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# A Situational Model of Displacement and Diffusion Following the Introduction of Airport Metal Detectors

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*Much of the discourse surrounding counterterrorism centers on the inevitability of displacement, or the substitution of another form of terrorist attack in place of the one that has been thwarted. Yet a longstanding tradition of research in situational crime prevention finds that displacement is far from inevitable, and often depends crucially on the specific features of the incidents in question. In fact, crime prevention efforts are often followed by a “diffusion of benefits” (i.e., crime reductions) to incidents, groups, or locations that were not the intended target of the intervention. The current study examines various forms of displacement and diffusion in response to airport metal detectors among terrorist groups that had been involved in the perpetration of aviation attacks prior to their implementation. Using data from the Global Terrorism Database, the findings from interrupted time series models suggest a complex set of displacement and diffusion effects with respect to alternative attack modes, target types, and weapon usage.*

**Keywords** airport security, displacement, hijackings, homeland security, metal detectors, situational crime prevention, substitution effect, terrorism

## Introduction

For the past three decades, the inevitability of ensuing shifts of terrorist attacks has become customary discourse when addressing the use and effectiveness of defensive counterterrorism measures. Hardening targets, erecting technological barriers, and other defensive policies aimed at reducing opportunities for terrorist attacks through

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the manipulation of the situational environment have been characterized as piecemeal campaigns that often spur the substitution of other attacks in place of the one originally prevented.<sup>1</sup> Known as the “substitution effect,” Sandler, Tschirhart, and Cauley argued that, while government actions that increase the “price” of a terrorist act lower the “demand” associated with that activity, they simultaneously increase the demand associated with activities whose prices have remained constant.<sup>2</sup> Consequently, terrorists’ actions are substituted, or in criminological language, displaced, to other modes of operation since its relative costs are now cheaper.<sup>3</sup> The substitution effect generally argues that implementation of situational counterterrorism measures, designed to make a particular kind of terrorist attack more difficult and costly, do not diminish the terrorists’ firm resolve but simply divert attacks elsewhere.<sup>4</sup>

The notion that terrorists simply exchange attacks when faced with situational interventions has generated concern. Because governments largely resort to defensive strategies, they may be unsuccessful in effectively curbing terrorism.<sup>5</sup> For example, Enders and Sandler found that while the global proliferation of airport metal detectors in the early 1970s led to a significant reduction in skyjackings, the subsequent rise in the number of other hostage attacks and assassinations offset the gains associated with the airport security measures.<sup>6</sup> Similarly, fortifying U.S. embassies prompted a substitution into assassinations.<sup>7</sup> In light of these findings, terrorism researchers assert that governments must eschew their reliance on situational measures, since such security upgrades are an inefficient allocation of resources and may deflect attacks toward more vulnerable targets.<sup>8</sup>

By examining the substitution (i.e., displacement) effect through a situational prevention lens, our study underscores the growing awareness in criminology and terrorism studies that expanding our knowledge of the intersections between crime and terrorism will greatly advance our understanding of the causes of and responses to terrorism.<sup>9</sup> Like terrorism, crime scholars have long been concerned about the threat of displacing crime in response to situational prevention measures. Undergoing a similar skepticism in criminology since T. A. Repetto first introduced the concept of crime displacement, the emergence of other modes of crime as a consequence of focused opportunity reduction efforts has been the most heated debate about the scope and value of situational crime prevention.<sup>10</sup> Repetto stated that displacement referred to the shift of crime, in terms of space, time, or type of offense, from the original targets of crime prevention intervention.<sup>11</sup> So when confronted with reduced opportunities, offenders will simply shift their attention to some other time, place, or target; will change their tactics; or will begin to commit some other type of crime altogether.<sup>12</sup> Akin to the substitution effect, the displacement of crime is based on the assumption that situational initiatives do not alter the offender’s motivation to offend, and that plenty of alternative criminal opportunities not affected by the interventions will always be available.<sup>13</sup>

Despite these collective fears of displacement, criminological research has suggested that displacement is far from certain.<sup>14</sup> In particular, displacement is often less extensive and pervasive than many critics suggest, and its effects tend to be less than the gains achieved by the situational intervention.<sup>15</sup> These findings support the situational perspective that the immediate context of crime creates strong influences on potential criminals, in which opportunities for crime are relatively limited so offenders will have difficulty relocating their deviant activities.<sup>16</sup> In the same vein, terrorism is a contextual phenomenon where proximal circumstances can enable

or constrain terrorist activities.<sup>17</sup> As such, terrorist activity is a decision-making process whereby choosing to wage an attack is the result of a series of calculated choices conditioned by situations and circumstances that shape the costs and rewards of the attack in relation to the terrorists' abilities and resources.<sup>18</sup> Thus, a practical application of situational crime prevention theory to the study of terrorism is apparent.

### **Situational Terrorism Prevention**

In explaining the utility of situational crime prevention strategies for reducing terrorist violence, Clarke and Newman emphasized that crucial decisions made by terrorists are greatly determined by situational contingencies and constraints.<sup>19</sup> The situational prevention of terrorism is concerned with understanding the opportunities derived from the social, technical, and physical features of society that terrorists exploit when carrying out specific forms of terrorist acts.<sup>20</sup> In other words, situational researchers investigate *how* terrorists plan and complete their attacks by analyzing the processes, components, and procedures involved in carrying out specific kinds of terrorist attacks.<sup>21</sup> Underlying the study of opportunity is the assumption that terrorists are primarily committed to the successful completion of their immediate objectives. This implies that, although the motivation of terrorists (and criminals) may well derive from an internal state that compels them to acts of violence, terrorists choose their situations and align their behavior to those situations to maximize the likelihood of achieving their goals.<sup>22</sup>

Situational terrorism prevention centers on a thorough analysis of the opportunity structure for terrorism, which refers to the mosaic of factors necessary for terrorist groups to form and make particular kinds of terrorist attacks possible.<sup>23</sup> These include, for example, social and economic factors, national history and culture, the physical environment, technology, and government activity. Terrorist groups and the framework within which they operate may form out of these conditions, and opportunities to carry out terrorist acts may be present depending on the level of security and societal regulations. Whether the opportunity is exploited depends on careful deliberation of its elements such that they offer advantage to the terrorist for carrying out the attack.<sup>24</sup>

With this in mind, Clarke and Newman classified the opportunities for terrorists according to targets, weapons, tools of everyday life, and facilitating societal conditions.<sup>25</sup> In theory, there are an unlimited number of targets, but they do not all offer the same opportunity for attack and, thus, terrorists must choose among the various characteristics of targets in relation to their goals and capability.<sup>26</sup> Likewise, terrorists must choose weapons, and are more likely to select those that possess the attributes conducive to the successful completion of their goals.<sup>27</sup> For example, weapons that are obtainable, familiar, and reliable may be preferred. The availability of tools (tangible products used in the course of attack) and presence of facilitating conditions (societal features and systems that make specific terrorist attacks possible) are two major factors that bring weapons and targets together. These aspects of the opportunity structure enable terrorists to efficiently mount their attacks by making it easier for them to acquire weapons or enhance their effectiveness, and help them select and reach their targets. Examples of the features considered are the ease of acquiring false identification documents, and a local community that can be used as cover by foreign terrorists.<sup>28</sup>

A common concern regarding applying the tenets of situational crime prevention to the reduction of terrorism is that the nature of crime and terrorism are vastly different. The organized nature of terrorism leads some to believe that it is a structured act that requires a good deal of planning and thus is less opportunistic than conventional crimes. Furthermore, terrorists are driven by extremist ideologies rather than criminal interests, and terrorism seems to involve different objectives than crime (e.g., publicity, as opposed to anonymity).<sup>29</sup> To alleviate these reservations, situational prevention researchers argue that the mechanics and operations of crime and terrorism can both be analyzed systematically.<sup>30</sup> This is because the perpetration of a criminal or terrorist act requires a sequence of behaviors that are logically connected from beginning to end, and this sequence of action occurs within a limited setting of time and space.<sup>31</sup> Specifically, the behavior of would-be terrorists operates along the same principles that provide opportunities and pose constraints to would-be criminals.<sup>32</sup> Supplying support for this claim, Townsley et al. found that terrorist attacks in an insurgency environment appear to follow basic situational principles originally explored for the description of property crime.<sup>33</sup>

To illustrate the versatility of their approach to effectively address the problem of terrorism, Clarke and Newman have noted that there are as many differences among the various kinds of crime as there are between the two broad categories of crime and terrorism.<sup>34</sup> These authors point out that crime consists of a vast range of prohibited acts committed for a large assortment of motives by a heterogeneous group of offenders. Yet, situational crime prevention has been successfully applied to a wide variety of crimes, ranging from routine forms of crime (e.g., burglary, assault, car theft) to “new” crimes (e.g., cybercrime, identity theft) that have grown out of fresh opportunities provided by globalization and the information technology revolution.<sup>35</sup>

With regard to the prevention of terrorist attacks, situational prevention scholars argue that a major strength of their approach is that it has direct translation to counterterrorism actions. Clarke and Newman explained that removing the opportunities that make terrorism possible is practical and brings immediate protection from terrorist attacks.<sup>36</sup> In support of this, Cothren et al. examined the pre-attack planning and preparation process of terrorists groups in the U.S. They found that these behaviors (e.g., procurement of false IDs, theft of explosives or weapons, residing in close proximity to the target) occur in measurable dimensions of time and space, suggesting that patterns of preparatory conduct may exist that could assist law enforcement officials, investigators, and prosecutors in early intervention.<sup>37</sup>

### **A Situational Assessment of Adaptation: Displacement Versus Diffusion**

Clarke and Newman reasoned that the increased risk, effort and/or reduced rewards involved in committing an attack elsewhere, or in some other way, may not be feasible or judged worthwhile by most terrorists.<sup>38</sup> While it may be intuitive to think that displacement automatically occurs with defensive measures, a situational assessment of this issue reveals that displacement is more complex than commonly thought. As discussed, individuals explicitly choose a particular situation as one that is suitable for offending.<sup>39</sup> In doing so, they make choices based on the balancing of anticipated costs, risks, effort, and reward in relation to their own capacity and resources and in interaction with the everyday arrangements of society that provide opportunities for action.<sup>40</sup> Underscoring the saliency of situational attributes,

LaFree et al. found that, despite virulent anti-U.S. ideology, anti-U.S. foreign terrorist groups rarely attacked U.S. targets and operated primarily at home against local targets due to the tremendous difficulty of perpetrating attacks from afar.<sup>41</sup> Foreign attackers, for example, typically encounter an environment in which they have a limited understanding of local language, culture, and everyday life.<sup>42</sup>

Rather than displacing crime, situational prevention theorists posit that situational interventions might actually diffuse benefits beyond their anticipated reach. Clarke and Weisburd defined “diffusion of benefits” as the “spread of a beneficial influence of an intervention beyond the places which are directly targeted, the individuals who are the subject of control, the crimes which are the focus of intervention or the time periods in which an intervention is brought.”<sup>43</sup> Clarke and Weisburd identified the two main processes underlying diffusion of benefits as deterrence and discouragement.<sup>44</sup> In deterrence, offenders generally overestimate the crime prevention efforts and their perception of apprehension or punishment is much higher than reality.<sup>45</sup> Even though offenders are no longer under an increased threat of detection and arrest, many of them continue to believe that they may be and desist from offending due to their perception of increased cost of crime. Furthermore, the deterrent reach of situational interventions may be overestimated by potential offenders who believe they are under a greater threat of apprehension than is the case because they do not know how extensive the risk is.<sup>46</sup>

Besides the costs of crime, offender decision making may be manipulated by making the reward obtained inadequate in relation to required effort. Offenders may be discouraged from committing a crime, even when the risks of detection are tolerable or have not increased, but because the effort needed will not be sufficiently compensated by the rewards acquired from the offense.<sup>47</sup> This alludes to the idea that the different kinds of crime are not all equally rewarding; therefore, once the opportunities to commit an offense are reduced, the costs of carrying out other, less rewarding, illicit endeavors may not be worthwhile to the offender.

In addition to short-term adaptations including displacement and diffusion, criminals can adopt long-term adaptations in response to the reduction of opportunities for crime. Contrary to the immediate change in criminals’ behavior designed to displace their offending, would-be offenders might discover new crime vulnerabilities after preventive measures have been in place for some time.<sup>48</sup> In the context of terrorism, long-term adaptations or innovation (as it is known in the terrorism literature) is a long-term process marked by gradual learning whereby terrorists develop ingenious ways to defeat defensive measures.<sup>49</sup>

## **Current Focus**

Given past empirical support for the strong preventative impact of airport metal detectors, this defensive policy is selected for our study to test for substitution effects. Choosing an effective intervention is important because it serves as a springboard for displacing attacks elsewhere.<sup>50</sup> To provide some background, metal detectors were installed in U.S. airports on January 5, 1973 by the Federal Aviation Administration (FAA) to screen all embarking passengers and their luggage. By increasing the certainty of apprehending perpetrators, this target-hardening measure greatly increased the cost of committing hijackings. After their introduction in the U.S., metal detectors were implemented worldwide shortly thereafter, and their use spread fairly quickly to other industrialized countries and was gradually adopted by most other

nations of the world.<sup>51</sup> So for our analysis, January 1974 is the date chosen for the introduction of the intervention.

Situational terrorism prevention informs us that not all terrorists are affected by a preventative measure. As discussed above, terrorists are primarily committed to the completion of their objectives and make choices that are structured by their goals, preferences, and abilities. Thus, the fact that the opportunities for airline hijackings were essentially eliminated by metal detectors probably had little impact on the activities of those terrorist groups that had never been involved in these types of attacks, and thus continue unabated with their schemes.<sup>52</sup> As Guerette and Bowers pointed out, “displacement is a term reserved for changes that original offenders make so they can continue to offend when faced with reduced opportunities.”<sup>53</sup> In applying the situational perspective to develop a sample for the study of displacement, we base our analysis on terrorist acts committed by groups that were implicated in aviation attacks prior to the introduction of airport metal detectors. Without such information, an observed increase in other modes of attack could have been the result of other factors unrelated to the security intervention.

As previously noted, while displacement refers to short-term adaptations in behavior, terrorists can innovate in response to situational prevention measures. A successful defensive policy, then, may trigger an immediate diversion elsewhere or an extended innovative response. While there is not a clear time frame differentiating short-term displacement and long-term adaptation effects, we limit our analysis to a four-year post-intervention period.<sup>54</sup> This draws upon the notion that as terrorists substitute between attack modes, the time series of terrorist incidents will be characterized by cycles.<sup>55</sup> More specifically, lulls in terrorist incidents following an effective countermeasure may be followed by an increase in attacks as terrorists substitute to other modes of attack. The duration of cycles are determined, in part, by the nature and characteristics of the act. For example, Enders and Sandler found that terrorist events with casualties impart a long-term and medium-term cycle, specifically, a downturn in incidents with casualties tend to be followed after two-and-a-half years by an upturn.<sup>56</sup> Similarly, when considering the logistical complexity of attacks, cycles range from about a year for simple terroristic threats to about five years for logistically intricate events.<sup>57</sup> In short, a four-year post-intervention period was chosen to obtain a sufficient number of cases for analysis and to accommodate the various characteristics of terrorist attacks. A period exceeding this time frame would likely be beyond the short-term effects of displacement or diffusion and into the realm of the long-term effects of innovation, which is beyond the scope of this study.

We proceed with two propositions in mind. In keeping with prior findings, we hypothesize that metal detectors are an effective situational intervention that reduce aerial hijackings. In addition to hijackings, we also include other forms of aviation terrorism. Although metal detectors hardened airports for the primary purpose of addressing airline hijackings, their influence may have spread to other types of aviation attacks due to incomplete information possessed by terrorists (i.e., limited/bounded rationality) regarding government interventions. This draws upon the previously discussed notion of diffusion of benefits in the criminological literature.

For displacement, we test the hypothesis that the introduction of airport metal detectors will inevitably result in terrorist groups (those previously implicated in aviation attacks) shifting their activities to other attack modes, targets, and weapons. In light of situational terrorism prevention, this study predicts that displacement to other forms of attack will not be a foregone conclusion, but will instead be highly

circumscribed. Terrorists, like criminal offenders, may have limited enthusiasm to attack in locations outside their normal domain, environments where they may stand out, and areas where they do not know the layout, the escape routes, or level of police activity.<sup>58</sup> Moreover, it may be erroneous to assume terrorist groups or individuals are equally competent or knowledgeable about all forms of attack, or that they have immediate access to the tools or weapons needed for the different acts. In short, the costs of displacement are considerable and are likely beyond the capabilities of most terrorist groups.<sup>59</sup>

### Data and Methodology

We conduct our analysis using data from version 3.0 (May 2009) of the Global Terrorism Database (GTD), an unclassified open-source, event-level database that encompasses incidents of domestic and international terrorism between 1970 and 2007. The GTD affords a new opportunity to study terrorist responses to airport

**Table 1.** Terrorist organizations involved in aviation attacks, 1970–1973

Organization	Total terrorist attacks 1970–1977	Total aviation attacks 1970–1977
1. 1st of May Group	4	2
2. Al-Fatah	1	1
3. Black December	2	1
4. Black Panthers	9	2
5. Black September	51	13
6. Croatian Nationalists	30	4
7. <i>Ejército Revolucionario del Pueblo</i> (ERP)	82	1
8. Eritrean Liberation Front	18	3
9. Irish Republican Army (IRA)	730	4
10. Japanese Red Army (JRA)	6	3
11. Jewish Defense League (JDL)	35	4
12. Jordanian National Liberation Movement	1	1
13. Mujahideen-I-Khalq (MK)	19	1
14. Popular Front for the Liberation of Palestine (PFLP)	46	13
15. Popular Front for the Liberation of Palestine, General Command (PFLP-GC)	4	3
16. Republic of New Africa	1	1
17. Revolutionary Communist League (LCR)	9	1
18. Revolutionary Patriotic Anti-Fascist Front (FRAP)	46	3
19. Tupamaros (Uruguay)	41	1
20. Turkish Leftists	1	1
21. Zero Point	1	1
Total	1,137	64

*Note:* The sum of total terrorist attacks includes all aviation and non-aviation attacks.

metal detectors. Since domestic terrorist attacks greatly outnumber foreign ones, the GTD's comprehensive collection of domestic and foreign attacks offers a more complete understanding of the impact of defensive interventions on terrorist attacks.<sup>60</sup> By analyzing only international terrorist attack data, past studies of terrorist adaptation are likely to provide an incomplete account, since foreign attackers are a select type of terrorist capable of perpetrating attacks abroad, which is beyond the scope of most terrorist groups.

Compared to most other major databases, the GTD utilizes a more comprehensive and inclusive definition of terrorism.<sup>61</sup> Past research on terrorism adopted definitions limited to political purposes, and thus excluded attacks that are instead motivated by religious, economic, or social goals. For example, in their seminal study of terrorism substitution, Enders and Sandler defined terrorism as the "premeditated use—or threatened use—of extranormal violence or force to gain a political objective through intimidation or fear."<sup>62</sup> For the present study, on the other hand, the GTD defines terrorism more broadly as the threatened or actual use of illegal force and violence by non-state actors to attain a political, economic, religious, or social goal through fear, coercion, or intimidation.

From the GTD, we extract all terrorist groups that were involved in at least one aviation attack between 1970 and 1973 inclusive. The selected groups include named terrorist organizations as well as groups of individuals united in a common cause (e.g., "Croatian Nationalists," "Turkish Leftists"), but they exclude protesters or attackers with ambiguous designations (e.g., "Arabs," "Palestinians," "Students"). The groups that are the focus of the analysis are listed in Table 1, along with the total number of terrorist attacks committed by each. The 21 groups collectively account for 1,137 total terrorist attacks between 1970 and 1977. Of these, 64 (5.6%) were incidents of aviation attacks, 21 of which were airline hijackings and 43 of which were other aviation attacks.

## Methods

To measure terrorism adaptation in response to airport security measures, this study employs interrupted time-series analysis, which Shadish et al. characterize as a strong quasi-experimental design.<sup>63</sup> The intervention models used in this study assume an immediate, permanent impact of airport security measures on the frequency of terrorist attacks. In other words, the intervention component is represented by a zero-order transfer function or step function, represented by a post-intervention dummy variable<sup>64</sup>:

$$Post_t = \begin{cases} 0 & 1 \leq t \leq 48(\text{Jan. 1970 to Dec. 1973}) \\ 1 & 49 \leq t \leq 96(\text{Jan. 1974 to Dec. 1977}). \end{cases}$$

A basic set of Autoregressive Integrated Moving Average (ARIMA) models, each of which is identical in the intervention component but differs in the specification of the "noise model," can be written as follows:

$$\text{ARIMA}(1, 0, 0): Y_t = \alpha + \beta Post_t + \rho Y_{t-1} + e_t$$

$$\text{ARIMA}(1, 0, 1): Y_t = \alpha + \beta Post_t + \rho Y_{t-1} + \theta e_{t-1} + e_t$$

$$\text{ARIMA}(1, 1, 1): \Delta Y_t = \alpha + \beta Post_t + \rho \Delta Y_{t-1} + \theta e_{t-1} + e_t$$

where,

$$\Delta Y_t = Y_t - Y_{t-1}.$$

The first model is equivalent to an AR(1) noise model, while the second is equivalent to an ARMA(1,1) noise model. A higher order of any of the ARIMA components is obviously possible. Specification tests aid in the determination of which noise model best characterizes the data generation process for each outcome series.<sup>65</sup>

We employ the Box-Jenkins methodology in choosing the noise model.<sup>66</sup> This includes a test for non-stationarity (Dickey-Fuller test) of the pre-intervention series to determine the order of integration, followed by tests for serial correlation (Breusch-Godfrey and Portmanteau tests) of the full stationary series to determine the order of autoregression. These tests are accompanied by inspection of the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to clarify the order of autoregression versus the order of the moving average, if present. In instances where multiple models generate “white noise” residuals, and each model is *prima facie* plausible, final model selection is guided by use of the Bayesian Information Criterion (BIC).

In addition to the attention we devote to the statistical significance of the impact estimate, we examine two effect size measures.<sup>67</sup> Cohen’s *d* is estimated by a ratio of the impact estimate from the ARIMA model to the pooled standard deviation of the outcome series for pre- and post-intervention months (0.2 = small, 0.5 = medium, 0.8 = large):

$$d = \hat{\beta} \times \frac{1}{\sqrt{(s_{Y_{Pre}}^2 + s_{Y_{Post}}^2)/2}}.$$

Pearson’s *r* is estimated by the standardized coefficient of the impact estimate from the ARIMA model (0.1 = small, 0.3 = medium, 0.5 = large):

$$r = \hat{\beta} \times \frac{s_X}{s_Y}.$$

These effect size coefficients will be used to judge the substantive significance of the impact estimates, apart from their statistical significance. For example, a statistically significant impact estimate might be of little practical consequence given a small effect size. On the other hand, a statistically non-significant impact estimate might be highly consequential because of a large effect size. These distinctions will be made at relevant points in the presentation of results.

## Analysis Plan

The analysis proceeds in two stages. First, we conduct an analysis of the intervention effects of airport security measures on the targeted outcome. A successful intervention is indicated by an impact estimate that is negative and possibly statistically significant, but yielding an effect size that exceeds the “small” threshold (i.e., Cohen’s  $|d| \geq 0.2$  or Pearson’s  $|r| \geq 0.1$ ). We consider the impact of the intervention

on the total frequency of aviation attacks, as well as its constituent outcomes: airline hijackings and other aviation attacks. In the GTD, an airline hijacking is defined as an “act whose primary objective is to take control of . . . [an] aircraft . . . for the purpose of diverting it to an unprogrammed destination, obtain payment of a ransom, force the release of prisoners, or some other political objective.” Other aviation attacks encompass “an attack that was carried out either against an airplane or against an airport,” excluding hijackings. The largest share of other aviation attacks are airport or airplane bombings (65%), followed by attacks against airport or airline property or personnel by means other than explosives (26%), with the balance including assassinations and hostage takings (7%) or unknown aviation attack types (2%).

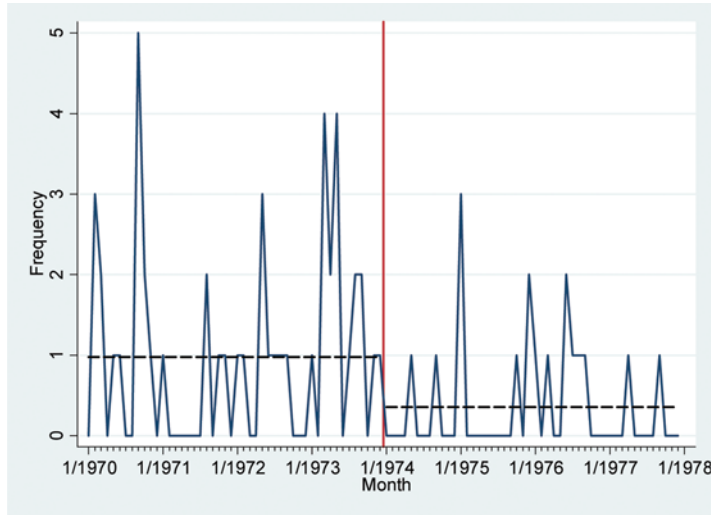
In the second phase of the analysis, we investigate terrorist responses to airport security measures. This is performed by an analysis of the impact of the intervention on the total frequency of non-aviation attacks. Substitution (displacement) is indicated by an impact estimate that is positive, whereas prevention (diffusion of benefits) is indicated by an impact estimate that is negative, and in both cases our interest is in effect sizes that exceed the “small” threshold. In addition to an analysis of total non-aviation attacks, we consider specific non-aviation attacks that differ in the mode of the attack (assassinations vs. armed assaults vs. bombings vs. hostage takings vs. infrastructure attacks), in the type of target (business vs. government vs. police vs. military vs. diplomatic vs. citizen vs. transportation), and in the usage of weapons (firearms vs. explosives vs. incendiaries), as they are classified in the Global Terrorism Database.

## Results

### *Analysis of Intervention Effects on Aviation Terrorism*

The analysis begins with an examination of total aviation attacks, to ascertain whether airport security measures were successful at reducing the kinds of incidents that were the intended target of the intervention. The frequency of total aviation attacks is shown in Figure 1, with the vertical line demarcating the pre- and post-intervention months. From 1970 to 1973, there was an average of 1.0 aviation attack per month (median = 1), for a sum total of 48 attacks during the four-year pre-intervention period. From 1974 to 1977, this declined to a mean of 0.4 aviation attack per month (median = 0), for a sum total of 17 attacks during the four-year post-intervention period. If we consider airline hijackings and other aviation attacks separately, the same basic pattern is observed (see Appendix).

Following investigation of the time series properties of total aviation attacks, an ARIMA(0,0,0) noise model is chosen, which corresponds to a standard regression model. The same noise model is selected for the two constituent series: airline hijackings and other aviation attacks. The results of the impact analyses are shown in Table 2. Total aviation attacks declined significantly following implementation of airport security measures, as do airline hijackings. In fact, the effect sizes can be regarded as “medium” (e.g.,  $d < -0.5$ ), indicating that the monthly frequencies of total aviation attacks and airline hijackings exhibit a sizable reduction in response to the intervention. While the decline in other aviation attacks is not statistically significant, the effect size is intermediate between “small” and “medium” ( $d = -0.33$ ;  $r = -0.16$ ), which we regard as a notable effect size.



**Figure 1.** Total aviation attacks by month, 1970–1977.

If we compute the ratio of the ARIMA impact estimate to the pre-intervention mean, we see that the introduction of airport security measures reduced the number of total aviation attacks by 64% ( $-0.625/0.979 = -0.638$ ). The reductions in airline hijackings and other aviation attacks were 89% and 46%, respectively. In a supplementary analysis, we computed the ratio of the number of aviation attacks to the total number of terrorist attacks, yielding the proportion of total attacks in a given month that were aviation attacks. Although not shown in the table, the impact estimate from this model is  $-0.054$  (s.e. = 0.02), which is statistically significant ( $p < 0.05$ ) as well as substantively significant ( $d = -0.51$ ;  $r = -0.25$ ). This indicates a compositional shift in the types of attacks perpetrated by the terrorist groups under study.

**Table 2.** Analysis of intervention effects of airport security measures, 1970–1977

Outcome	Pre-intervention series mean ( <i>SD</i> )	ARIMA noise model ( <i>p,d,q</i> )	Impact estimates coeff. (std. err.)	Effect sizes $ d / r $
Total aviation attacks	0.979 (1.21)	(0,0,0)	-0.625 (0.20)**	0.64/0.31
Airline hijackings	0.396 (0.84)	(0,0,0)	-0.354 (0.12)**	0.58/0.28
Other aviation attacks	0.583 (0.96)	(0,0,0)	-0.271 (0.17) <sup>‡</sup>	0.33/0.16

*Note:*  $T = 96$  ( $T_{Pre} = 48$ ;  $T_{Post} = 48$ ). The impact estimate corresponds to a dummy variable for 1974–1977 months contrasted with 1970–1973 months. The effect sizes provided are Cohen’s  $d$  based on the impact coefficient (0.2 = small, 0.5 = medium, 0.8 = large) and Pearson’s  $r$  based on the standardized impact coefficient (0.1 = small, 0.3 = medium, 0.5 = large). Robust standard errors are provided with the impact estimates.

<sup>†</sup> $p < .10$ , \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$  (two-tailed tests).

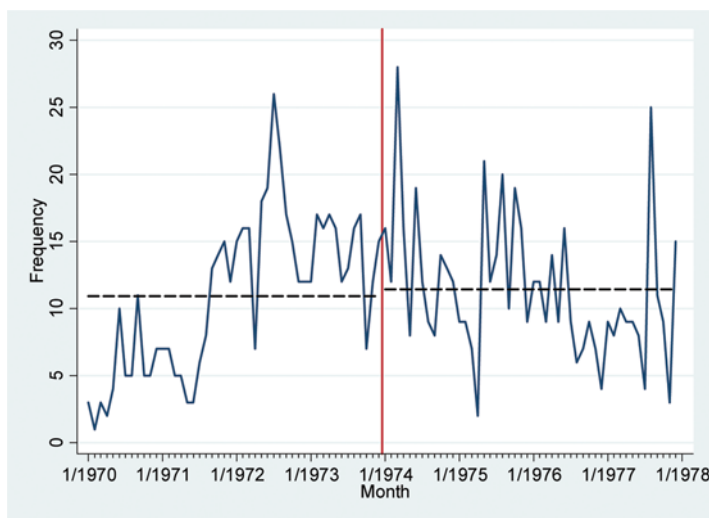
<sup>‡</sup> $p < .11$ .

Our conclusion that the introduction of airport security measures was successful in preventing airline hijackings harmonizes with prior research.<sup>68</sup> Yet we also observe a diffusion of benefits to other aviation attacks. The scope of our findings differs somewhat from these prior studies, because they concern the 21 identifiable groups selected from the Global Terrorism Database known to have perpetrated at least one aviation attack prior to the introduction of airport metal detectors. In the next phase of the analysis, we will explore the degree to which these terrorist organizations adapted with respect to attack modes, target types, or weapon usage.

### *Analysis of Displacement and Diffusion to Non-Aviation Terrorism*

Figure 2 displays the time series of non-aviation terrorism attributed to the 21 selected groups. From 1970 to 1973, there were an average of 10.9 incidents per month (median = 12), for a sum total of 524 non-aviation attacks during the four-year pre-intervention period. From 1974 to 1977, there was an average of 11.4 total incidents per month (median = 9.5), for a sum total of 549 attacks during the four-year post-intervention period. Thus far, then, there is little visual evidence for a substantial change in non-aviation terrorism. A diagnosis of the time series properties of total incidents results in the selection of an ARIMA(0,1,1) noise model. Although not shown, the impact estimate from this model is  $-0.365$  (s.e. = 0.22), which is marginally statistically significant ( $p = 0.09$ ) but not substantively significant ( $d = -0.06$ ;  $r = -0.03$ ). Indeed, the ratio of the impact estimate to the pre-intervention mean indicates a decline of only 3% in non-aviation terrorism following the introduction of airport metal detectors.

The foregoing findings demonstrate that, while the airport security measures eliminated many opportunities to perpetrate aviation attacks, the groups appear to have responded in such a way that their non-aviation terrorist activity remained effectively unchanged. It is likely that this overall stability in non-aviation terrorism masks a complex mix of displacement and diffusion effects. Table 3 compiles the results concerning modification of attack mode (5 outcomes), target type (7 outcomes), and weapon usage (3 outcomes). Each outcome is limited to



**Figure 2.** Total non-aviation attacks by month, 1970–1977.

**Table 3.** Analysis of adaptation effects of airport security measures, 1970–1977

Outcome	Pre-intervention series mean ( <i>SD</i> )	ARIMA		Effect sizes $ d / r $
		noise model ( <i>p,d,q</i> )	Impact estimates coeff. (std. err.)	
<b>Attack mode</b>				
Assassinations	4.437 (4.02)	(1,1,1)	-0.215 (0.08)**	0.07/0.04
Armed assaults	1.542 (1.99)	(1,0,0)	-0.263 (0.50)	0.15/0.08
Bombings/explosions	3.563 (2.49)	(1,0,0)	+0.619 (0.94)	0.20/0.10
Hostage takings	0.958 (1.13)	(2,0,0)	-0.310 (0.31)	0.31/0.15
Infrastructure attacks	0.354 (0.96)	(0,0,0)	+0.750 (0.47) <sup>‡</sup>	0.33/0.16
<b>Target type</b>				
Business targets	1.479 (1.43)	(4,0,0)	+1.441 (0.74) <sup>†</sup>	0.52/0.25
Government targets	0.333 (0.63)	(1,0,0)	+0.087 (0.17)	0.12/0.06
Police targets	0.917 (0.96)	(0,0,0)	+0.604 (0.22)**	0.55/0.27
Military targets	4.667 (4.41)	(1,1,1)	-0.192 (0.19)	0.07/0.03
Diplomatic targets	1.146 (1.27)	(0,0,0)	-0.500 (0.22)*	0.45/0.22
Citizen targets	1.187 (1.35)	(1,0,0)	+0.738 (0.35)*	0.51/0.25
Transportation targets	0.125 (0.39)	(0,0,0)	+0.146 (0.09) <sup>†</sup>	0.35/0.17
<b>Weapon usage</b>				
Firearms	6.063 (4.31)	(0,1,4)	-0.207 (0.15)	0.06/0.03
Explosives	3.583 (2.69)	(0,1,1)	-0.256 (0.05)***	0.08/0.04
Incendiaries	0.459 (0.99)	(0,0,0)	+0.875 (0.53) <sup>†</sup>	0.34/0.17

Note:  $T = 96$  ( $T_{Pre} = 48$ ;  $T_{Post} = 48$ ). The impact estimate corresponds to a dummy variable for 1974–1977 months contrasted with 1970–1973 months. The effect sizes provided are Cohen's  $d$  based on the impact coefficient (0.2 = small, 0.5 = medium, 0.8 = large) and Pearson's  $r$  based on the standardized impact coefficient (0.1 = small, 0.3 = medium, 0.5 = large). Robust standard errors are provided with the impact estimates.

<sup>†</sup> $p < .10$ , \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$  (two-tailed tests).

<sup>‡</sup> $p < .11$ .

non-aviation terrorism, and is mutually exclusive with respect to the other outcomes considered in the group (attacks, targets, weapons). An identical process of model selection and impact estimation is carried out for each non-aviation outcome. The ARIMA specifications, impact estimates, and effect sizes are provided in the table. The 15 non-aviation time series are shown in Appendix B.

We begin with an analysis of attack mode. Interestingly, the airport security intervention corresponds with a statistically significant decline in assassinations, contrary to the findings of Enders and Sandler.<sup>69</sup> While this implies a diffusion of benefits of airport security measures to assassinations, the effect size is not noteworthy. None of the other attack modes yields an intervention effect that achieves conventional statistical significance, yet several are associated with notable effect sizes. Namely, there is apparent diffusion of benefits with respect to hostage takings yet displacement with respect to bombings and infrastructure attacks, all of which exhibit effect sizes in the small-to-medium range.

Modification of target type also exhibits a mix of displacement and diffusion of benefits in response to the counterterrorism intervention. For example, there are displacement effects to business targets, police targets, citizen targets, and transportation targets, with impact estimates that are at least marginally significant and effect sizes that render them substantively significant, as well. The apparent displacement to business and citizen targets harmonizes with the findings of Brandt and Sandler.<sup>70</sup> On the other hand, there is a statistically significant and substantively meaningful diffusion of benefits to diplomatic targets, consistent with the finding of Enders and Sandler.<sup>71</sup>

Finally, we consider adaptation in weapon usage. It should be noted that about half (48%) of aviation attacks are perpetrated using explosives (e.g., projectiles such as rockets or mortars, grenades), followed by the use of firearms (22%) (e.g., automatic weapons, handguns) and incendiaries (11%) (e.g., arson or fire, gasoline), with the balance accounted for by the use of other weapons (3%) (e.g., fake weapons, knives or sharp objects) or unknown weapons (16%). Among non-aviation attacks, there is significant deflection away from the use of explosives, although the effect size is quite small and therefore inconsequential. Interestingly, terrorist use of incendiaries in non-aviation attacks exhibits a marginally significant and substantively meaningful increase following the counterterrorism intervention.

### *Supplementary Analysis*

To ensure that the results are insensitive to the composition of the groups included in the analysis, we expanded the sample to include any individuals or organizations that perpetrated an aviation attack between 1970 and 1973. We thus included protesters or attackers with ambiguous designations (e.g., “Arabs,” “Palestinians,” “Students”), as well as unknown perpetrators. The groups so defined account for 2,589 total terrorist attacks between 1970 and 1977, 145 (5.6%) of which were aviation attacks. Of the aviation attacks, 47 were airline hijackings and 98 were other aviation attacks. With respect to airline hijackings, the ARIMA results were virtually unchanged, confirming a statistically significant and substantively meaningful reduction in hijacking in the post-intervention period. In fact, the effect size for the impact estimate was intermediate between “medium” and “large” ( $d = -0.67$ ;  $r = -0.32$ ). With respect to other aviation attacks, on the other hand, the ARIMA impact estimate was in fact positive but was neither statistically nor substantively significant ( $d = +0.07$ ;  $r = +0.04$ ). Close inspection indicated that the latter result was due to the inclusion of “unknown” perpetrators. Exclusion of unknown perpetrators yielded impact estimates that were substantially similar to those previously reported.

We also re-estimated the models based on subsets of the 21 terrorist organizations in the sample. For example, we excluded the Irish Republican Army, which accounted for the lion’s share of terrorism activity, as shown in Table 1 (64% of total terrorist attacks). We also limited attention to the 16 organizations that were involved in at least two aviation attacks between 1970 and 1977. In both cases, the ARIMA impact estimates and effect sizes for total aviation attacks, as well as for airline hijackings and other aviation attacks, were substantially similar to those reported in Table 2.

After excluding the Irish Republican Army (IRA), the findings from the non-aviation terrorism models were sufficiently dissimilar to comment. Namely, there were fewer instances of displacement or diffusion. Inspection of the impact estimates and effect sizes indicated that the introduction of airport metal detectors was

followed by a decline in hostage taking (attack diffusion) and diplomatic targeting (target diffusion), but by concomitant increases in citizen targeting (target displacement) and the use of incendiaries (weapon displacement), similar to the findings reported in Table 3. On the other hand, exclusion of the IRA eliminated the apparent displacement to non-aviation terrorism including bombings, infrastructure attacks, business targets, police targets, and transportation targets.

## **Discussion**

This study offers a unique analysis of substitution effects by applying a situational perspective to examine the immediate reaction of terrorists with proven experience in the types of attacks prevented by a situational counterterrorism measure. We argue that, although terrorist organizations may substitute to other modes of attack, it is far from inevitable. Rather, the situational aspects of terrorist behavior significantly influence the nature of the terrorists' response. In support of this, the mixed results of displacement and diffusion of benefits observed in our analysis suggest that the terrorist response to situational counterterrorism measures is more complex than is often assumed. Our findings evoke a number of intriguing issues that are rooted in both the terrorism and situational crime prevention literatures.

As a whole, terrorists previously involved in aviation attacks were prevented from carrying out airline hijackings following the introduction of airport metal detectors. Interestingly, other aviation attacks were also included in the preventative reach of metal detectors, which includes attacks against airports and airlines. Perhaps the overall heightened perception of aviation security brought on by the advent of metal detectors and associated increase in security (e.g., screeners) deterred attackers from committing other kinds of aviation attacks. This recalls the situational argument that offenders typically have incomplete knowledge of the extent of situational prevention measures.

Diffusion of benefits is further suggested by the reductions in other attack modes and target types, namely diplomatic targets, hostage takings, and to a lesser extent, assassinations. What may be particularly relevant here is the notion that terrorists may be discouraged from committing an attack if its rewards are no longer commensurate with its costs. Not all terrorist attacks have equal value, thus once the opportunities to carry out a particular kind of attack that brought the greatest rewards are blocked, terrorists may be discouraged from committing to other behaviors that bring insufficient compensation. For example, once prevented from airline hijackings, other forms of hostage taking events may be deemed unsatisfying. This may be because airline hijackings attract enormous publicity to the terrorist cause.<sup>72</sup> And attacking airliners from flagship airlines closely associated with a targeted country (such as El Al) is a public way of striking at the heart of adversaries.<sup>73</sup> In addition to a particularly rewarding type of event, terrorist attacks may complement one another such that combinations of attack modes are needed to produce one or more basic commodities. So when a complementary event is decreased, all complements are reduced.<sup>74</sup> For example, airline hijackings when combined with assassinations of prominent individuals or attacks against diplomatic targets may make a government respond harshly. In turn, terrorist groups can use these acts to justify their own hostilities and garner support for their missions.<sup>75</sup>

Besides our finding of a diffusion of benefits, our results also suggest evidence of displacement from aviation to non-aviation attacks with similar profiles. Though not

inevitable, substitution likely occurs when two modes of attack fulfill similar purposes, are logistically similar, and can be executed without greatly increased effort or risk.<sup>76</sup> Our finding of displacement is consistent with situational crime prevention's assessment that offenders displace to the same or similar opportunities for alternative courses of actions that the criminal perceives as being extremely critical to their goals, abilities, and preferences.<sup>77</sup> This seems to be the case for the terrorist groups in our study sample who have experience in carrying out aviation attacks and may be ready to commit the acts needed to successfully complete other comparable types of attack. Perhaps to continue attacking targets critical to society's day-to-day functioning, the terrorists shifted their attention to infrastructure attacks and other transportation targets—which are also logistically similar to aviation attacks.

We also observe an increase in bombings/explosions as an attack mode within non-aviation attacks, which follows the preference of our terrorist groups, as our data indicate that the use of explosives accounted for the largest proportion of aviation attacks. This substitution is augmented by the logistical similarity in carrying out bombings, whether it is against aviation or non-aviation targets. There is also evidence that the terrorists diverted their efforts to “softer” targets or those that are now relatively less guarded. Consistent with previous research, private citizens and businesses increasingly became the targets of attacks following the strengthening of aviation security.<sup>78</sup> While the results illustrate a shift to less protected targets, they caution that target transference may not conform solely to the ease of an attack. Among the various types of targets analyzed, the increase in attacks on police received the strongest statistical confirmation of displacement. The police are typically not an easy target *per se*, but they may possess other features (e.g., symbolic, legitimate) that matter more to terrorist groups in terms of their goals, abilities, and preferences.

Next, there appears to be a shift in the weaponry used to commit non-aviation attacks following airport metal detectors. The increase in use of incendiary devices implies that changes in weapon use occur in conjunction with new target preferences. By increasing or decreasing attacks against certain target types following an intervention, weapon selection may also fluctuate to ensure success of the new missions. While there are other contingencies involved in terrorists' choice of weapons, the first set of factors considered likely depends on whether there is a particular target in mind.<sup>79</sup> Interestingly, while similar to explosives (which may be a preferred choice for our study sample since bombings comprised the largest share of other aviation attacks), greater reliance on incendiaries by the terrorist groups appears to signal a shift “down” in the lethality of weaponry. It may be fruitful, then, for future studies to examine changes in the number of fatalities and injuries of terrorist attacks due to changes in weapons use associated with substitution to other attack modes.

While we found that terrorists substituted to other types of attack, it is important to note that most of the displacement we observed is attributed to the Irish Republican Army (IRA). This finding lends support to the situational view that waging a terrorist attack is dependent on situational contingencies in relation to the capabilities and resources of the terrorists. Specific to displacement, inadequate knowledge about a new attack or insufficient familiarity with alternative opportunities may present significant costs and obstacles that most terrorists cannot overcome.<sup>80</sup> Notwithstanding that the life span for most terrorist organizations is quite short, there is a select cadre of terrorist groups that have lasted for a long period during which they have greatly expanded and improved their capabilities to carry out

and substitute terrorist operations.<sup>81</sup> As it is in our case, for example, the IRA has been in existence for many decades and, over time, developed their organizational learning and made continuous improvement efforts, such as designing and manufacturing novel weapons systems, maintaining an engineering department, building training facilities for new recruits, and establishing relationships with other terror groups to obtain training, technology, and weapons.<sup>82</sup>

Finally, while we found that airport metal detectors resulted in no net change in total non-aviation terrorism, it is possible to interpret this as a net benefit for our study sample. At the urging of an anonymous reviewer, and to provide context for the terrorism activity of the study sample, we considered non-aviation terrorism by all other perpetrators in the Global Terrorism Database who were not involved in aviation terrorism prior to 1974 (excluding “unknown” perpetrators, although our conclusions were unchanged when we retained them). The time series for this “background trend in non-aviation terrorism” (the reviewer’s words) is provided in Appendix C, along with the trend in non-aviation terrorism for the 21 organizations of interest in this study (already shown in Figure 2). In an ARIMA(1,0,1) noise model for perpetrators with no history of aviation terrorism, the impact estimate is 5.736 (s.e. = 5.49), which is not a statistically significant increase ( $p = 0.30$ ) but in effect size metric is substantively meaningful ( $d = +0.43$ ;  $r = +0.16$ ). As noted earlier, in the counterpart ARIMA(0,1,1) noise model for perpetrators with a history of aviation terrorism, the impact estimate is  $-0.365$  (s.e. = 0.22), which is a marginally significant reduction ( $p = 0.09$ ) but not substantively significant ( $d = -0.06$ ;  $r = -0.03$ ). When the two series are transformed into log metric to stabilize the variances, statistical significance and effect sizes are little changed.

Therefore, while our initial conclusion is that the introduction of airport metal detectors was followed by no change in total non-aviation terrorism in the study sample (in fact, a mix of increases and decreases in specific forms of non-aviation terrorism), the same is not true in the broader context of non-aviation terrorism. Indeed, non-aviation terrorism perpetrated by organizations with no history of aviation terrorism increased substantially, although we obviously do not attribute this increase to the causal impact of airport metal detectors. An intriguing modification of our initial conclusion is that, for our study sample, the intervention in fact resulted in a relative reduction in total non-aviation terrorism in light of the broader increase in non-aviation terrorism. (Our thanks go to the anonymous reviewer for suggesting this as a possibility.)

The time series for all other terrorist organizations can also serve as control series for the 21 terrorist organizations in the study sample. We re-estimated each ARIMA model shown in Table 3 after including the counterpart time series for all other terrorist organizations, in order to determine whether the intervention retained its impact once the counterpart series—and by implication, secular changes in non-aviation terrorism—were controlled. The impact estimates and effect sizes were substantially similar, with three exceptions. Attack displacement with respect to bombings ( $b = +0.498$ ; s.e. = 1.01;  $d = +0.16$ ;  $r = +0.08$ ) and target displacement with respect to transportation targets ( $b = +0.071$ ; s.e. = 0.09;  $d = +0.17$ ;  $r = +0.08$ ) were no longer substantively meaningful (i.e.,  $|d| < 0.2$ ;  $|r| < 0.1$ ). On the other hand, attack diffusion with respect to armed assaults ( $b = -0.426$ ; s.e. = 0.54;  $d = -0.25$ ;  $r = -0.12$ ) became notable for its effect size.

While we view this study as a contribution to the literature on terrorism, it is not without limitations. Even though the GTD is presently the most extensive

open-source collection of worldwide terrorist incidents, it relies on data culled from news sources and, therefore, may be biased toward the most newsworthy forms of terrorism.<sup>83</sup> It is conceivable that some terrorist attacks are missed by the media and, as a result, are excluded from the GTD and this study's analyses. LaFree and Dugan contend that this is particularly the case for attacks that were averted by authorities, or that occurred in regions of the world with less media penetration and freedom.<sup>84</sup> Furthermore, because this study uses known, non-generic perpetrator information in the GTD to isolate those terrorist groups involved in the previous attacks of interest, it is possible that some fraction of the excluded cases was actually carried out by the groups in the analysis and therefore their terrorist activity is underrepresented in the data.

Finally, it is important to bear in mind that the ARIMA methodology used in this study is a quasi-experimental one. Although we have attempted to strengthen the case for causality by controlling for broader secular changes with respect to non-aviation terrorism in the ARIMA models, we are unable to confidently rule out the possibility that some other event coincided in close temporal proximity with the intervention of interest. It is also possible that the function form of the intervention is misspecified, and is characterized by something other than a step function (i.e., an intercept shift). In both cases, the impact estimates and effect sizes would be biased to an unknown degree. Therefore, while we regard our findings as suggestive, it is prudent to exercise caution.

Despite the study's limitations, the results suggest to policymakers and security personnel that terrorist substitution is likely not a foregone conclusion. Rather than adopting a blanket reproach to defensive counterterrorism measures based on the inevitability of displacement, terrorism policy discussions should devote special attention to situational concepts and considerations discussed in this study. Given the results of the study, government officials might also want to consider that in addition to increasing attacks elsewhere, there is the potential for beneficial effects associated with situational anti-terrorism interventions. Taken together, this research points to the current discrepancy between the perceived dangers of displacement and the actual risk it poses, suggesting that officials should become cognizant of this disconnect that currently grips public discussions on the inevitability of the substitution effect.<sup>85</sup>

## **Conclusion**

Researchers, policymakers, and the public have long predicted that terrorists will simply shift their tactics to other forms of hostility when thwarted from carrying out a particular kind of attack. We provide a situational crime prevention perspective on the so-called "substitution effect," emphasizing that it is a complex phenomenon with intriguing implications for understanding terrorist behavior. The results harmonize with the expectation that displacement is not unavoidable, and is likely reserved for the most capable terrorist organizations. There is also support for the diffusion of benefits beyond the anticipated reach of the situational measure.

Our findings highlight the potential to significantly expand the inquiry of terrorists' responses to situational counterterrorism measures. It may be beneficial for future studies to explore what is needed to overcome the costs of displacement. For instance, certain organizational attributes, such as longevity and familiarity, may play a critical role. Future research may question what forms the basis for

familiarity: Is familiarity broadly distributed or focused? It is possible that being proficient in an assortment of terrorist activities may lower the threshold for displacement. In any event, future research would benefit from a focus on the conditions and circumstances that make displacement more and less likely. Hopefully, as scholars continue to develop this area, disconnect between the perceived dangers of displacement and the actual risk it poses will be further illuminated.

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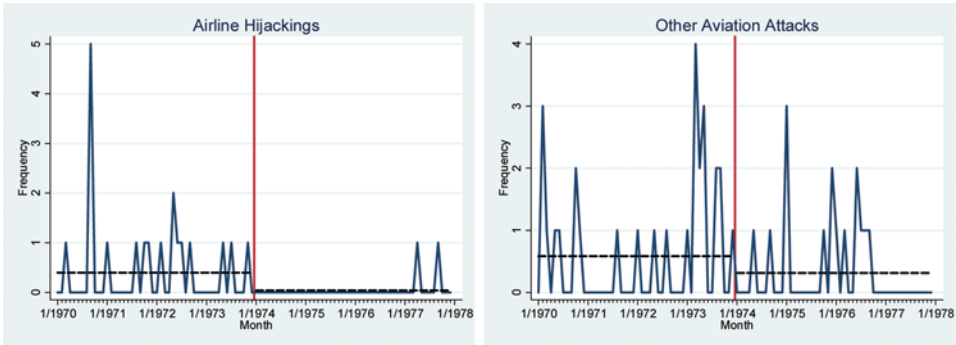
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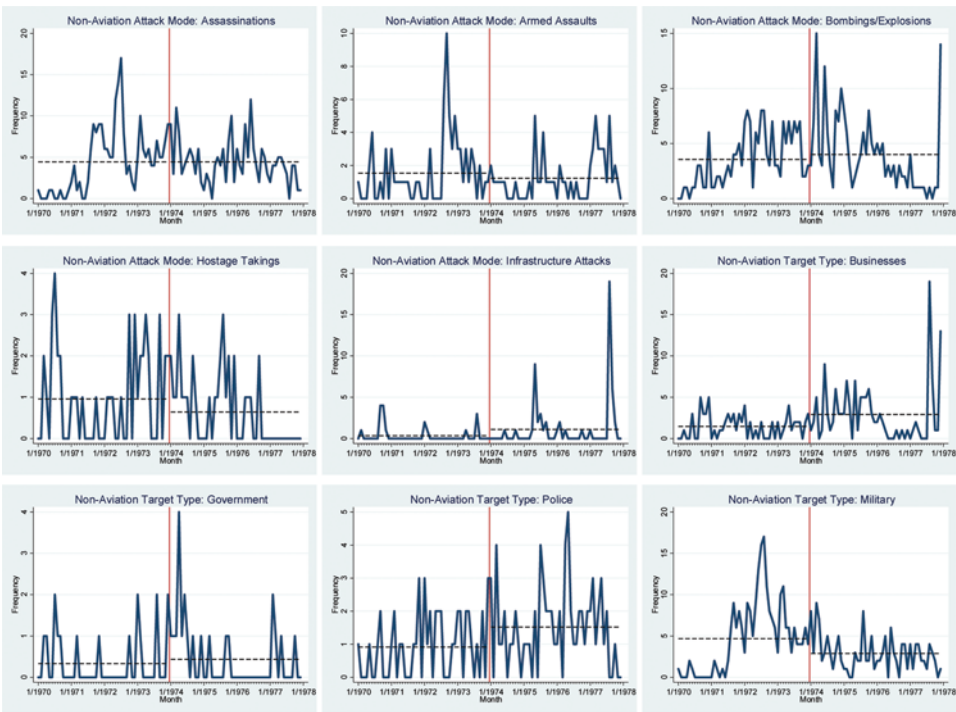
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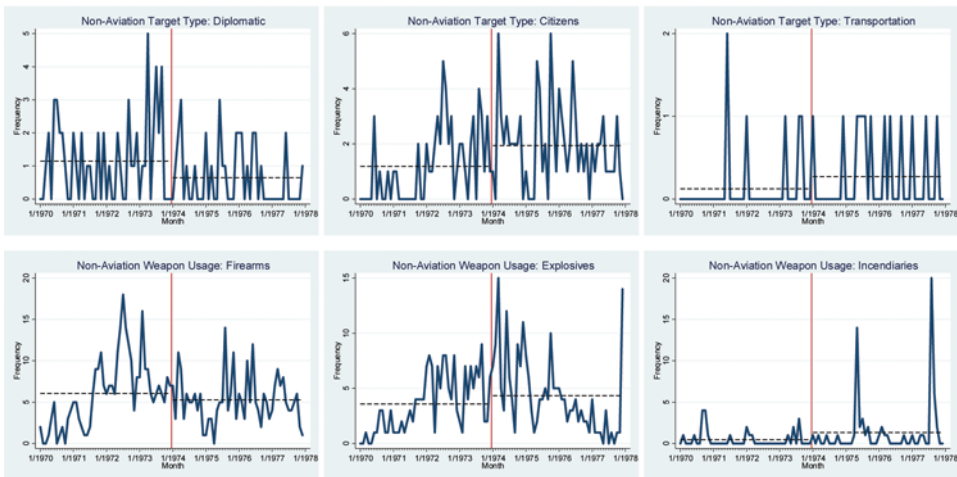
## Appendix

### Aviation Attack Subtypes by Month, 1970–1977

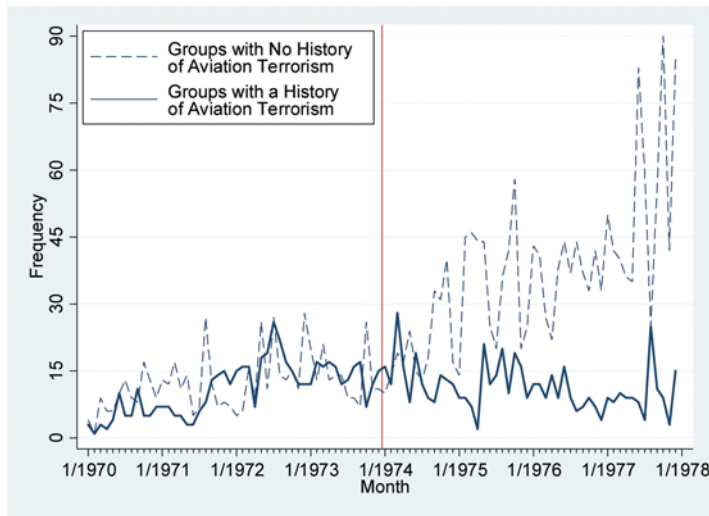


### Non-Aviation Attack Subtypes by Month, 1970–1977





**Total Non-Aviation Attacks by Month and History of Aviation Attacks, 1970–1977**



*Note:* The solid line is the same time series as is shown in Figure 2 for the 21 organizations in the study sample.