - 1 = 0$$

which coincides with the no-liability FOC derived above.

subject to

$$
\begin{aligned}
\Gamma'(A) &= \rho_r(\hat{s},\hat{r})B(L,\hat{v}) \\
\textit{equation} & \quad (3.12) \\
\textit{equation} & \quad (3.13)
\end{aligned}
$$

Analysis of this problem yields the following proposition:

Proposition 3.6. *If the policy choice of α and β is unconstrained, and if (A1) holds, then the optimal strict liability regime (α^*, β^*) is unique and implements the constrained second-best allocation of the social planner's problem, $\{\hat{r}, \hat{s}, \hat{v}\}$. The optimal liability regime is given by:*

$$
\begin{aligned}
\beta^* &= \left.\frac{\left(\rho_r \frac{d\hat{r}}{d\hat{v}}\right)(\hat{v}D + L)}{\rho\left(s_i, r_i\right) D}\right|_{\{\hat{r},\hat{s},\hat{v}\}} \\
\alpha^* &= \left.\frac{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)(L + \beta^* \hat{v} D) - \rho(r_i, s_i)\beta^* D \frac{dv_i}{ds_i} + \left(\rho_s + \rho_r \sum_j \frac{dr_i}{ds_j}\right)(\hat{v}D + L)}{\left[-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)((N-1)\,L) + \sum_{j \neq i}\left(\rho_r \frac{dr_j}{ds_i}\right) L\right]}\right|_{\{\hat{r},\hat{s},\hat{v}\}}
\end{aligned}
$$

Moreover, under this regime, $\beta^* < 0$, and thus targets always would have potential cause of action against their subsidiary victims, but not vice versa. The net transfer of resources from unaffected targets to affected targets is ambiguous in sign, but increases with the extent of risk-shifting: that is, moving inversely in $\frac{dr_j}{ds_i}$ and in $\frac{dv_i}{ds_i}$.

Perhaps the most surprising aspect of the above proposition is its implications for victims. Indeed, the socially optimal liability rules require that victims reimburse affected targets in the event of an attack, and not vice-versa. This counter-intuitive result is due to the negative externality victims impose on targets: as noted above victims tend to free-ride off the protection investments of targets, failing to account for the enhanced risk their patronage places on other victims and the target itself.

As noted in Section 2, however, it is difficult to believe that allowing a cause of action against subsidiary victims is a viable policy choice for regulators. Indeed, not only will those defendants be more likely to be judgment-proof, but they will have also suffered significant injuries (or death) themselves, a fact that makes it difficult (perhaps prohibitively so) for a cause of action against victims to be politically palatable. To account for this tension, we introduce one more constraint on the regulator's problem, in which she is confined to choosing only nonnegative values for β. Adding this constraint to the regulator's problem immediately yields the following proposition:

Proposition 3.7. *If the policy choice of α and β is constrained so that $\beta \geq 0$, then the optimal strict liability regime (α_c^*, β_c^*) does not implement the constrained second-best social planner's optimum, but instead implements $\{r_c, s_c, v_c\}$,* *where $v_c > \hat{v}$ and $r_c > \hat{r}$. Here, the optimal liability regime is given by*

$$\beta^* = 0$$
$$\alpha^* = \frac{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right) L + \left(\rho_s + \rho_r \sum_j \frac{dr_i}{ds_j}\right)(\hat{v}D + L)}{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)((N-1)L) + \sum_{j \neq i}\left(\rho_r \frac{dr_j}{ds_i}\right) L}$$

Under this regime, targets neither have a cause of action against their subsidiary victims, nor do victims have a cause of action against targets. The net transfer of resources from unaffected targets to affected targets is positive if and only if, at the social optimum,

$$\frac{1}{L} < -\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)\Big|_{\{\hat{r},\hat{s},\hat{v}\}}$$

and increases with the extent of risk-shifting: that is, moving inversely in $\frac{dr_j}{ds_i}$ and in $\frac{dv_i}{ds_i}$.

The next subsection discusses some of the core intuitions behind the above two propositions.

3.6 The Economics of the Optimal Liability Regime

The optimal liability regime is built to solve three basic problems, each of which contributes to the form of the optimal transfer payments described above. The easiest way to understand the results in toto is to isolate each of the three market failures present in this environment: (1) Failure of targets to account for the interests of victims; (2) External effects of targets on other targets; and (3) External effects of victims on targets and other victims. Below we show how each of these factors is captured in the above results. We concentrate on the two-target case for expositional reasons (though the results carry forward to the N target case).

3.6.1 Failure to Account for Victims

The first and most conventional source of market failure is the inability of targets to account for the interests of their subsidiary victims, absent a liability regime. To focus attention on this problem, we will suppose that there are no external effects of target behavior, $\frac{dr_2}{ds_1} = 0$, and that victim behavior has no external effects on targets, $\frac{dr}{dv} = 0$.

In this case, the optimal liability transfers reduce to:

$$\alpha L = -vD \tag{3.14}$$
$$\beta = 0 \tag{3.15}$$

In the event of an attack, the target pays the unaffected target the value of victim losses, but no other transfers are made.

The only externality is the failure of the target to account for the damages incurred by victims. The target's private return to protection excludes the expected losses of victims and is thus less than the social return to protection. All other margins of decisionmaking are efficient. To correct this problem, the optimal liability rule requires that the target pay for victim losses.

Note, however, that this payment does not go to victims. In this environment, victim decisionmaking is exactly efficient: victims do not shift external risk onto targets. As a result, transfers to victims would only be distortionary, and would encourage over-patronage of targets. Moreover, note that the payment being made *to* the unaffected target is largely incidental. In this particular case, the money received by the unaffected target has no impact on its incentives, because the unaffected target cannot alter the risk of attack, regardless of what it does with the extra money. Therefore, the unaffected target functions here as nothing more than a repository for the payment made by the damaged target. As such, this liability rule can be equivalently implemented as a fine paid by the affected target, where the fine is set equal to the value of victim losses. This reinforces the importance of decoupling liability for victim losses from payments to victims.

3.6.2 External Effects Among Targets

We now consider external effects among targets, or the possibility that $\frac{dr_2}{ds_1} \neq 0$. Without loss of generality, consider the case of target substitution, where $\frac{dr_2}{ds_1} > 0$, so that protection expenditures by one target cause terrorists to substitute to another target. In this case, the optimal liability transfer becomes:

$$\alpha L = vD \overbrace{\frac{\rho_s + \rho_r \frac{dr_1}{ds_1}}{\rho_r \frac{dr_2}{ds_1} - (\rho_s + \rho_r \frac{dr_1}{ds_1})}}^{-1 \leq \cdot \leq 0} + L \overbrace{\frac{\rho_r \frac{dr_2}{ds_1}}{\rho_r \frac{dr_2}{ds_1} - (\rho_s + \rho_r \frac{dr_1}{ds_1})}}^{1 \geq \cdot \geq 0} \tag{3.16}$$

$$\beta = 0 \tag{3.17}$$

Since victim behavior involves no external effects in this case, there continues to be no reason to transfer resources to or from victims. However, the fine paid by the affected target is now partially offset by a transfer from the unaffected target. The logic here is that the behavior of the other targets contributed in part to the losses experienced by victims. As a result, the bill for victims' losses is borne jointly. Similarly, there is also a transfer from the unaffected target to the affected one, to compensate it for its own losses caused by risk-shifting. This transfer is a fraction of the target's own losses, and represents the way in which these losses are also borne jointly.

This type of arrangement might be difficult to implement through the courts, because judges might be reluctant to hold an unaffected target liable for having been too secure. However, a mutual insurance pool presents us with a feasible way of implementing this policy. The pool can be designed to exploit the fact that the transfer from one target to another is always less than $vD + L$.

To take the simplest structure—one that lacks any insurance features—suppose that all potential targets of terrorism contribute $vD+L$, total damages in the event of an attack, to a pool. If an attack does not take place, their money is refunded. If an attack does take place, the affected target receives back the amount $vD + (1+\alpha)L > 0$; this results in a net transfer to the affected target of size αL. The pool will necessarily have enough funds on hand to make this transfer, because $\alpha L \leq vD + L$. Remaining funds in the pool are then refunded to the unaffected targets.

If $\alpha L > 0$, the affected target receives a net transfer, and the pool can also incorporate an insurance feature. If there are N targets, each can contributes $\frac{vD+L}{N}$ to the pool. In the event of an attack, the affected target can then be paid αL, and the remainder can be refunded to the unaffected targets. If N is large, this approximates the efficient outcome.

3.6.3 Externalities from Victim Behavior

Finally, we analyze the externalities in victim behavior. If terrorists value casualties, $\frac{dr_1}{dv_1} > 0$. This results in inefficiency, because victims do not consider the impact of their behavior on the risk faced by targets.

Adding the victim externalities introduces a transfer from victims to the affected target, to account for the risk they shift onto the target: $\beta = -\left(\frac{\rho_r}{\rho}\frac{\partial\hat{r}}{\partial\hat{v}}(\hat{s},\hat{r})\right)\left(\frac{\hat{v}D+L}{D}\right)$. This transfer from victims to targets aligns victims' private margins with social margins, but it actually introduces distortion into target decisionmaking. When $\beta = 0$, the private returns to protection are exactly equal to the social returns. Nonzero β eliminates this result. As a result, equation 6.6 incorporates a transfer payment that purges the effect of β from the target's decision problem, by causing targets to disgorge a component of this payment to other targets (capitalized within the transfer payment going between affected and unaffected targets).

In other words, payment by victims leads to efficient behavior for them, but funneling this payment to targets can pervert targets' incentives. A better solution might be to impose payments or fines—or, more realistically, offer only incomplete insurance to risk-averse victims—on victims, while at the same time maintaining a mutual pool among targets to correct problems in their decisionmaking.

4 Caveats and Extensions

Before concluding, we turn briefly to two caveats and/or extensions of our model. First, we consider alternative liability regimes (such as negligence). We then consider the effect of more general "public good" dimensions of target hardening – i.e., the possibility that more impervious targets may create a general benefit for society because people feel 'safer.'

4.1 Alternative Liability Approaches

The discussion above has focused exclusively on relatively simple "strict" liability rules versus no liability. In many ways, this makes sense, given the fact that these two options are well represented among states (see Section 2 above). Moreover, so long as the regulator's choice is unrestricted (i.e., β can be either positive or negative), we demonstrated that a strict liability system can replicate the outcome of the social planner's problem. However, other possible variations exist – particularly variations on negligence rules – and we turn brief attention to such variations here.

Consider first the possibility of a simple negligence regime governing both target liability to other targets and target liability to victims. Under a target-on-target regime, liability of an unaffected target to an affected one turns on whether the that targets have exceeded a prescribed threshold level of precautions, s^N. Only if an unaffected target's expenditures exceed this level will liability be found. Thus, with appropriately large sanctions, it is always possible to induce targets to implement no more than the prescribed level of precaution.

On the other hand, implementing a negligence regime for victims is extremely problematic. Indeed, as has already been demonstrated, when victims respond to target-hardening by increased patronage, the case for any liability at all becomes difficult to defend on efficiency grounds. Equivalently, then, the optimal negligence scheme would place the negligence standard at zero, so that all firms satisfied it.

Nevertheless, one could envision – at least in theory – a negligence regime that was based on liability of victims to affected targets. Under this view, victims would be liable to an attacked target whenever their aggregate patronage of the target exceeded some prescribed threshold level. But such an approach is even less satisfactory on pragmatic grounds than strict liability of victims to targets. First, just as with strict liability, victims may be liquidity-constrained, and not in a position even to make damages payments to targets. Second, because each victim contributes only a portion of the overall congestion in a given target, it is virtually impossible to implement a negligence rule for victims: indeed, this would require which victim(s) effectively "caused" overall patronage to exceed the level that is prescribed by the negligence standard.

Consequently, the optimal negligence rule in our model would look very much like the optimal strict liability rule: victims would have no cause of action against attacked targets, but attacked targets would have a potential cause of action against other targets if the degree of risk shifting were sufficiently high.[32]

It is also interesting and of some general importance that the strict liability regime is equivalent to a system of decoupled liability payments. Conventionally, defendants' payments are constrained to be exactly equal to the receipts of plaintiffs. In our model, we have shown the difficulties of such an arrangement: targets may need to be penalized for ignoring victims, but funnelling those

[32]A similar set of arguments would apply to other variations on negligence, such as comparative and contributory negligence. We therefore omit them in our analysis.

payments to victims themselves ends up inefficiently distorting their behavior. The general problem is one of two-sided investment, in which the incentives of both parties are subject to misalignment; it will not generally be the case that a transfer from one party to another will exactly align the incentives of both. One possible solution is to decouple the payments of defendants from the receipts of plaintiffs, but this raises the difficulty of what to do with the money. We have shown that, in an environment with complex litigation, standard liability payments in multiple directions can sometimes solve the two-sided incentive problem.

4.2 Public Goods

In focusing on incentive effects, we did not discuss the role of public goods in protection against terrorism (Lakdawalla and Zanjani, 2005). If society is particularly interested in the patronage of certain landmark buildings or downtown areas, there may be social reasons to compensate victims in the event of a terrorist attack. Similarly, if there is a public good associated with the construction of landmark buildings that might be more heavily targeted by terrorists, society may have incentives to encourage such building by providing additional protection against terrorism.

These types of victim compensation plans can be deployed in conjunction with liability arrangements. Perfectly insuring victims against losses has undesirable incentive effects, but partial compensation from society to victims may promote the public good while still retaining efficient incentives to avoid high-profile targets.

Similarly, there may be public goods associated with building in high-profile downtown areas. This may justify transfers, perhaps in the form of subsidized terrorism insurance, from society to the targets of terrorism. Such transfers can be incorporated into the mutual insurance pool described above, by allowing taxpayers to contribute to the pool and thus implicitly underwrite insurance against terrorist attacks.

5 Concluding Remarks

We close with a brief discussion of the practical implementability of an optimal liability regime within our framework. In theory, liability could guarantee a Pareto-optimal allocation of security resources under the threat of terrorism. In practice, the type of liability regime required would be quite difficult to implement, and would offer no advantages over a simpler approach involving mutual insurance for targets and direct compensation to victims. In particular, the optimal liability regime involves transfers *from* victims to targets, and among the entire set of possible targets, including potential targets who escaped attack. At a minimum, there are few precedential grounds for justifying tort claims by victims against targets.

To focus attention on the incentive problems posed by terrorism, we considered a world with risk-neutral, symmetrically informed agents, all of whom understand the decision problems faced by their counterparts. As we have argued, it is preferable to consider risk-neutrality in this context and to leave risk-aversion to public and private insurance markets. Moreover, it is not clear that incomplete information would dramatically alter our findings. Clearly, if agents are widely uninformed or misinformed, liability probably has little role to play, because it is not clear what incentives agents will respond to. On the other hand, asymmetric information might provide some grounds for a liability regime that shifts much of the risk onto the agent(s) with the best information. The difficulty with such an approach, in this context, is identifying a well-informed agent. Apart from the government, it is not clear which agents in society have above average information about the risk of terrorism or the effectiveness of protective investments.

There is, however, one crucial distinguishing feature of terrorism that we have not considered: the role of public goods like national security or prestige. Terrorism policy is made in the context of a war effort, where terrorists seek to undermine national confidence and security. Because of such public goods, victim compensation may be appropriate and welfare-enhancing, as a demonstration of national solidarity, and an inducement to continue with normal life in the face of terrorism risk. A key point made by this paper though is that there are few reasons for this compensation to come from targets; direct compensation from the government may be more appropriate. Contributing to this conclusion is the government's own set of terrorism incentives: government actions likely influence terrorism risk, perhaps more than any other private actor we have considered; payments from the government thus make sense on pure incentive grounds. From this point of view, the September 11 Victims' Compensation Fund was well-conceived but may not have gone far enough in ruling out tort claims. More research is needed on the public goods problem as it relates to liability and other public policy solutions to terrorism.

This paper also relates to a general point about decoupling liability payments. We have explored a context in which transfer payments can be used to correct incentives, but where there is no private recipient of the payment whose behavior will not be distorted by it. This points to the importance of considering decoupled liability payments, where the recipient is the state or some other disinterested third-party, when conventional liability arrangements lead to distortion.

6 References

1. Choi, Albert H. and Sanchirico, Chris William, 2002. "Should Plaintiffs Win What Defendants Lose?: Litigation Stakes, Litigation Effort, and the Benefits of 'Decoupling"' . USC CLEO Research Paper No. C02-7; and UVA Law and Economics Research Paper No. 02-1.

2. Freeman, S., 1996. The Spatial Concentration of Crime, 40 J. URBAN ECON. 216.

3. Hakim, S. & Rengert, G. (eds.), 1981. Crime Spillover.

4. Hui-wen, K. & I. P. L. Png, 1994. Private Security: Deterrent or Diversion?, 14 INT'L REV. L. & ECON. 87.

5. Lakdawalla, D., and G. Zanjani, 2004. "Insurance, Self-Protection, and the Economics of Terrorism." Working Paper WR-171-ICJ. Cambridge, MA:

   RAND Corporation.

6. Lakdawalla, D., and G. Zanjani, 2005. "Insurance, Self-Protection, and the Economics of Terrorism." Journal of Public Economics Forthcoming.

7. McKinnon R., & T. Nechyba, 1997. Competition in Federal Systems, *in* The New Federalism (John Ferejohn and Barry R. Weingsat eds.).

8. McNamara, R. (ed.), 1994. Crime Displacement.

9. Newman, G., R.V. Clarkeand & S.Shoham (eds.), 1997. Rational Choice and Situational Crime Prevention.

10. Polinsky, A.M & Yeon-Koo Che, 1991. "Decoupling liability: optimal incentives for care and litigation," 22 RAND J. Econ. 562.

11. Shavell, S., 1987. Economic Analysis of Accident Law. Cambridge, MA: Harvard University Press.

12. Shavell, S., 1991. Individual Precautions to Prevent Theft: Private Versus Socially Optimal Behavior, 11 INT'L REV. L. & ECON. 123 (1991).

13. Woo, G. (2002). "Quantifying Insurance Terrorism Risk." Manuscript, Risk Management Solutions, Newark, CA.

Appendix

This appendix clarifies (in very rough form) some of the variable construction from the text, as well as providing proofs of the propositions (when necessary).

A.1 Variable Construction

A.2 Terrorist Comparative Statics

In the two-target case (the N-target case is virtually identical), the terrorists' first order conditions can be written as:

$$\Gamma'(A) - \rho_r(s_1, r_1)B(L, v_1) = 0 \quad (6.1)$$

$$\Gamma'(A) - \rho_r(s_2, r_2)B(L, v_2) = 0 \quad (6.2)$$

$$R - A - r_1 - r_2 = 0 \quad (6.3)$$

Assuming a symmetric equilibrium with two targets (i.e., $r_1 = r_2 = r^e$) and differentiating with respect to s_1 yields the relationships between terror investments and target protection:

$$\begin{aligned}\frac{\partial r_1}{\partial s_1} &= \frac{\rho_{rs}B(\Gamma'' + \rho_{rr}B)}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} < 0 \\ \frac{\partial r_2}{\partial s_1} &= \frac{(-\Gamma'')(\rho_{rs}B)}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} \geq 0 \\ \frac{\partial A}{\partial s_1} &= \frac{\rho_{rs}\rho_{rr}B^2}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} > 0\end{aligned} \tag{6.4}$$

These expressions also demonstrate the implication of deterrence cited in the text: $\left|\frac{\partial r_1}{\partial s_1}\right| > \left|\frac{\partial r_2}{\partial s_1}\right|$

The comparative static relationships between victim choices and terrorist decisions are similar. In the symmetric two-target case, differentiating with respect to v_1 reveals that:

$$\begin{aligned}\frac{\partial r_1}{\partial v_1} &= \frac{\rho_r B_v(\Gamma'' + \rho_{rr}B)}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} > 0 \\ \frac{\partial r_2}{\partial v_1} &= \frac{(-\Gamma'')\left(\rho_r B_v\right)}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} < 0 \\ \frac{\partial A}{\partial v_1} &= \frac{\rho_r B_v \rho_{rr} B}{(\Gamma'')^2 - (\Gamma'' + \rho_{rr}B)^2} < 0\end{aligned} \tag{6.5}$$

These expressions demonstrate that an increase in protection by any one target increases the aggregate number of victims exposed to terrorism: $\left|\frac{\partial r_1}{\partial v_1}\right| > \left|\frac{\partial r_2}{\partial v_1}\right|$

A.3 Victim Comparative Statics

Differentiating the equilibrium condition for the marginal victim yields the following expressions:

$$\begin{aligned}\frac{dv_1}{ds_1} &= \frac{d}{ds_1}\left[2\theta\left(G - G_0 - \rho\left(s_i, r_i(\overrightarrow{s}, \overrightarrow{v})\right)D\right)\right] \\ &= 2\theta'\left(G - G_0 - \rho\left(s_i, r_i\right)D\right) \cdot \left(-\rho_s D - \rho_r D\left[\frac{\partial r_1}{\partial v_1}\frac{\partial v_1}{\partial s_1} + \frac{\partial r_1}{\partial s_1}\right]\right) \\ &\Leftrightarrow \\ \frac{dv_1}{ds_1} &= \frac{2\theta'\left(G - G_0 - \rho\left(s_i, r_i\right)D\right) \cdot \left(-\rho_s D - \rho_r D \cdot \frac{\partial r_1}{\partial s_1}\right)}{1 + 2\theta'\left(G - G_0 - \rho\left(s_i, r_i(\overrightarrow{s}, \overrightarrow{v})\right)D\right) \cdot \rho_r D \cdot \left(\frac{\partial r_1}{\partial v_1}\right)} > 0\end{aligned}$$

$$\begin{aligned}
\frac{dv_1}{ds_2} &= \frac{d}{ds_2}\left[2\theta\left(G - G_0 - \rho\left(s_i, r_i(\overrightarrow{s}, \overrightarrow{v})\right)D\right)\right] \\
&= 2\theta'\left(G - G_0 - \rho\left(s_i, r_i\right)D\right)\cdot\left(-\rho_r D\left[\frac{\partial r_1}{\partial v_1}\frac{\partial v_1}{\partial s_2} + \frac{\partial r_1}{\partial s_2}\right]\right) \\
&\Leftrightarrow \\
\frac{dv_1}{ds_2} &= \frac{2\theta'\left(G - G_0 - \rho\left(s_i, r_i\right)D\right)\cdot\left(-\rho_r D\frac{\partial r_1}{\partial s_2}\right)}{1 + 2\theta'\left(G - G_0 - \rho\left(s_i, r_i\right)D\right)\cdot\left(\rho_r D\frac{\partial r_1}{\partial v_1}\right)} < 0
\end{aligned}$$

These equations also imply the result given in the text, that :

$$\left|\frac{\partial v_1}{\partial s_1}\right| > \left|\frac{\partial v_1}{\partial s_2}\right| = \left|\frac{\partial v_2}{\partial s_1}\right|$$

A.4 Equilibrium for Victims

The victims' first order conditions are:

$$\begin{aligned}
\gamma\left(v_1\right) + \rho\left(s_1, r_1\left(v_1, v_2, s_1, s_2\right)\right)D - \Delta_G &= 0 \\
\gamma\left(v_2\right) + \rho\left(s_2, r_2\left(v_1, v_2, s_1, s_2\right)\right)D - \Delta_G &= 0
\end{aligned}$$

which have an associated Jacobian:

$$J = \begin{bmatrix} \gamma'\left(v_1\right) + \rho_r\left(s_1, r_1\right)D\cdot\frac{\partial r_1}{\partial v_1} & \rho_r\left(s_1, r_1\right)D\cdot\frac{\partial r_1}{\partial v_2} \\ \rho_r\left(s_2, r_2\right)D\cdot\frac{\partial r_2}{\partial v_1} & \gamma'\left(v_2\right) + \rho_r\left(s_2, r_2\right)D\cdot\frac{\partial r_2}{\partial v_2} \end{bmatrix},$$

which in turn has determinant:

$$|J| = \left(\gamma'\left(v_1\right) + \rho_r\left(s_1, r_1\right)D\cdot\frac{\partial r_1}{\partial v_1}\right)\cdot\left(\gamma'\left(v_2\right) + \rho_r\left(s_2, r_2\right)D\cdot\frac{\partial r_1}{\partial v_1}\right) - \left(\rho_r\left(s_1, r_1\right)D\cdot\frac{\partial r_1}{\partial v_2}\right)\cdot\left(\rho_r\left(s_2, r_2\right)D\cdot\frac{\partial r_2}{\partial v_1}\right)$$

Evaluated at a symmetric equilibrium, we know that $r_1 = r_2 = r_e; s_1 = s_2 = s_e, v_1 = v_2 = v_e, \frac{\partial r_1}{\partial v_1} = \frac{\partial r_2}{\partial v_2} = \frac{\partial r_i}{\partial v_i}; \frac{\partial r_1}{\partial v_2} = \frac{\partial r_2}{\partial v_1} = \frac{\partial r_i}{\partial v_j}$. And thus we have:

$$\begin{aligned}
|J| &= \left(\gamma'\left(v_e\right) + \rho_r\left(s_e, r_e\right)D\cdot\frac{\partial r_i}{\partial v_i}\right)^2 - \left(\rho_r\left(s_e, r_e\right)D\cdot\frac{\partial r_i}{\partial v_j}\right)^2 \\
&> 0
\end{aligned}$$

where $i = 1, 2$. We can sign this determinant as positive since, as demonstrated above, $\left|\frac{\partial r_i}{\partial v_i}\right| > \left|\frac{\partial r_i}{\partial v_{-i}}\right|$.

Now consider how a change in s_1 affects equilibrium values of v.The vector of s_1 derivatives of the victims' market clearing condition is:

$$\begin{bmatrix} \rho_s + \rho_r \frac{\partial r_1}{\partial s_1} D \\ \rho_r \frac{\partial r_2}{\partial s_1} D \end{bmatrix}$$

Note that both of these terms are positive. The substituted Jacobian is therefore:

$$J = \begin{bmatrix} \rho_s + \rho_r \frac{\partial r_1}{\partial s_1} D & \rho_r (s_1, r_1) D \cdot \frac{\partial r_1}{\partial v_2} \\ \rho_r \frac{\partial r_2}{\partial s_1} D & \gamma' (v_2) + \rho_r (s_2, r_2) D \cdot \frac{\partial r_2}{\partial v_2} \end{bmatrix},$$

which, when evaluated at a symmetric equilibrium, has determinant:

$$|J_1| = \overbrace{(\gamma' (v_e) \rho_s)}^{(-)} + \overbrace{(D\rho_r)}^{(-)} \left(\overbrace{\gamma' (v_e) \frac{\partial r_i}{\partial s_i}}^{(-)} + \overbrace{\frac{\partial r_i}{\partial v_i}}^{(-)} \rho_s + \overbrace{D\rho_r}^{(+)} \left[\overbrace{\frac{\partial r_i}{\partial v_i} \frac{\partial r_i}{\partial s_i}}^{(-)} - \overbrace{\frac{\partial r_i}{\partial v_j} \frac{\partial r_j}{\partial s_i}}^{(-)} \right] \right)$$

If the square bracketed term is weakly negative, then $|J_1| < 0$. But this is clearly satisfied, since we know from above that the own partials on r_i have higher absoluate value than the cross partials on r_i. Thus, we have:

$$\frac{\partial v_1}{\partial s_1} = -\frac{|J_1|}{|J|} = -\frac{(\gamma' (v_e) \rho_s) + D\rho_r \left(\gamma' (v_e) \frac{\partial r_i}{\partial s_i} + \frac{\partial r_i}{\partial v_i} \rho_s + D\rho_r \left(\frac{\partial r_i}{\partial v_i} \frac{\partial r_i}{\partial s_i} - \frac{\partial r_i}{\partial v_{-i}} \frac{\partial r_j}{\partial s_i} \right) \right)}{\left(\gamma' (v_e) + \rho_r (s_e, r_e) D \cdot \frac{\partial r_i}{\partial v_i} \right)^2 - \left(\rho_r (s_e, r_e) D \cdot \frac{\partial r_i}{\partial v_j} \right)} > 0$$

Now consider comparative statics on v_2.The substituted Jacobian is:

$$J_2 = \begin{bmatrix} \gamma' (v_1) + \rho_r (s_1, r_1) D \cdot \frac{\partial r_1}{\partial v_1} & \rho_s + \rho_r \frac{\partial r_1}{\partial s_1} D \\ \rho_r (s_2, r_2) D \cdot \frac{\partial r_2}{\partial v_1} & \rho_r \frac{\partial r_2}{\partial s_1} D \end{bmatrix},$$

which, when evaluated at a symmetric equilibrium, has determinant:

$$\begin{aligned} |J_2| &= \rho_r D \left(\gamma' (v_e) \frac{\partial r_i}{\partial s_j} - \frac{\partial r_i}{\partial v_j} \rho_s + D\rho_r \left[\frac{\partial r_i}{\partial v_i} \frac{\partial r_j}{\partial s_i} - \frac{\partial r_i}{\partial v_j} \frac{\partial r_i}{\partial s_i} \right] \right) \\ &= \rho_r D \left[\left(\overbrace{\gamma' (v_e) \frac{\partial r_2}{\partial s_1}}^{(+)} \right) - \left(\overbrace{\frac{\partial r_i}{\partial v_j} \rho_s}^{(+)} \right) \right] \end{aligned}$$

Thus, we have

$$\frac{\partial v_2}{\partial s_1} = -\frac{\rho_r D \left(\gamma' (v_e) \frac{\partial r_i}{\partial s_j} - \frac{\partial r_i}{\partial v_j} \rho_s \right)}{|J|}$$

This derivative is negative so long as:

$$
\begin{aligned}
\gamma'(v_e)\frac{\partial r_2}{\partial s_1} &< \frac{\partial r_2}{\partial v_1}\rho_s \\
&\Leftrightarrow \\
\gamma'(v_e) &< \frac{\rho_r \rho_s B_v}{\rho_{rs} B}
\end{aligned}
$$

The interpretation here is simple: So long as the "crowding" effect on a target is not "too" large, victims will tend to flock away from targets that have lower relative protection. When crowding effects are large, on the other hand, hardening a target will induce more victims to enter the risky activities, so much so that some of them may choose to spend time at the unhardened target (realizing that, in equilibrium, terrorists will be spending less effort to attack it).

A.5 Proof of Proposition 3.5

The proposition follows immediately from the textual analysis, and the proof is therefore omitted.

A.6 Proof of Proposition 3.6

The unconstrained liability problem can be solved in two stages. Victim behavior only depends on β. Target behavior depends on both. So we proceed by fixing β optimally, and fixing α optimally given β.

Recall that the social optimum for $\hat{v}$ is characterized by:

$$G - G_0 - \gamma\left(\frac{\hat{v}}{2}\right) - \rho(\hat{s},\hat{r})D = \left(\rho_r \frac{d\hat{r}}{d\hat{v}}\right)(\hat{v}D + L)$$

whereas the market clearing condition for victims is:

$$G - G_0 - \gamma\left(\frac{v}{2}\right) - \rho\left(s_i, r_i\right)D = -\rho\left(s_i, r_i\right)D\beta$$

Evaluating both expressions at the social optimum and substituting allows us to solve for β by setting the RHS of the two above expressions equal to one another:

$$\beta^* = \frac{\left(\rho_r \frac{d\hat{r}}{d\hat{v}}\right)(\hat{v}D + L)}{\rho\left(s_i, r_i\right)D}$$

Given this value of β, we consider the target's optimal choice, similarly comparing it to the social optimum, so that (after substitution):

$$
\begin{aligned}
&\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)\left(\left(1 - (N-1)\alpha\right)L + \beta v_1 D\right) + \rho(r_i, s_i)\beta D\frac{dv_i}{ds_i} + \sum_{j\neq i}\left(\rho_r \frac{dr_j}{ds_i}\right)\alpha L \\
=\ &\left(\rho_s + \rho_r \sum_j \frac{dr_i}{ds_j}\right)(\hat{v}D + L)
\end{aligned}
$$

Solving the above expression for α yields:

$$\alpha^* = \frac{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)(L + \beta v_1 D) - \rho(r_i, s_i)\beta D \frac{dv_i}{ds_i} + \left(\rho_s + \rho_r \sum_j \frac{dr_i}{ds_j}\right)(\hat{v}D + L)}{\left[-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)((N-1)L) + \sum_{j\neq i}\left(\rho_r \frac{dr_j}{ds_i}\right)L\right]}$$

QED.

A.7 Proof of Proposition 3.7

Since the constraint on β must be binding, we know that $\beta = 0$. Substituting this value into the target's optimality condition, and comparing to the social optimality condition allows us to solve for α as follows:

$$\alpha = \frac{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)L + \left(\rho_s + \rho_r \sum_j \frac{dr_i}{ds_j}\right)(\hat{v}D + L)}{-\left(\rho_s + \rho_r \frac{dr_i}{ds_i}\right)((N-1)L) + \sum_{j\neq i}\left(\rho_r \frac{dr_j}{ds_i}\right)L} \tag{6.6}$$

It is easily confirmed from the target's FOC that

$$\frac{ds_i}{d\alpha} < 0$$

and thus the target will be a net recipient if and only if its level of protection was inefficiently high in the absence of liability. This condition is tantamount to the inequality condition given in the proposition.

The first expression is straightforward: paying victims in the event of a loss makes them less averse to such a loss. In the second expression, the effect of target transfers on victims depends entirely on how these affect target protection. If target transfers increase the level of protection, they draw more victims in, and vice-versa. QED

References

Lakdawalla, D., and G. Zanjani (2004). "Insurance, Self-Protection, and the Economics of Terrorism." *Working Paper WR-171-ICJ.* Cambridge, MA: RAND Corporation.

Lakdawalla, D., and G. Zanjani (2005). "Insurance, Self-Protection, and the Economics of Terrorism." *Journal of Public Economics* Forthcoming.

Woo, G. (2002). "Quantifying Insurance Terrorism Risk." Manuscript, Risk Management Solutions, Newark, CA.