

# Optimal Liability for Terrorism\*

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## Abstract

This paper analyzes the appropriate normative role for civil liability in aligning terrorism precaution incentives when the perpetrators of terrorism are themselves 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 sometimes even 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.

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# 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,<sup>1</sup> the degree to which civil liberties should be sacrificed for greater security,<sup>2</sup> and the proper role for government in insuring against the risk of terrorism.<sup>3</sup> However, as the immediate security and intelligence exigencies that followed September 11 were addressed (and along with them some measure of civic goodwill), 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.<sup>4</sup> 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.

On the surface, liability might not appear to be the appropriate vehicle for social risk-bearing in the case of terrorism, because the agents most directly responsible for harm—terrorists themselves—are largely beyond the reach of civil and criminal courts. If the law is simply unable to deter the agents that cause harm, common sense would seem to point away from civil liability at all as a . Even though litigation can help spread risk, without a meaningful deterrence role litigation is a weak substitute for more direct insurance mechanisms.

Closer inspection, however, yields a more complex view of liability’s role. While the threat of liability may not deter terrorists directly, it clearly can shape the incentives of those who experience 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) of precautions on

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

<sup>2</sup>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].

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

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

behalf of licensees, permittees, and other bystanders likely to be affected when a target is successfully attacked. In addition, the implicit insurance afforded to 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. Because terrorism brings to the fore the problems of individual action in the face of a collective risk, it should not be surprising that courts are seriously entertaining the viability of these claims.

In this paper, we ask how—in light of the complex relationships among affected targets, unaffected targets, and victims—civil liability can improve the efficiency of incentives to take care against terrorism. To frame the analysis, we introduce a formal, game-theoretic model of behavior in which terrorists, targets, and individuals all take the legal system as a given and take actions that maximize their own individual expected welfare. (We assume throughout, of course, that terrorists are beyond the reach of the civil courts).

Our analysis suggests that, while it is possible to envision a system of liability rules that promotes efficient incentives, its contours would tend to diverge from existing doctrinal templates in at least two ways. First, an ‘optimal’ liability would generally not allow passers-by, bystanders, or permittees to recover against a damaged target for their injuries, but it might well allow the target to recover against the bystanders. In addition, it is generically the case that the amount of damages defendants ought to pay could be more or less than plaintiffs receive from a cause of action – but rarely would an optimal system involve defendants paying *exactly* what plaintiffs recover. From a pragmatic perspective, the unconventional forms of liability that our analysis suggests might render civil liability somewhat of an unattractive and politically infeasible alternative if an alternative mechanism could also provide the same incentives. We suggest that a possibly more direct mechanism for implementing our suggestions might be through a form of social insurance (not unlike the 9/11 victims’ compensation fund, but without the ability to opt out). Indeed, such a scheme would naturally decouple the amounts that some pay in from those that others receive, and need not take the unpalatable litigious form that our analysis suggests to be the equivalent alternative.

## 1.1 Basic Intuition

Although we relegate our formal analysis to a later section, it is perhaps worthwhile exploring a few of the intuitive highlights of our argument here. Consider first the possibility that a target (such as the owner of an office building) may owe a duty to compensate individual passers-by who might be injured should the target suffer an attack. On first blush, this is probably the most intuitive form of liability rule, in that it can provide incentives to a target so that it undertakes efficient precautions that internalize the benefit bestowed on individuals. If the building is an efficient harm avoider, such liability encourages the building to take due care in ensuring the safety of those inside and around

it. If this were the only incentive problem, a simple policy holding targets liable for victims' losses might be appropriate.

Cutting against the effectiveness of this liability rule is the strategic behavior of terrorists. Since terrorists' payoff likely increases in the number of casualties they inflict, victim patronage increases the risk faced by targets. Unfortunately, patrons do not account for how their actions may "draw fire" onto targets. The result, even in the absence of liability, is over-patronage of targets by victims. Introducing liability payments from targets to victims generally exacerbates this externality. Therefore, while there may be corrective justice or insurance rationales for compensating individual passers-by, and reasons to provide targets for incentives to make some investments in safety, decoupling those payments from one another may well be efficiency-enhancing.

Moreover, strategic terrorists also create incentive problems that require claims by one target against another. The simple liability rule posited above does not envision such payments. However, if terrorists are strategic maximizers, then the protection decisions of one target can significantly affect the risk faced by another, even one thousands of miles away. If terrorists have limited resources, the decision to erect a new building in a high-risk zone will "draw fire" away from existing structures and thus yield benefits to owners of existing structures. Conversely, a decision to self-protect by hardening an existing target may have negative consequences for other buildings, who become more attractive targets. As a result, a society under threat from terrorism may both overprotect and underinvest when targets bear full responsibility for their own losses and those of subsidiary victims. If liability is to solve these incentive problems, it must make possible claims among potential targets of terrorism.

Given these incentive problems, we find that the optimal liability regime has three key features. First, it forces targets to bear the losses of victims, but all of those payments are optimally decoupled and sent to a third-party. Second, victims would be required to pay for the risk they draw onto targets, but at least some portion of these payments would be decoupled toward third parties. Finally, transfers among damaged and unaffected targets can be used to address externalities in target protection.

While this liability regime results in an 'optimal' allocation of terrorism risk and protection resources in our model,<sup>5</sup> implementing it would face significant difficulties in our current court system. First, decoupling of damages is not a widespread practice, and courts may be reluctant to force targets to extract damages payments behalf of victims, but then deprive victims from receiving those payments. In addition, courts would be chary about allowing a suit by targets against victims, or suits against targets that escaped attack because they were "too secure." As a result, we argue that an optimal incentive shaping arrangement can be more easily and pragmatically achieved through a mutual

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<sup>5</sup>By *optimal*, we implicitly wish to convey something less than first best – in which the terrorist's activity level could be directly controlled by the courts/regulatory system. Our benchmark for social optimality, then, is whether the liability system can implement activity levels by victims and targets that are socially optimal constrained by the non-regulability of terrorist actors.

insurance pool for targets—that would govern net transfers among targets—combined with incomplete insurance for victims of terrorist attacks.

## 1.2 Caveats and Preview

There are two caveats to our analysis that deserve explicit mention before proceeding. First, in what follows we abstract from the effects of risk-aversion, assuming instead that all actors maximize expected payoffs in a risk-neutral fashion. Although this assumption simplifies our technical analysis considerably, there are other, more substantively central, reasons for it. 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. Introducing risk-aversion might uncover an additional rationale for a liability regime, but it would be a spurious one, as such a task is best addressed by an active insurance market. In our estimation, then, the unique role of legal liability should be to shape incentives, while the insurance market is the best vehicle for spreading risk.

The second caveat to our analysis is that we assume terrorists to be beyond legal sanctions and beyond the jurisdiction of the relevant judicial actors. 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. Although adding this possibility would be relatively simple, it would take away what most believe to be the most central and salient characteristic of *most* (though certainly not all) terrorist acts: the lack of jurisdiction over the individuals most responsible for the harm. The analysis of such a context, then, would be consistent with traditional economic analyses of tort law (cf. ?).

Our analysis proceeds as follows. In Section 2, we briefly explore the relevant legal issues surrounding terrorism litigation, and conclude that private plaintiffs are likely to be able to raise at least plausible claims for recovery under common law tort doctrines. At the same time, however, because there are also plausible countervailing doctrines that work against these claims, the outcome of these suits is far from clear, and courts may be asked to make difficult policy judgements about whether to impose liability. This open policy question naturally motivates our analytical model of terrorism 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 allocate legal recover rights 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 wellbeing 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 moreover one could 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.<sup>6</sup> Another strand of recent cases have 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).<sup>7</sup> Both of these trends might

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<sup>6</sup>See, e.g., *Washington v. City of Chicago*, 720 NE2d 1030 (Ill. 1999).

<sup>7</sup>See generally, Keating, G. 2004, "Abusing Duty" (unpublished manuscript).

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*<sup>8</sup>). 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.<sup>9</sup> In the terrorism context, intervening actors are likely to play a significant role; for 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.<sup>10</sup> 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.

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<sup>8</sup>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.

<sup>9</sup>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 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);

<sup>10</sup>Indeed, Keating (2003) criticizes the spillover of the foreseeability doctrine on exactly these grounds.

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 that 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 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.<sup>11</sup> Other states, in contrast, follow what has become known as the “civil law” doctrine.<sup>12</sup> 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

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<sup>11</sup>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).

<sup>12</sup>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).



variations, appear to have been adopted in approximately twenty-two states each.<sup>13</sup>

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 of a younger than the other two described above,<sup>14</sup> lies between them substantively and essentially is 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.<sup>15</sup> In many respects, the reasonable use doctrine replicates the basic templates of nuisance law for surface water hazards,<sup>16</sup> and it is treated that way in the Restatement of Torts.<sup>17</sup> Although still a minority position among jurisdictions (embraced in about six jurisdictions), it is widely perceived to be growing quickly in its influence.<sup>18</sup> 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 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

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<sup>13</sup>See *Keys v. Romley*, supra (counting jurisdictions); and Annot. 93 A.L.R.3d 1193, 1207-11 (1979).

<sup>14</sup>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).

<sup>15</sup>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).

<sup>16</sup>*Pendergrast v. Aiken*, 293 N.C. 201, 236 S.E.2d 787 (1977).

<sup>17</sup>Restatement (Second) of Torts, § 833 (1979).

<sup>18</sup>It is also beginning to infiltrate the other two doctrines, which in some jurisdictions have begun to embrace some components of fault.

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 general 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

As noted in the previous section, an important goal of liability policy is to improve the allocation of resources by providing individuals with efficient incentives in a “second best” world where the perpetrators of terrorism are beyond courts’ jurisdiction. While pure incentive problems are far from the only policy goals in the case of terrorism — problems of efficient risk bearing and the provision of public goods like national security are also significant factors — incentive provision is both important in the overall policy landscape and uniquely amenable to a liability solution. In this section, we explore the incentive problems created by terrorism and how a liability system could solve them.

Before proceeding, it is important to note that our analysis above considered a number of different types of parties: Actual or potential targets hit by a terrorist attack; collateral targets (such as adjacent buildings) that are not targeted themselves but suffer significant damage from their proximity to the affected target; individual victims (such as vendors or employees) who are in contractual privity with targets; and victim bypassers who are not in contractual privity with targets. In order to simplify our model, we will lump targets together with victims that are in privity with targets, assuming that they will allocate their joint risks efficiently amongst themselves.<sup>19</sup> These groups will simply go under the banner of “Targets”. We will also lump together 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 will refer to these groups generically as “Victims.”<sup>20</sup>

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<sup>19</sup>Thus, we define “targets” to include owners of buildings, landmarks, shopping centers, government offices, well-known business, 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. Therefore, grouping together agents who can write complete contracts sacrifices little generality in this context.

<sup>20</sup>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

As already noted, a key assumption running throughout our analysis concerns the impossibility of reaching the terrorists themselves who are the most directly responsible for the injury suffered. Also, and as already noted, we exclude as impractical any suits brought against an individual victim for his/her incremental contribution to the likelihood of an attack. With these caveats in mind, 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 effects. And finally, we ask whether a prudently designed liability system could improve upon this equilibrium in welfare terms. 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 of (normalized) circumference 1 and have respective locations of  $\{\frac{1}{N}, \dots, \frac{N}{N}\}$ .<sup>21</sup> Successful attacks depend on planning and preparation. To that end, terrorists invest in preparation against each target  $i$ , denoted as  $r_i$ , where  $i = 1, 2, \dots, N$ . The terrorist group has total resources  $R$  to allocate among targets, as well as a non-violent activity (e.g., political rallies, bake sales, etc.) that yields an expected payoff of  $\Gamma(A)$ , where  $\Gamma$  is twice differentiable, increasing, and strictly concave. Terrorists allocate their resources to maximize their expected utility, described specifically below.

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  $B(\cdot)$  is assumed to be increasing in both its arguments.

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. In particular, 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 intuitive 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. Victim behavior influences the incentives of terrorists to attack a particular target. Given the anticipated decisions of victims and terrorists, targets minimize the

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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 19, victims are assumed unable to write complete ex ante contracts with targets.

<sup>21</sup>This distribution is not relevant to the terrorists, but is to the victims, as described below.

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  $|k - \frac{i}{N}|$ , and to bear travel costs of  $\gamma(|k - \frac{i}{N}|)$ . We assume that  $\gamma(0) = 0, \gamma' > 0$ , and  $\gamma'' > 0$ . Consequently,  $\gamma$  is invertible, and we therefore define the function  $\theta(y)$  to denote  $\gamma^{-1}(y)$ .<sup>22</sup> Subsidiary victims maximize the net 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.

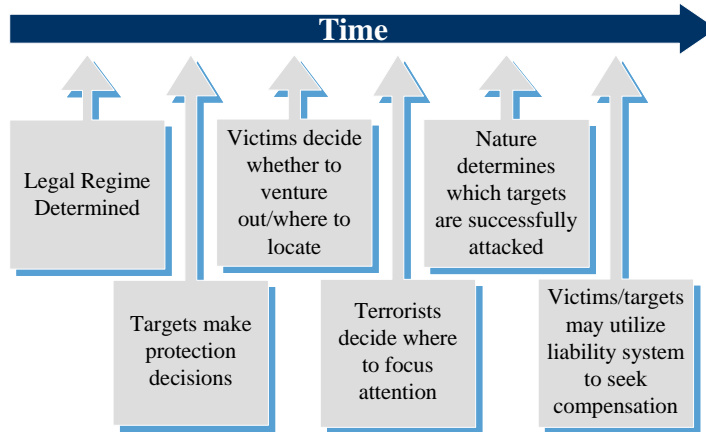


Figure 1. Sequence of Moves

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

We also make a technical assumption that  $G - G_0 < \gamma(\frac{1}{2N})$ , so that the victims who are furthest away from any target will simply choose to stay home, even in the absence of terrorist risk. Relaxing this assumption, we conjecture, has little effect on our results.

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

## 3.2 Equilibrium and Welfare in the Absence of Liability

To analyze equilibrium behavior in this game, 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. To characterize the equilibria of the game, we employ standard backward induction techniques, beginning with the terrorists, then moving to the secondary victims, and then finally moving to primary targets.

### 3.2.1 Terrorists

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

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

Given the concavity of  $\rho$  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:

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

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 non-violent 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 ?.<sup>23</sup> 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.

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.

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<sup>23</sup>? proves the result for  $s_i$ ; the result for  $v_i$  is symmetric.

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  $h(k) \in \{0, 1, \dots, N\}$ . It is easily verified that  $v_i = \int_{h(k)=i} dk$  denotes the size of the sub-population patronizing target  $i$ , for  $i \in \{1, \dots, N\}$ .

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  $i \in \{1, 2, \dots, N\}$  is

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

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:<sup>24</sup>

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

This expression implies that victims located within the radius  $\theta(G - G_0 - \rho(s_i, r_i(v_1, \dots, v_N)) D)$  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<sup>25</sup>:

$$v_i = 2\theta(G - G_0 - \rho(s_i, r_i(\vec{s}, \vec{v}))) D \quad (3.4)$$

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

<sup>24</sup>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.

<sup>25</sup>And consequently, the total number of potential victims who pursue the safe option is:

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



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  $\{\bar{s}\}$ , 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 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 invests resource  $s_i$  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:

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

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

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

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  $\rho(\cdot)$  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:

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

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.

By placing on  $\rho$  sufficient technical regularity conditions,<sup>26</sup> one can show that,  $\frac{dr_i}{ds_i} < 0$  for all values of  $s_i$ ,  $\lim_{s_i \rightarrow \infty} \frac{dr_i}{ds_i} = 0$ ; and  $\lim_{s_i \rightarrow \infty} \frac{d^2 r_i}{ds_i^2} = -\infty$ . 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:*

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

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

<sup>26</sup>Derivation available from the authors.

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 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 protection (depending on which of these effects dominates).<sup>27</sup>

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.<sup>28</sup> 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

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<sup>27</sup>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.

<sup>28</sup>Note that this formulation does not include the welfare of terrorists, which seems most natural in this context. It 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 definition below.

terrorists:<sup>29</sup>

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

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 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:

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

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

where

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

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

---

<sup>29</sup>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.

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  $\{s^{NL}, v^{NL}, r^{NL}\}$ .

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:

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

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  $\{\hat{r}, \hat{s}, \hat{v}\}$ :*

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

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).<sup>30</sup>

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:

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

where the policy parameter  $\alpha$  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  $\beta$  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  $\beta$  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:<sup>31</sup>

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

---

<sup>30</sup>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.

<sup>31</sup>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.

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:

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

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:

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

subject to

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

$$\text{equation} \quad (3.12)$$

$$\text{equation} \quad (3.13)$$

Analysis of this problem yields the following proposition:

**Proposition 3.6.** *If the policy choice of  $\alpha$  and  $\beta$  is unconstrained, and if (A1) holds, then the optimal strict liability regime  $(\alpha^*, \beta^*)$  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:*

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

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  $\beta$ . Adding this constraint to the regulator's problem immediately yields the following proposition:

**Proposition 3.7.** *If the policy choice of  $\alpha$  and  $\beta$  is constrained so that  $\beta \geq 0$ , then the optimal strict liability regime  $(\alpha_c^*, \beta_c^*)$  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*

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

*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 Intuition Behind Results

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 three market failures: (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 Accounting 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:

$$\alpha L = -vD \quad (3.14)$$

$$\beta = 0 \quad (3.15)$$

In the event of an attack, the target of interest pays the unaffected target the value of victim losses, but no other transfers are made. Victim behavior has no external effects on targets, and target behavior has no effects on other targets. The only inefficient margin of decisionmaking is the target's private return to protection, which excludes the expected losses of victims from an attack and thus fails to match the social return to protection. 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. Transfers to victims would only be distortionary. Moreover, note that the payment being made *to* the unaffected target is largely incidental. We could just as easily have required that the target pay the government a fine equal to victim losses. In this particular case, the money received by the unaffected target has no impact on its incentives, because the unaffected target cannot manipulate the risk of attack. In this case, the unaffected target functions as nothing more than a repository for the payment made by the damaged target. Therefore, 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:

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

$$\beta = 0 \quad (3.17)$$

Since victim behavior involves no external effects, 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 a target liable for being 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  $\alpha L$ . 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 contribute  $\frac{vD+L}{N}$  to the pool. In the event of an attack, the affected target can then be paid  $\alpha L$ , 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, so that  $\frac{dr_1}{dv_1} > 0$ . 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  $\beta$  eliminates this result. As a result, equation 6.6 incorporates a transfer payment that purges the effect of  $\beta$  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 decision-making.

## 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.,  $\beta$  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 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.<sup>32</sup>

## 4.2 Public Goods

In focusing on incentive effects, we did not discuss the role of public goods in protection against terrorism (?). 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

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<sup>32</sup>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.

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.

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## 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:

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

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:

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

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

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:

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

which have an associated Jacobian:

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

which in turn has determinant:

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

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:

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

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 absolute 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  $\beta$ . Target behavior depends on both. So we proceed by fixing  $\beta$  optimally, and fixing  $\alpha$  optimally given  $\beta$ .

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:

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

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

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

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

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

Solving the above expression for  $\alpha$  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  $\beta$  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  $\alpha$  as follows:

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

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