The Wane of Command*

Evidence on drone strikes and control within terrorist organizations

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Abstract

This paper investigates how counterterrorism targeting terrorist leaders affects terrorist attacks. This effect is theoretically ambiguous and depends on whether terrorist groups are modeled as unitary actors or not. The paper exploits a natural experiment provided by strikes by Unmanned Aerial Vehicles (drones) 'hitting' and 'missing' terrorist leaders in Pakistan. Results suggest that terrorist groups *increase* the number of attacks they commit after a drone 'hit' on their leader, compared to after a 'miss'. This increase amounts to 29 terrorist attacks (43%) worldwide per group in the six months after a drone strike. Additional analysis of heterogenous effects across groups, and the impact of drone hits on the timing, type and target of attacks, attacks by affiliated terrorist groups, infighting and group splintering, suggests that strategic interactions *within* terrorist groups and networks, or problems of control, explain these results better than alternative theoretical mechanisms.

Keywords: Terrorism, Targeted Leader Killing, Unmanned Aerial Vehicles, Drones

JEL Codes: D74, F5, O10

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1 Introduction

> The United States and its partners will *defeat* terrorist organizations of global reach by attacking their [. . .] leadership; command, control [. . .]
>
> *US National Strategy for Combating Terrorism 2003*
>
> (emphasis in original)

Targeting terrorist leaders has become a commonly used US counterterrorism policy since 9/11. According to the US National Strategy for Counterterrorism 2018, targeting key terrorists to "disrupt, degrade and prevent reconstitution of terrorist networks" remains the number one priority action. This policy is also referred to as targeted leader killing or "cutting off the head of the snake" – implying that if one does so, the body dies.

These quotes also illustrate that the underlying goal of this policy is to undermine *control* within terrorist organizations: the ability of individuals higher up the hierarchy, or more central to the network, to determine what others in the organization do.

Terrorist leaders are primarily targeted using armed drones, or Unmanned Aerial Vehicles. These unmanned airplanes can surveil and help identify individual targets, and kill them. The US now owns hundreds of these armed drones[1], and there have been over 6500 US drones strikes worldwide to date[2]. Drone technology is spreading rapidly: 28 other countries have acquired weaponized drones in the last ten years[3].

The prominence of targeted leader killing and the proliferation of drones invite the question whether this policy works to decrease terrorist violence. This paper addresses that research question. More precisely, it investigates how drone strikes targeting terrorist leaders, thereby undermining control within terrorist organizations, affect terrorist attacks[4].

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[1] UK Business Insider, "Chart of the US drone fleet", 1 March 2016.

[2] https://www.thebureauinvestigates.com/projects/drone-war, accessed 13 February 2019

[3] New America Foundation, "World of Drones", 15 March 2017.

[4] Defined as "the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation", following the Global Terrorism Dataset.

The effect of killing a terrorist leader on terrorist violence is theoretically ambiguous, and depends on whether terrorist groups are modeled as a unitary actor or not. Theoretical models that consider the terrorist group as unitary – as a single organism as the snake analogy would suggest – predict that killing a leader decreases the capacity of the group to commit attacks and decreases terrorism (Sandler and Arce, 2003; Sandler and Siqueira, 2006; Powell, 2007; Bandyopadhyay and Sandler, 2011). However, if terrorist organizations are modeled as non-unitary actors, predictions are less straightforward. Models that consider terrorist groups as organizations subject to collective action and principal-agent problems, which I will call *problems of control* for short, suggest that undermining control within terrorist groups may not be effective, or may even backfire (Enders and Jindapon, 2010; Shapiro, 2013).

This leaves an empirical question. However, investigating the causal effect of counterterrorism on terrorist violence empirically is challenging. Although counterterrorism may well affect terrorist violence, it is equally possible that terrorist violence invites counterterrorism.

To overcome this problem, this paper exploits a natural experiment provided by drone strikes 'hitting' and 'missing' terrorist leaders in the Federally Administered Tribal Areas (FATA) of Pakistan, which is inspired by Jones and Olken (2009). I construct a new dataset of drone attempts on terrorist leaders' lives, executing several cross-checks to safeguard data quality. This dataset captures variation across time and terrorist organizations. I argue that conditional on a drone attempt to kill a terrorist leader, drone 'hits' and 'misses' are quasi-random. Drone hits and misses are not statistically significantly different from one another on an extensive range of characteristics, including pre-trends in terrorist violence. Narratives of why drones miss also suggest that misses are largely driven by chance. This enables a difference-in-difference design, investigating changes in attacks by a terrorist organization before and after a drone hit on its leader, compared to before and after a miss.

Results indicate that a drone hit on a terrorist organization's leader is associated with an increase in the number of terrorist attacks by this organization, compared to a miss. Estimates indicate that this increase amounts to 29 additional terrorist attacks in total across the world in the six months after a drone hit, an increase of 43% compared to the six months after a miss. This result cannot be explained by terrorist organizations ‘speeding up’ the timing of attacks, or by a decrease in the lethality of attacks.

Several game-theoretical models provide explanations for the results obtained. A first family of models considers *problems of control.* A principal-agent model by Shapiro (2013) suggests that leader killing, by increasing the costs for the leader to control his operatives, could lead to increased terrorist violence if operatives have a greater preference for (indiscriminate) violence than the leader. Modeling terrorist violence as a public good to terrorists, Enders and Jindapon (2010) suggest that terrorist networks strategically decrease the number of network connections in response to targeted leader killing, leading individual nodes to increase their efforts to commit attacks as they can no longer free-ride on the efforts of others in the network. Other families of models provide alternative explanations of why targeted leader killing may increase terrorist violence: terrorist groups may respond to a loss in *capacity* by substituting a few high-capacity attacks with many low-capacity attacks, pro-active counterterrorism policies that result in civilian casualties may create *backlash* if they spur terrorist recruitment, and terrorist organizations may commit more terrorist attacks after their leader has been killed to *signal* strength.

Further analysis suggests that problems of control explain the main result better than alternative theoretical mechanisms. The observed increase in terrorist attacks is primarily driven by attacks that leaders of terrorist organizations do not favour: attacks on civilian and private targets – which terrorist leaders repeatedly instruct their followers to avoid – and attacks by its members that the organization does not publicly claim responsibility for. The observed effect is also stronger for terrorist organizations and leaders that rely more strongly on central control. Furthermore, a drone hit is associated with proxies for network breakdown: an increase in group splintering and infighting. Simultaneously however, results suggest that a drone strike on one group's leader is associated by an increase in terrorist attacks by other groups, affiliates[5], in its network.

A considerable number of existing studies investigate empirically the impact of targeted killing of leaders of terrorist organizations, yet results are mixed. Some authors conclude that targeted leader killing is effective, either because it speeds up the decline of terrorist organizations (Price, 2012) or diminishes the number or intensity of terrorist attacks (Jaeger and Paserman, 2009; Johnston, 2012). Others conclude that it has no effect (Jordan, 2009; Mannes, 2008; Hafez and Hatfield, 2006), or even an adverse effect – either on terrorist organizations in general or on particular categories of terrorist organizations (Kaplan et al., 2006; Jordan, 2009; Mannes, 2008; Abrahms and Potter, 2015; Abrahms and Mierau, 2017).

The above studies encounter some combination of three challenges. Most of these studies cannot distinguish between different theoretical explanations for their results, and do not consider problems of control as a possible explanation. Notable exception are Abrahms and Mierau (2017), who pioneer the study of targeted leader killing from a principal-agent perspective. Empirically, these studies struggle to convincingly demonstrate the *causal* effect of targeted leader killing. A handful of studies employ a similar 'hit-or-miss' design as in this paper (Johnston, 2012; Abrahms and Mierau, 2017; Jaeger and Paserman, 2009), but data used lacks either variation across terrorist groups or over time. Specifically, Abrahms and Mierau (2017), are forced to consider all terrorist groups in the Afghanistan-Pakistan area as one. For these designs to be convincing, the probability of a hit must not be related to trends in violence over time or across groups. These conditions would be violated in many plausible circumstances, and this paper provides strong evidence that the probability of a hit indeed displays a strong time trend. Unlike other studies, the present study can control for trends over time and differences across terrorist groups by including group and

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[5] An affiliate is defined as a terrorist organization that has either (a) pledged fealty to the parent group and relies on it for support or guidance; or (b) shares a similar ideology or goals and coordinates operations with the parent group; (c) once operated under the same banner as the parent group and consolidated resources with the parent (Crenshaw, 2012).

time-fixed effects, substantially improving causal identification. Lastly, none of these studies investigate whether killing the leader of one organization affects its affiliates[6].

Hence, this paper *primarily* contributes to existing literature by showing that problems of control affect terrorist organizations, and that counterterrorism policies that aggravate these problems of control can increase terrorist violence. This is theoretically relevant as it shows that theoretical models considering terrorist organizations as non-unitary can provide empirically better insights. Empirically, this paper better identifies the causal effect of targeted leader killing, and distinguishes between a comprehensive set of theoretical explanations of this effect. In addition, this paper contributes to the literature on targeted leader killing by investigating its impact not just on the organization that has its leader killed, but also on this organization's affiliates.

This paper contributes to an emerging literature on drone strikes by providing evidence on the medium term (rather than just the short term) impact of drone strikes, and by providing evidence on the impact of drone strikes outside the immediate area where they occur. A small but growing literature addresses the effect of drone strikes on terrorist organizations (Johnston and Sarbahi, 2016; Jaeger and Siddique, 2011; Smith and Walsh, 2013). These papers argue that the week-to-week timing of drone strikes is quasi-random due to factors such as the weather. Consequently, these studies can only investigate the short-term effect of drone strikes (typically the time horizon is less than one month). Finally, these papers only consider the effect of drone strikes on terrorist violence in Pakistan and/or Afghanistan, whereas drone strikes target organizations "of global reach".

The remainder of this paper is organized as follows: section two provides background, section three spells out insights from game theory and derives hypotheses, section four sets out data and methods used, section five provides main results and robustness checks, section six considers evidence for different theoretical explanations of the main results. Section seven concludes.

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[6] An exception is unpublished work by Tominaga (2014), which does not employ a quasi-experimental design.

2 Background

This study focusses on drone strikes in Pakistan[7]. A drone strike is a strike by an Unmanned Aerial Vehicle, an unmanned airplane with both surveillance and strike capability. Up to September 2015, when the Pakistani government acquired armed drones, the US was the only actor conducting drone strikes on Pakistani territory. An estimated 430 confirmed strikes by US drones have taken place in Pakistan from 2004 to date[8]. The Central Intelligence Agency (CIA) conducts these strikes, with the consent of the Pakistani government until this was withdrawn in 2013 (Byrne, 2016). Drone strikes target terrorist leaders, both high and low level, as well as named or anonymous militants. There are no confirmed instances of any conventional airstrikes by the US in Pakistan.

All but a handful of drone strikes have taken place in the Federally Administrated Tribal Areas (FATA), an area of Pakistan which borders Afghanistan. The Pakistani military conducts operations in FATA; there is limited civilian government oversight (Staniland et al., 2018). The region is known as a sanctuary for numerous terrorist organizations, which operate in Pakistan and transnationally. Al-Qaida and the Taliban are the most well-known organizations.

Anecdotal evidence suggests that high-ranking and low-ranking members of these terrorist organizations have different ideas on who should be the target of terrorist attacks, and that leaders cannot fully control their operatives. Intercepted letters from Al-Qaida suggests that its leaders repeatedly admonished subsidiary groups, particularly Al-Qaida in Iraq, to commit less violence against Muslim civilians (Crenshaw, 2012). Similar correspondence from Al-Qaida in Iraq to its subsidiary cells suggests admonishes them to “Stop the killing of people unless they are spying, military or police officers” (Shapiro, 2013). Abrahms and Mierau (2017) provide a detailed case study of how leaders of the Taliban tried but on various

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[7] There have been a substantial number of drone strikes in Afghanistan, Somalia and Yemen. Data on Afghanistan (2015-2017) overlaps insufficiently with data on terrorism. Strikes from Somalia and Yemen are excluded as these virtually exclusively target a single terrorist organization. Given this, country-specific trends cannot be controlled for and could bias the analysis.

[8] https://www.thebureauinvestigates.com/projects/drone-war/pakistan, accessed 17 April 2018.

occasions failed to stop lower level members from perpetrating indiscriminate violence against civilians due to "severe command and control problems within its ranks".

Terrorist organizations in FATA are also prone to splintering. Infighting between three leaders of the Tehrik-i-Taliban Pakistan (TTP) led to a split of the organization in 2009 (Crenshaw, 2012). Pakistani newspaper Dawn regularly reports on the formation of new TTP splinter factions, such as Jamaat Al-Ahrar[9] or Jundullah [10].

There is a fierce and unresolved debate about the number of civilian casualties that drone strikes cause, which is of limited relevance to this paper, since the main analysis uses data on named leaders whose relationship to terrorist groups is not disputed. Obama's chief counterterrorism advisor once claimed that no civilians at all were killed by drones in 2010 (Byman, 2013). A well-cited study put the civilian casualty rate at 32% between 2004-2010, stating that drone accuracy had increased over that time period (Bergen and Tiedemann, 2011, 2010). There are good reasons to doubt these and other claims. There is a tendency on the part of US officials to assume that all military-aged male casualties are militants (Byman, 2013), terrorist groups often cordon off the area of a drone strike and do not allow witnesses that might confirm or deny reports, and Pakistani media commonly publish unsubstantiated and high civilian casualty counts (Taj, 2010).

Regardless of their number, terrorist organizations explicitly refer to drone strikes hitting civilians in their recruitment material. Qualitative analysis of terrorist propaganda suggests that Al-Qaida in the Arab Peninsula refers to drone strikes, not to emphasize 'successful' drone hits on terrorist leaders, but to portray drone strikes as a 'failing' policy, mainly causing civilian deaths (Ludvigsen, 2018).

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[9] Dawn, "TTP commanders form a new spliter group 'Jamatul Ahrar"', 26 August 2014.

[10] Dawn, "TTP claims attack on Rawalpindi Imambargah, three killed", 18 February 2015.

3 Insights from game theory and hypotheses

Four families of game-theoretical models provide hypotheses on how drone strikes killing a terrorist group's leader might affect terrorist attacks, through problems of control, terrorist capacity, backlash and signaling. According to all four of these, it is possible that a drone hit on a terrorist leader is associated with increased terrorist violence. To empirically distinguish between these theoretical mechanisms, I derive a set of auxiliary hypotheses. An overview of these hypothesis can be found in Table 1. For a more comprehensive overview of game theory and terrorism, see Sandler (2011) and Sandler (2015).

3.1 Problems of control within terrorist organizations

Problems of control consist of principal-agent problems, and collective action problems.

Principal-agent models suggest that counterterrorism may aggravate problems of control within the terrorist group, with ambiguous consequences for terrorist violence. Shapiro (2013) models a terrorist group consisting of a leader and an operative, which have different preferences regarding which types of terrorist attack best promote the group's goals. In this model, the leader can communicate his preferred target to the operative or punish an operative that attacks non-preferred targets, but communication or punishment are costly to the leader as these make him more vulnerable to detection by those engaging in counterterrorism. As counterterrorism efforts, and thereby the cost of communication and punishment increase, a high-control equilibrium, in which the leader communicates and the operative attacks the leader's preferred target rather than their own preferred target, becomes harder to sustain. The predicted impact of increasing costs of control on the level of terrorist violence is ambiguous: this depends on the relative preferences of the leader and the operative.

If the operative has a greater preference for violence, this model predicts that increasing the cost of control leads to *more* violence. There are empirical reasons to believe that this is indeed the case for organizations in FATA, particularly for violence against private and civilian targets. The previous section sets out empirical evidence that terrorist leaders in FATA repeatedly admonished lower level members to cease violence against Muslim civilians.

In terms of this model, a drone strike that hits a terrorist leader increases the cost of control more steeply than a drone strike that misses a terrorist leader. It is plausible that the new leader is, at least initially, less capable of exerting control. If the new leader were better than the old leader at exerting control, presumably he would already *be* the leader. Furthermore, counterterrorism agencies plausibly have less information about the new leader, giving the new leader a strategic incentive to keep hidden and not exert control.

Applying Shapiro (2013)'s model to drone strikes in FATA, I derive the following hypotheses. Drone strikes successful in killing terrorist leaders are predicted to lead to a decrease in control by the leader over operatives (H1.1). A decrease in control may be expressed empirically by an increase in terrorist attacks on civilian and private targets, or by an increase in terrorist attacks committed, but not claimed by the organization. This effect is predicted to be stronger for organizations and leaders that rely more strongly on central ties. The first leader of a terrorist organization subject to a drone strike is hypothesized to rely more strongly on central ties than subsequent leaders. Leaders heading a terrorist organization prior to the existence of drone strikes may have already revealed information about themselves that they can no longer hide (e.g. family ties), while subsequent leaders may have greater strategic incentives to hide such information by refraining from exerting control (H1.4).

Other models consider networks of terrorist organizations subject to *collective action problems*, predicting that counterterrorism may lead to the breakdown of networks between terrorist organizations or cells, but to an increase in terrorist violence. Enders and Jindapon (2010) provide such a network model of terrorism. In this model, individual nodes derive utility from the actions of other nodes, if they are connected. A central planner chooses whether nodes are connected or not, individual nodes choose their level of activity. Counterterrorism increases the cost of connectivity, as the exposure of one node risks the exposure of others connected to it. As counterterrorism intensifies, the central planner decreases connectivity. Individual nodes however, no longer able to freeride on the efforts of other nodes they were formerly connected to, increase their level of activity.

From this model, I derive the following hypotheses: drone strikes that succeed to kill a terrorist organization's leader are related to a breakdown of the network structures within and among terrorist organizations (H1.2), as evidenced by increased splintering of that terrorist organization and increased fighting between that organization and others. This model also predicts that a successful drone strike on the leader of one terrorist organization increases terrorist attacks by its (former) affiliates (H1.3).

3.2 Capacity

A drone strike can be considered an example of a proactive counterterrorism policy aiming to eliminate terrorist resources, thereby decreasing the capacity of a terrorist group to commit attacks. In numerous models, proactive policies are assumed to decrease the likelihood of a terrorist attack globally (Sandler and Arce, 2003; Sandler and Siqueira, 2006; Powell, 2007; Bandyopadhyay and Sandler, 2011).

However, if terrorist groups choose between attack types which require several types of resources in different proportions, capacity models can predict an increase in (particular types of) terrorist attacks. If proactive counterterrorism policies disproportionately eliminate one type of resource, terrorist groups may substitute away from attack types that use this resource intensively. If this substitution effect dominates the 'income effect' (fewer terrorist attacks when fewer resources are available), the frequency of terrorist attacks may increase in response to proactive counterterrorism (Enders and Sandler, 2004).

A decrease in one terrorist group's capacity may affect the level of violence its affiliates commit in two ways. A decrease in the parent group's capacity implies there are fewer resources available for any subsidiary groups. On the one hand, this may decrease the amount of violence the affiliate commits both because of an income effect and because the subsidiary is induced to internalize negative effects of terrorist violence committed in their home country on grass-roots support (Siqueira and Sandler, 2006). On the other hand, affiliates may be subject to a similar substitution effect as the parent.

Capacity models provide a further hypothesis. A decrease in terrorist group capacity due to a drone hit on its leader is predicted to lead to a substitution of high-capacity with low-capacity terrorist attacks by that organization itself or its affiliates (H2.1). This could manifest in more 'failed' terrorist attacks, smaller terrorist attacks in terms of number of victims, or substitution of attacks on military targets and US citizens or attacks abroad, with attacks on private and civilian targets or attacks in Pakistan.

3.3 Backlash and recruitment

Proactive terrorism policies may cause 'backlash' if they result in civilian collateral damage, thereby spurring terrorist recruitment. This could occur if terrorist organizations use civilian casualties to foment ideological opposition (Bueno de Mesquita, 2005). Alternatively, Kalyvas (2000) suggests that those facing indiscriminate violence by the hands of one party to a violent conflict, may protect themselves by joining the other. If violence is completely indiscriminate, joining does not pose additional risk, but provides the new recruit with information on when and where such indiscriminate violence might occur. A fully informed government may still wish to engage in counterterrorism creating backlash, if it trades off an increase in future attacks for a decrease in current attacks (Jacobson and Kaplan, 2007) or if it does not fully internalize the global costs of proactive counterterrorism because this increases recruitment, but displaces terrorist attacks to softer foreign targets (Rosendorff and Sandler, 2004).

Backlash need not remain limited to the terrorist organization subject to pro-active terrorism policies, but may extend to its affiliates. Siqueira and Sandler (2007) provide a model in which pro-active counterterrorism measures against one terrorist group, triggers reprisal attacks by other groups.

Game-theoretical models considering backlash predict that drone strikes that hit civilians, may lead to increased terrorist attacks, both by the terrorist organization that was the target of the drone strike and its affiliates (H3.1).

3.4 Signaling

A drone strike that hits a terrorist leader may introduce uncertainty about a terrorist group's ability or resolve to continue terrorist attacks, which in turn may give terrorist groups an incentive to commit more or larger attacks in the periods after the drone strike by way of a signal. Signaling models are multi-period models in which a government must decide whether to make concessions to a terrorist group at the end of the first period but is uncertain about the resolve or resources commanded by the terrorist group. Weak (and in some models strong) groups have an incentive to commit more or larger terrorist attacks in the first period, in an attempt to convince the government of their strength or resolve and induce concessions from government (Arce and Sandler, 2007; Overgaard, 1994; Lapan and Sandler, 1993).

To the extent that a drone strike killing the leader of one terrorist group casts doubt on the resolve or capacity of its affiliate groups, affiliate groups may similarly engage in signaling. Alternatively, affiliate groups may want to signal strength to their parent group, or to a population of recruits.

Signaling models thus hypothesize that a drone strike hitting a terrorist leader leads to an increase in terrorist attacks that send a strong signal (H4.1). The strongest signal arguably consists of terrorist attacks which immediately follow the drone strike hitting a terrorist leader, which hit a 'hard' target, such as a military target or a US citizen, and which are claimed by the terrorist organization. Affiliates of the terrorist organization subject to the drone strike may also send such signals (H4.2). Furthermore, we might hypothesize that these effects are stronger for more prominent leaders (H4.3): the more prominent the leader

Table 1: Hypotheses

	Hypothesis: Drone strikes killing a terrorist organization's leader are related to...	Evidence
	1. Problems of Control	
H1.1	... a **decrease in control** by the leader over operatives, as evidenced by:	
	(a) an increase in attacks by the organization on private and civilian targets;	(a) Yes
	(b) an increase in attacks by the organization's operatives that the organization does not claim.	(b) Yes
H1.2	... a **weakening of the network structure** within and among terrorist organizations, as evidence by:	
	(a) an increase in violence between the terrorist organization and other terrorist organizations;	(a) Yes
	(b) an increase in the probability of splintering of the terrorist organization.	(b) Yes
H1.3	... an **increase in attacks by affiliates** of the terrorist organization.	Yes
H1.4	... a **stronger increase in terrorist attacks** for:	
	(a) terrorist organizations relying more strongly on central ties;	(a) Yes
	(b) the first leader of the organization struck.	(b) Some
	2. Capacity	
H1.2	... a **substitution** by the terrorist organization, or by its affiliates, of high-capacity attacks with low-capacity attacks, specifically:	
	(a) a decrease in the probability of a successful attack;	(a) No
	(b) a decrease in the number of victims per attack;	(b) No
	(c) substitution of attacks on military targets and US civilians with attacks on private and civilian targets;	(c) No
	(d) substitution of attacks in Afghanistan and other locations outside Pakistan with attacks in Pakistan.	(d) No
	3. Backlash	
H3.1	Drone strikes targeting a terrorist organization, yet causing **civilian casualties**, are related to an increase in attacks by that terrorist organization, or by its affiliates.	No
	4. Signaling	
H4.1	... an increase in attacks by the terrorist organization that **send a strong signal**, specifically:	
	(a) attacks taking place shortly after the drone strike;	(a) No
	(b) attacks on military targets;	(b) No
	(c) attacks on US targets;	(c) No
	(d) attacks by that terrorist organization that the organization claims.	(d) Yes
H4.2	... an **increase in attacks by affiliates** of the terrorist organization as in H4.1.	Yes
H4.3	... a **stronger increase** in terrorist attacks by the organization for **more prominent leaders**.	No

killed by drone, the stronger the signal required to convince others of the organization's resolve.

4 Data and methods

4.1 Data

This paper uses a newly constructed panel dataset of successful and failed targeted leader killings, capturing variation across terrorist groups and over time. The unit of observation is the group-month. Various cross-checks have been carried out to make this dataset arguably less subject to reporting bias compared to relying on a single data source. Balance checks substantiate the assertion that drone hits and misses are quasi-random. This dataset is supplemented by coding additional information on the importance of a leader within the terrorist group and on affiliates of these terrorist groups.

4.1.1 Drone strikes

To construct a dataset of successful and failed targeted killings of terrorist leaders, I code 443 narratives about individual drone strikes between 2004-2015 collated by the Bureau of Investigative Journalism (BIJ)[11], and cross-check these with data from the New America Foundation (NAF)[12] and information on terrorist leaders from the Mapping Militants Project at Stanford University (Crenshaw, 2012). For each drone strike reported by the BIJ, I code whether a terrorist leader was targeted and whether this leader in fact died. The terrorist group(s) the drone strike targeted is also recorded. For full coding rules, see the Appendix section A.2.

The resulting data on terrorist leaders was cross-checked with data from the NAF. This organization also provides information on terrorist leaders targeted (but not killed) and

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[11] https://www.thebureauinvestigates.com/stories/2017-01-01/drone-wars-the-full-data

[12] https://www.newamerica.org/in-depth/americas-counterterrorism-wars/pakistan/

killed, which is used by previous studies (e.g. Abrahms and Potter (2015); Johnston (2012); Abrahms and Mierau (2017); Jaeger and Siddique (2011). This data has substantial downsides. The NAF for unknown reasons does not report missed strikes on leaders between 2012-2015 and is extremely broad-brushed when classifying terrorist groups. For example, the Afghan Taliban, local (Pakistani) Taliban, Tehrik-i-Taliban Pakistan (TTP) and the Punjabi Taliban are all coded as 'Taliban'. This forces authors using NAF leaders data to consider all groups targeted as a single unit and truncate the data in 2011 (Abrahms and Mierau, 2017), creating a single short time series. By contrast, coding BIJ narratives results in information on thirteen different terrorist groups, forming a panel dataset covering a longer period. An overview of these thirteen groups can be found in the Appendix section A.1.

Cross-checking data between the BIJ and the NAF gives insight in how information from single data sources might be biased. Although both BIJ and NAF are nonpartisan and construct their data on the basis of (more often than not the same) reputable news sources, when reading between the lines, the NAF appears to have a more positive outlook on use of drones than the BIJ. This gives the NAF a stronger tendency to portray those killed by a drone strike as a leader. I cross-check 48 named individuals the NAF classifies as 'leaders killed'. Deaths of all but one of these individuals are also found in the BIJ data, within two days of the NAF-recorded data. However, the BIJ does not always classify these individuals as 'leaders'.

To mitigate bias in the interpretation of who is a leader, I cross-check data coded with leaders mentioned by the Stanford Mapping Militants project. If US counterterrorism agencies have an incentive to inflate the importance of individuals once they are struck by a drone, this affects both NAF and BIJ data, arguably more strongly than the Stanford data. NAF and BIJ primarily rely on (the same) reports about the drone strike itself, whereas the Stanford data is based on reports independent of drone strikes. Indeed, only about one third (45 out of 139) of those individuals recorded as 'leaders' by the BIJ is recognized as such by the Mapping Militants Project. In the preferred specification, only leaders who are considered as such by the Stanford project are included, although results using alternative definitions are presented as a robustness check.

Note also that it is the rule rather than the exception for the death of a leader, especially those leaders recognized by the Stanford project, to be confirmed by *both* sources in the US government and the terrorist organization. Terrorist organizations commonly publish statements about the death of their leader, put out eulogies, or place online pictures of his funeral. This does not hold for those marked as 'leaders' by the NAF or BIJ only, who are sometimes only identified by some less-than-unique nickname.

Resulting data illustrates the prevalence of targeted leader killing as a counterterrorism policy: of the 59 leaders identified by the Stanford project, over one third have been targeted at least once. The final dataset includes 45 attempts on terrorist leaders, fifteen of which succeeded in killing the target. Ten leaders were both missed and hit (see Appendix section A.3 for details).

The identification strategy of this paper relies on the quasi-randomness of hits and misses: indeed, there is virtually no evidence that there is a pattern to hits and misses. Table 2 displays results from regressing a wide set of variables on an indicator for hit. Results indicate that the probability of a hit is not driven by prior drone activity, Pakistani military action or peace agreements between the terrorist groups and the Pakistani government, all of which could reveal information about terrorist leaders and make a hit more likely. Table 2 also finds no evidence that the probability of a hit is statistically significantly different when Pakistani military action or a peace agreement might be anticipated. The probability of a hit does not significantly differ by importance of the leader, number of leaders involved, district, target type or terrorist group. Hits do not cause a significantly higher or lower number of (civilian) casualties. There is some evidence that terrorist groups are less likely to be the target of a drone strike after a drone hit on their leaders (results are only marginally statistically significant). Therefore, a robustness check will control for drone strikes not

Table 2: Balance tests

	control mean	hit	p-value
Strikes in previous 6 mths	4.8667	0.2000	0.87
'Hits' in previous 6 mths	0.2000	0.0667	0.62
'Misses' in previous 6 mths	0.3333	0.0000	1.00
Pak. military action in previous 6 mths	0.3333	-0.1333	0.36
# Pak. military action days in previous 6 mths	3.3667	-1.2333	0.44
Peace agreement in force previous 6 mths	0.4667	-0.0667	0.68
Peace agreement start previous 6 mths	0.2667	-0.1333	0.32
Peace agreement end previous 6 mths	0.1333	0.0000	1.00
Strikes in next 6 mths	5.1000	-1.7667	0.10*
'Misses' in next 6 mths	0.2667	-0.0667	0.63
'Hits' in next 6 mths	0.2000	0.0667	0.69
Pak. military action in next 6 mths	0.3667	-0.2333	0.11
# Pak. military action days in next 6 mths	3.5667	-2.3667	0.10
Peace agreement in force next 6 mths	0.5000	-0.2333	0.14
Peace agreement start next 6 mths	0.1000	-0.1000	0.21
Peace agreement end next 6 mths	0.1000	-0.1000	0.21
Year	2,010	2.2333	0.00***
Leader reward (M$)	2.4333	-0.9667	0.57
First in command	0.3000	-0.1667	0.23
Total casualties - low est.	12.9667	-7.3667	0.15
Total casualties - high est.	18.1667	-7.9667	0.19
Civilian casualties - low est.	4.6333	-3.7000	0.35
Civilian casualties - high est.	7.4667	-5.0667	0.31
Child casualties - low est.	3.2667	-2.7333	0.41
Child casualties - high est.	3.4667	-2.9333	0.39
Injuries - low est.	3.8333	-1.5000	0.40
Injuries - high est.	5.9333	-2.2000	0.33
Number leaders involved	1.0333	-0.0333	0.49
area==Bajaur Agency	0.1000	-0.1000	0.21
area==Khyber Agency	0.0000	0.0667	0.16
area==Khyber Pakhtunkhwa province	0.0000	0.0667	0.16
area==North Waziristan	0.6000	0.0667	0.67
area==Orakzai Agency	0.0333	-0.0333	0.49
area==South Waziristan	0.2667	-0.0667	0.63
targettype==Vehicle	0.1333	-0.1333	0.14
targettype==Building	0.5667	-0.1000	0.54
targettype==Both	0.1333	0.1333	0.28
groupid==Al-Qaida	0.2667	0.1333	0.37
groupid==Harkatul Jihad-e-Islami	0.1333	-0.0667	0.51
groupid==Haqqani Network	0.1333	0.0667	0.57
groupid==Taliban	0.0333	0.0333	0.62
groupid==Tehrik-i-Taliban Pakistan	0.4333	-0.1667	0.29

targeting leaders. There is strong evidence that the probability of a hit increased over time. This highlights the importance of including time-fixed effects, which will be included in all specifications.

Anecdotally, drone misses seem to be mostly driven by chance. They fall into three broad categories: drone strikes hitting locations or meetings where the targeted leader is not yet or no longer present, instances where the targeted leader has been merely wounded and instances when reports of a leader's death are credible enough to be taken up by reputable news sources only for the leader to later show up alive. To mitigate concerns that misses are underreported, results using an alternative definition of a 'miss' will be presented as a robustness check.

I supplement the dataset of terrorist leaders with information on the importance of a leader within a terrorist group. Two metrics are used. First, an indicator equalling one if the Stanford Mapping Militants Project indicates an individual was ever 'first in command' or similar of a terrorist group. Secondly, the maximum reward amount offered for information on a terrorist leader by the US Department of State's Reward for Justice Programme.

4.1.2 Terrorist violence, affiliated terrorist groups and other data

Data on drone strikes targeting the thirteen terrorist groups present in the BIJ data is linked to data on terrorist attacks by these groups from the Global Terrorism Database (GTD). If there are multiple sensible ways to aggregate groups, I present robustness checks using these alternative aggregations.

The main dataset is restricted to the thirteen groups subject to drone strikes, because the identification strategy in this paper hinges on comparing groups that had their leader hit and missed at different times. Including terrorist groups not subject to drone strikes in the sample does not contribute to the identification of the coefficients of interest, but does artificially inflate the sample size and introduces needless heteroskedasticity. The Appendix section B.3 illustrates that, unsurprisingly, including all terrorist groups that committed

Table 3: Descriptive statistics

	count	mean	sd	min	max
Number of terrorist attacks	1733	5.066359	15.59163	0	175
Unclaimed attacks	1733	2.632429	7.836554	0	75
Claimed attacks	1733	2.383151	8.416812	0	109
% successful attacks	1733	.2776709	.4352409	0	1
Attack in Pakistan	1733	.8072706	3.155664	0	31
Attack in Afghanistan	1733	3.174841	14.64073	0	175
Attack in rest of the world	1733	1.079631	5.432294	0	73
Mean # victims per attack.	1733	1.442927	5.858005	0	139
Attack on private target	1733	1.577034	4.837961	0	47
Attack on civilian target	1733	5.057703	15.56407	0	175
Attack on military target	1733	2.493941	9.398454	0	126
Attack with US victim	1733	.06809	.3579882	0	5
Pakistani military action	1304	.0858896	.2803084	0	1
Peace agreement in force	1304	.2062883	.4047952	0	1
Attack by affiliate	1733	22.60358	50.78005	0	423
Splintering	1733	.0155799	.1238791	0	1
Infighting between terrorist groups	1733	.0230814	.2267818	0	5

more than one attack in Afghanistan or Pakistan in the sample does not affect the main results.

Data on peace agreements between the Pakistani government and terrorist groups and Pakistani military action against particular terrorist groups up to March 2013 was collected by Staniland et al. (2018).

To investigate the impact of the death of a group's leader on the behaviour of affiliated terrorist groups, I code new data on the affiliations of the thirteen terrorist groups. First, I record all affiliations, alliances, mergers, rivalries and splits involving the thirteen terrorist groups identified by Crenshaw (2012), and locate the terrorist groups involved in the GTD. For the purpose of this paper, any terrorist group that was ever affiliated, allied or merged with one of the thirteen groups is considered an affiliate. These affiliates are typically terrorist organizations committing large numbers of terrorist attacks (median 102) outside Afghanistan or Pakistan. Figure 1 shows the distribution of affiliates for those terrorist organizations coded as having any. Al-Qaida has the most affiliations, both in terms of the number of affiliates and the number of attacks they commit, although most other terrorist organizations included in the dataset have substantial affiliations as well. Second, I identify all terrorist groups (other than the included thirteen) in the GTD that ever committed a terrorist attack in Afghanistan or Pakistan. Using a web search, I code these as having an affiliation to one or more of the thirteen terrorist groups in the drone strike dataset, or as unaffiliated (see Appendix section A.4 for details). These groups have typically committed a small number of terrorist attacks (median 2). Anecdotally, these groups are often splinter groups of the main terrorist groups. The first attack by such a terrorist group recorded by GTD is taken as a proxy for splintering.

Figure 1: Distribution of affiliates by terrorist organization

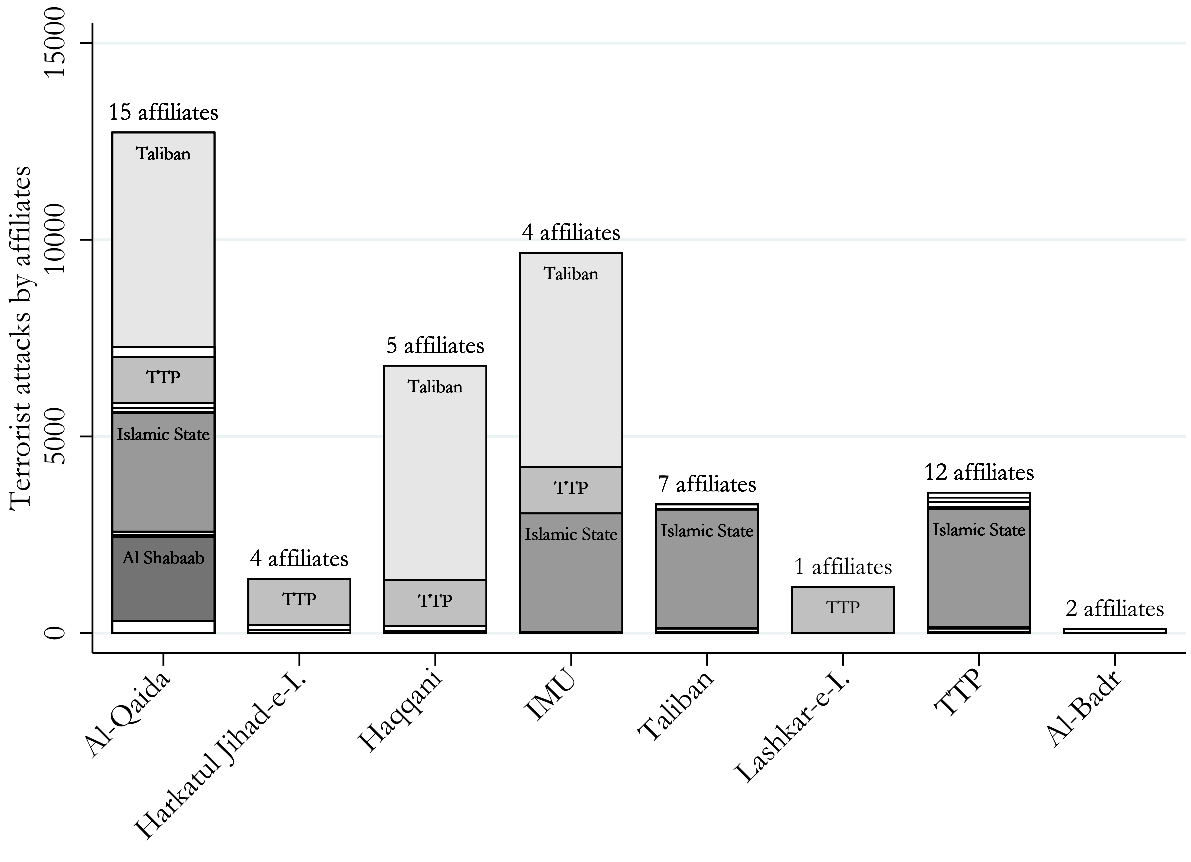

Table 3 provides descriptive statistics for the main outcome variables of interest at the group-month level.

4.2 Empirical strategy

The main specification of interest is the following:

$$Y_{it} = \sum_{k=-6}^{6} \beta_{i,t-k} hit_{i,t-k} + \sum_{k=-6}^{6} \delta_{i,t-k} attempt_{i,t-k} + \mu_i + \theta_t + \epsilon_{it} \tag{1}$$

where subscript t indicates a month and subscript i a terrorist group. Y_{it} is the outcome variable of interest, most commonly a count of the number of terrorist attacks. *attempt* is an indicator equalling one if a group's leader was targeted by a drone strike, and *hit* equals one if the leader was targeted by drone and died. μ_i and θ_t are vectors of group and month-fixed effects respectively. Standard errors are Newey-West standard errors with bandwidth twelve, although the Appendix section B.3 investigates the robustness of results to using different standard errors and bootstrapping test statistics using randomization inference. Specification 1 is estimated using an Ordinary Least Squares model, although the Appendix section B.3 also presents alternative results using a negative binomial model.

The individual coefficients on the lags of *hit* – and the F-statistic for their joint significance – are the main coefficients of interest. These reflect the effect of a drone hit on a terrorist leader, compared to a drone miss. The coefficients on the lags of *attempt* reflect the effect of a drone miss.[13]

To credibly identify the causal impact of targeted leader killing, the probability of a hit must not be driven by prior trends in the outcome variable. This would for example be the

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[13] To see this, note that the coefficients on *attempt* in specification 1 are identical to the coefficients on *miss*, an indicator equalling one if a terrorist group's leader was targeted by drone but did not die, in the following specification:

$$Y_{it} = \sum_{k=-6}^{6} \beta_{i,t-k} hit_{i,t-k} + \sum_{k=-6}^{6} \delta_{i,t-k} miss_{i,t-k} + \mu_i + \theta_t + \epsilon_{it}$$

case if counterterrorist organizations would accept a higher or lower probability of a hit for terrorist groups that commit an increasing number of terrorist attacks. To verify the parallel trends assumption, each specification includes six leads of *attempt* and *hit*, in addition to six lags. If the coefficients on the leads of *hit* are statistically significant, this provides evidence that the parallel trends assumption has been violated. F-statistics for the joint significance of leads of *hit* will be provided for all regressions.

To estimate the effect of killing a group's leader on attacks by affiliated terrorist groups, I employ the following specification:

$$Y_{jit} = \sum_{k=-6}^{6} \beta_{i,t-k} hit_{i,t-k} + \sum_{k=-6}^{6} \delta_{i,t-k} attempt_{i,t-k} + \sum_{k=-6}^{6} \rho_{j,t-k} hit_{i,t-k} + \sum_{k=-6}^{6} \phi_{j,t-k} attempt_{j,t-k} + \mu_j + \theta_t + \epsilon_{jit} \tag{2}$$

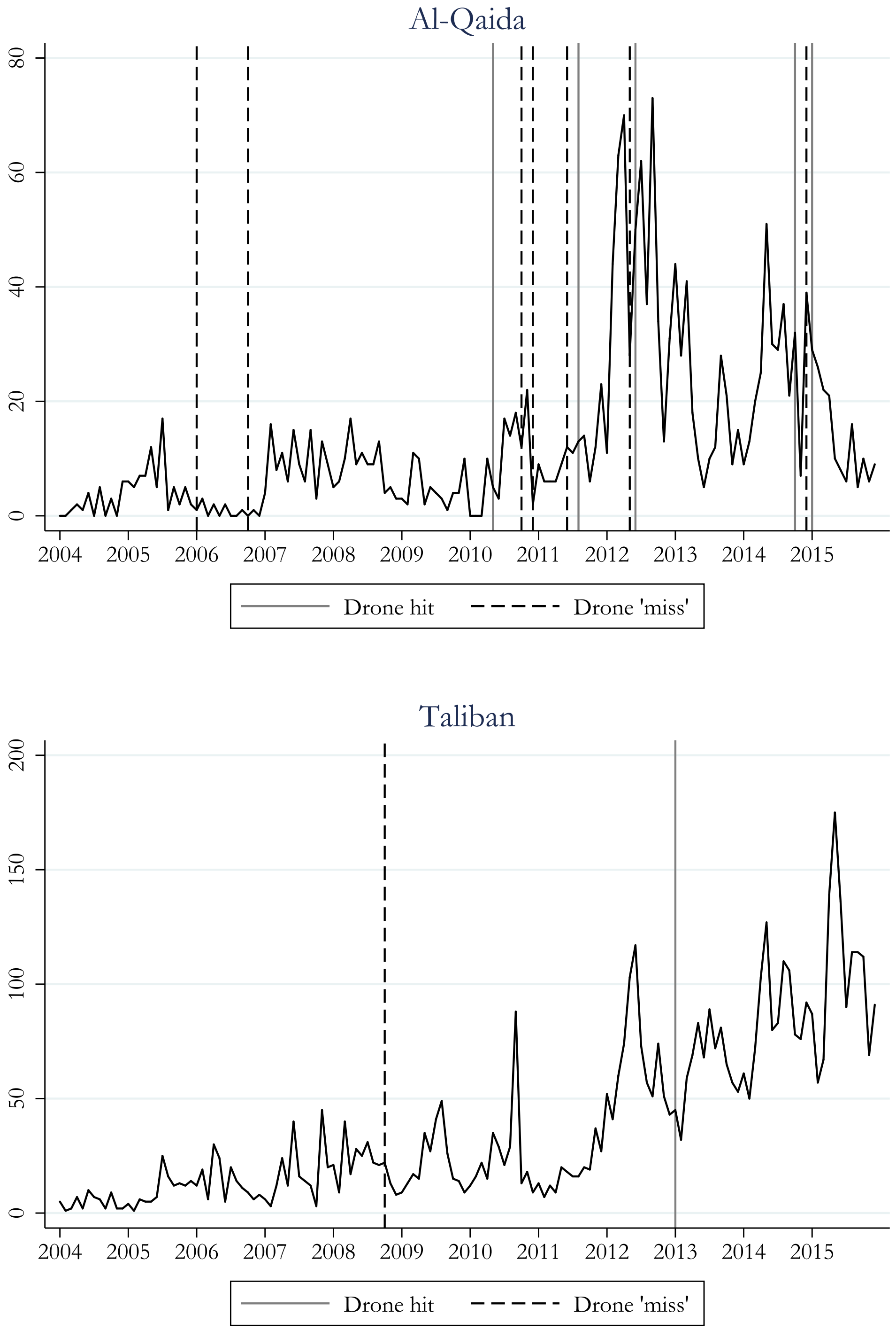
where Y_{jit} represents terrorist attacks perpetrated by group j affiliated to parent group i. The coefficients of interest are the coefficients on the lags of hit_i, which represent the effect of a drone hit (compared to a miss) on the parent group on violence perpetrated by the affiliate. As some groups are both parent groups and affiliate, this specification controls for drone misses and hits on the leaders of the affiliate groups. Inclusion of affiliate-group fixed effects (μ_j), makes including parent-group fixed effects redundant.

5 Results

5.1 Descriptive results

As a first pass, Figure 2 shows the number of terrorist attacks over time committed by the Taliban and Al-Qaida respectively, and the timing of drone hits and misses on its leaders. For both groups, but particularly for Al-Qaida, we can see that the number of terrorist attacks peaks strongly after a drone hit on a leader, whereas no such trend can be observed after a drone miss. To save space, equivalent figures for other terrorist groups with at least one drone hit and drone miss are relegated to the Appendix section B.1. For these groups,

Figure 2: Descriptive relationship for Al-Qaida and the Taliban



eyeballing the raw data does not reveal a similar difference in trends when comparing a drone hit and a drone miss.

5.2 Main results

Main results suggest that the number of attacks committed by a terrorist group *increases* in the six months after a drone strike hits one of its leaders, whereas no change in terrorist violence can be detected after a strike that targets but misses a leader.

Figure 3 displays the results from specification 1. These results are also reproduced in Table 5, column 1. It displays the coefficient estimates and 95% confidence intervals for six leads and lags of the variables *hit* (left panel) and *attempt* (right panel). It also displays a quadratic trend for the six lags of *hit* and its 95% confidence interval. Recall that coefficients on the lags of *hit* reflect the effect of a drone hit compared to a miss, that coefficients on *attempt* reflect the effect of a miss, and that group and period fixed effects are included in this specification.

Results suggest that the number of terrorist attacks increases after a leader has been hit, compared to when he has been missed. There is no evidence that the trend in the number of terrorist attacks was already different prior to a hit, compared to prior to a miss: coefficient estimates on leads of *hit* (indicated by $t - k$) are individually and jointly insignificant. However, there is an increase in the number of terrorist attacks after a drone hit compared to after a miss. This increase is statistically significant at the 5% level for the third and sixth lag of *hit* and the coefficients on all lags of *hit* (indicated by $t + k$) are jointly statistically significant at the 5% level. The increase in the number of terrorist attacks is substantial: the sum of coefficients on the lags suggest that a drone hit on a terrorist group leader is associated with an additional 29 terrorist attacks globally by this group over a period of six months, over an average 67 attacks in the six months after a miss.

The right panel of Figure 3 suggests that drone strikes that target but miss a leader have no statistically significant effect on the number of terrorist attacks over the next half year. Coefficients on all leads and lags of *attempt* are individually and jointly insignificant.

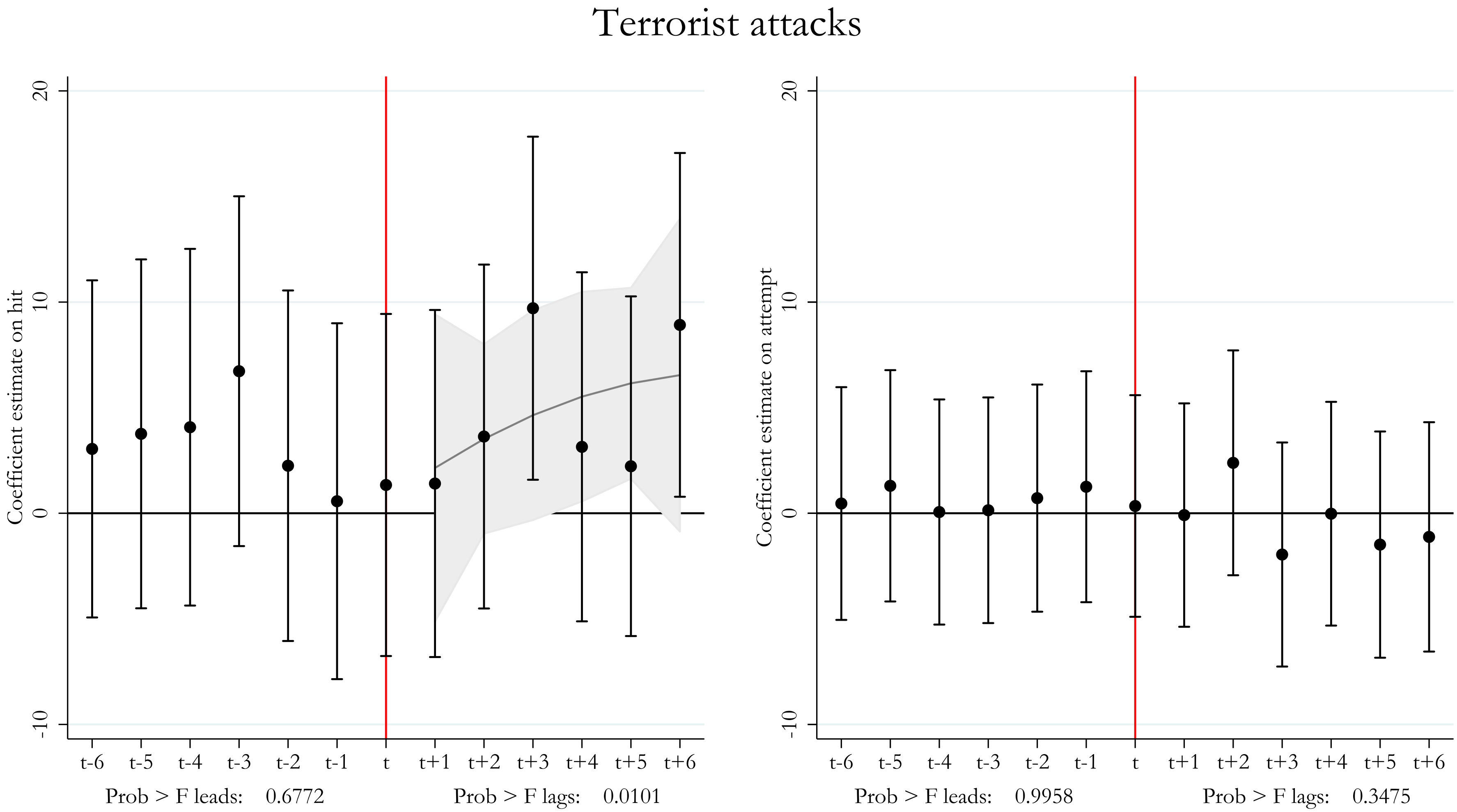


Figure 3: Main results

5.3 Timing of attacks

The main results presented would not necessarily imply an increase in terrorist attacks overall, if terrorist groups were merely changing the timing of already planned attacks after a drone strike has hit their leader, so that attacks are concentrated in the six months after the strike. I find no evidence that this is the case.

Results suggest that the effect of a hit on a terrorist leader on terrorist attacks persists for approximately nine months, after which it tapers off. Figure 4, which displays coefficients on *hit* and a quadratic trend obtained when including nine leads and lags of *hit* and *attempt* in specification 1, illustrates this.

Figure 4: Main results – 9 leads and lags

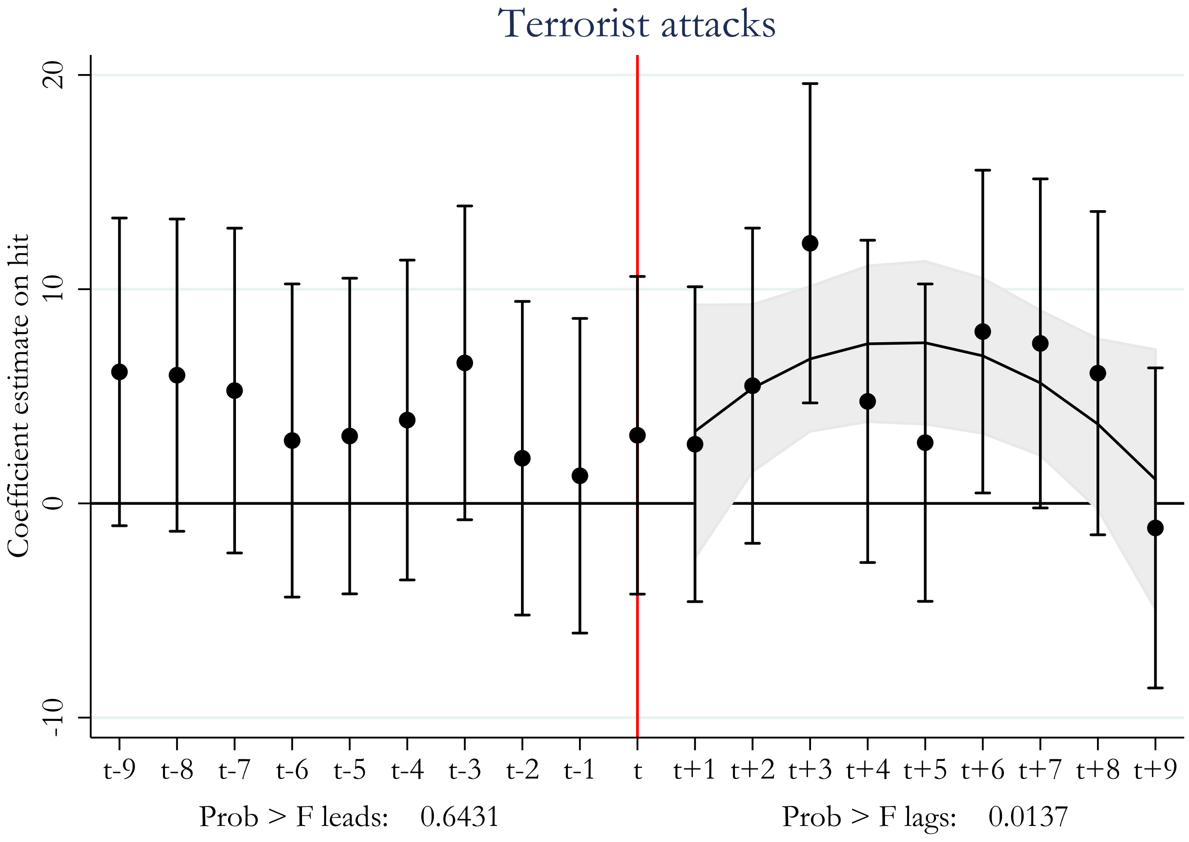
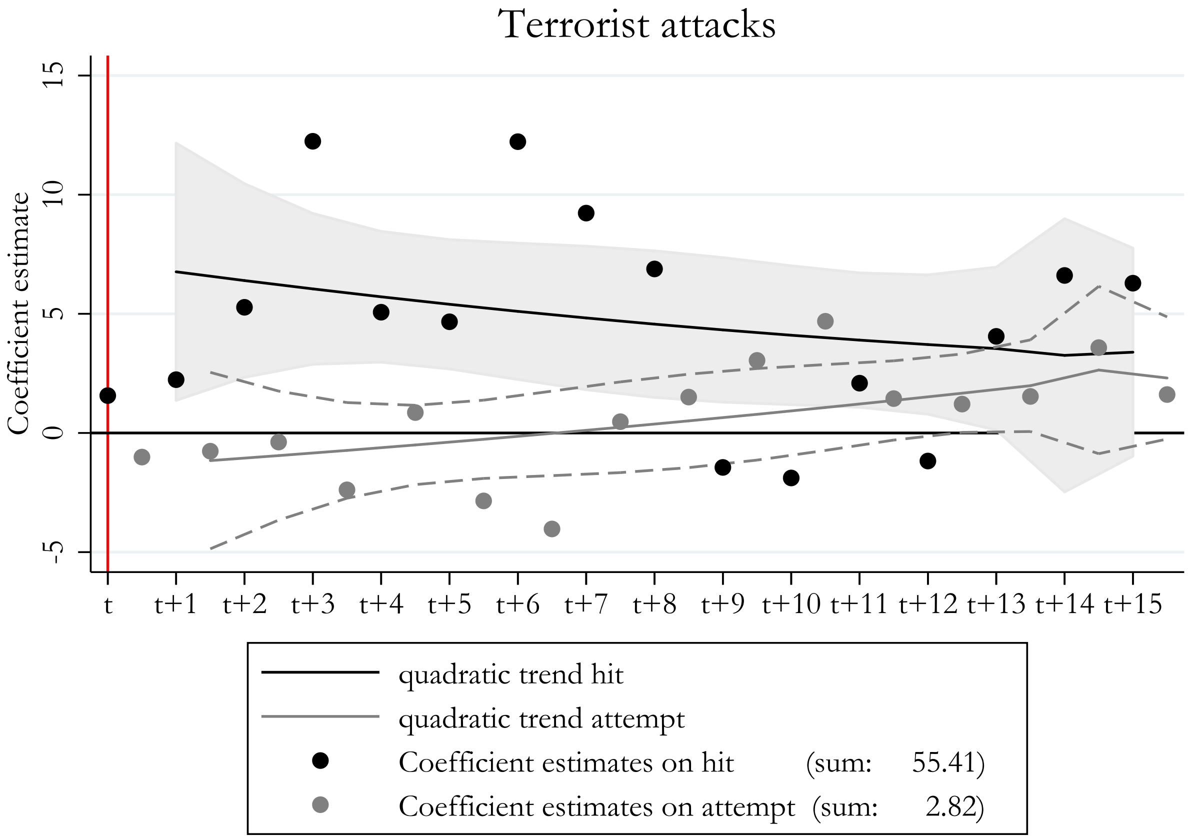


Figure 5: Timing of terrorist attacks



However, there is no evidence that the total number of terrorist attacks after a miss 'catches up' with total attacks after a hit. Figure 5 displays results from specification 1, including fifteen leads and lags. For readability, only the coefficients on the lags of *hit* and *attempt* are displayed, in addition to a quadratic trend and its 95% confidence interval. Trends in the number of terrorist attacks do converge, but there is no statistically significant decline in the number of terrorist attacks in month nine to fifteen after a hit, as we might expect if terrorist attacks planned for this period were committed earlier in response to a drone hit on a leader. There is also no statistically significant increase in the number of terrorist attacks in the fifteen months after a miss. The extended model still predicts 55 additional terrorist attacks in the fifteen months after a hit compared to only 3 additional

Table 4: Duration in days to first terrorist attack

VARIABLES	(1) OLS First terrorist attack	(2) cox First terrorist attack	(3) OLS First claimed attack	(4) cox First claimed attack	(5) OLS First unclaimed attack	(6) cox First unclaimed attack
hit	-13.15	-0.0505	-41.56	0.354	22.10	0.318
	(36.19)	(0.283)	(32.45)	(0.314)	(29.67)	(0.248)
Constant	61.78***		99.14***		20.40	
	(12.34)		(11.06)		(10.65)	
Observations	44	44	44	44	39	39
R-squared	0.003		0.029		0.058	
Number of groups	5		5		4	
Group FE	YES	NO	YES	NO	YES	NO
Stratified on group	NO	YES	NO	YES	NO	YES

Clustered (group) standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

attacks after a miss. The fifteen lags of *hit* are jointly statistically significant at the 5% level, the lags of *attempt* are not.

Table 4 investigates the duration in days from a drone strike targeting a leader of a terrorist group, to the first terrorist attack committed by this group. There is no statistically significant difference in the duration to the first attack comparing a drone hit to a drone miss. If the timing of the first terrorist attack after the drone strike is sped up, this effect is small: point estimates suggest the first attack occurs about 13 days earlier after a hit compared to after a miss (column 1). The Cox hazard model presented in column 2 similarly suggests that the hazard of a first attack occurring is not significantly higher after a drone hit compared to after a drone miss. If the timing of first terrorist attack is sped up after a drone hit, this effect is too small to account for the main results.

5.4 Robustness

Main results are robust to including leader-fixed effects, including several control variables, varying the number of leads and lags, estimating the F-statistic for the joint significance of lags of *hit* through randomization inference, expanding the sample beyond the thirteen included groups, and using a series of alternative econometric specifications. Similar, but somewhat weaker results are also obtained when employing an alternative definition of 'leader'. Main results are sensitive to varying which Al-Qaida branches are considered part of Al-Qaida, but not to other alternative treatments of terrorist groups.

Table 5 investigates the robustness of the main results, which are reproduced in column 1. Controlling for six leads and six lags of the number of drone strikes other than those hitting or missing a terrorist leader does not meaningfully affect the main results (column 2). Results are furthermore robust to including leader-fixed effects (column 3).

Column 4 and column 5 control for six leads and lags of an indicator for Pakistani military action against a terrorist group and the existence of a peace agreement between the terrorist group and the Pakistani government. This strengthens the main results: coefficients on more individual lags of *hit* are statistically significant, and coefficients on lags are jointly statistically significant at the 1% level. Worryingly, the leads of *hit* are now also jointly statistically significant in column 4, raising concerns that the parallel trends assumption may be violated. However, including these controls leads to a substantial number of observations being dropped, including almost half the observations with a drone hit. This makes estimates quite sensitive to outliers. Indeed, restricting the research period without adding additional control variables suggest that the leads of *hit* gaining joint statistical significance is an artefact of restricting the period under investigation, not controlling for Pakistani military action.

Table 5: Robustness of main results

VARIABLES	(1) Baseline Terr.att.	(2) Drone Strike 6L&Ls Terr.att.	(3) Baseline Terr.att.	(4) Pak. mil action 6L&Ls Terr.att.	(5) Peace agreem. 6L&Ls Terr.att.	(6) Alt. aggreg. AQ Terr.att.	(7) Alt. aggreg. TTP Terr.att.	(8) Alt. leader. coding Terr.att.
t	1.339	1.833	0.759	4.528	10.88**	-1.332	1.042	3.103
	(4.129)	(4.161)	(4.802)	(3.784)	(5.037)	(3.915)	(4.208)	(2.702)
t+1	1.409	1.679	3.383	7.071*	15.16***	0.0507	1.510	2.840
	(4.189)	(4.246)	(4.354)	(3.803)	(5.079)	(3.974)	(4.269)	(2.723)
t+2	3.634	3.611	4.934	3.716	6.845	0.654	3.866	4.971*
	(4.151)	(4.181)	(4.468)	(3.964)	(5.040)	(3.935)	(4.230)	(2.745)
t+3	9.709**	9.111**	10.43**	16.37***	20.65***	4.430	9.554**	5.635**
	(4.141)	(4.171)	(4.319)	(3.940)	(5.054)	(3.926)	(4.211)	(2.711)
t+4	3.146	2.685	2.336	0.679	1.773	1.699	3.019	2.088
	(4.213)	(4.259)	(4.305)	(4.216)	(5.567)	(3.996)	(4.289)	(2.743)
t+5	2.228	2.561	1.695	6.147	5.841	1.577	1.784	3.626
	(4.100)	(4.150)	(4.315)	(3.865)	(5.126)	(3.887)	(4.214)	(2.757)
t+6	8.921**	8.819**	8.459**	10.54***	16.13***	3.188	8.542**	3.300
	(4.149)	(4.177)	(4.242)	(4.046)	(5.329)	(3.929)	(4.265)	(2.820)
Observations	1,577	1,577	1,577	1,148	1,148	1,577	1,492	1,577
R-squared	0.556	0.560	0.564	0.560	0.607	0.556	0.558	0.560
Group FE	YES	YES	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES	YES	YES
Leader FE	NO	NO	YES	NO	NO	NO	NO	NO
Prob > F lags hit	0.0101	0.0207	0.0138	0.0000	0.0000	0.7044	0.0168	0.3604
Prob > F leads hit	0.6772	0.6031	0.6612	0.0011	0.1929	0.9443	0.6460	0.7584
Prob > F lags attempt	0.3475	0.1981	0.2756	0.2635	0.1554	0.4643	0.4739	0.8709
Prob > F leads attempt	0.9958	0.9572	0.8479	0.1001	0.0237	0.9491	0.9886	0.9583
Control mean	11.0792	11.0792	11.0792	11.0792	11.0792	5.4158	11.0792	8.8261

Newey-West standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

The next columns of Table 5 investigate the sensitivity of main results to alternative ways of aggregating terrorist groups. The dependent variable for Al-Qaida in the baseline specification is an aggregation of terrorist attacks by all Al-Qaida branches[14]. I argue that this is the most appropriate set-up to analyse Al-Qaida terrorist attacks for several reasons. First, leaders of these branches are at times present in FATA. Leaders of Al-Qaida in Iraq, Al-Qaida in the Arab Peninsula and Al-Qaida in the Indian Subcontinent are named by the BIJ. Second, Al-Qaida leaders based in FATA at least attempt to exert control over the activities of its branches (see section 2). Third, reducing attacks by branches is likely a motivation for drone strikes in FATA. Otherwise, Al-Qaida being the target of over 25% of drone strikes in FATA seems out of proportion with only 30 (0.34% – none of which in 'Western' countries) terrorist attacks in the sample committed by Al-Qaida proper. Nevertheless, column 6 presents results obtained if only attacks by Al-Qaida proper and Al-Qaida in the Indian Subcontinent are 'counted' as Al-Qaida terrorist attacks. Main results are clearly sensitive to this alternative treatment of Al-Qaida branches. The reader unconvinced by the arguments above may have to conclude that drone strikes on a terrorist group's leader do not affect the number terrorist attacks this group commits. However, considering Al-Qaida branches as independent organizations affiliated to Al-Qaida only strengthens the results obtained in section 6.3 indicating that drone strikes hitting a terrorist group's leader increase the number of terrorist attacks committed by this group's affiliates.

Main results are robust to recoding 'local Taliban' as TTP from December 2007 onwards. GTD appears to code all terrorist attacks by the Taliban in Pakistan after this date as committed by TTP, whereas the BIJ distinguishes the TTP from the 'local Taliban'. This recoding does not affect the main results (column 7).

Lastly, column 8 presents results when using an alternative coding rule for who constitutes a terrorist leader. Under this alternative rule, all individuals marked by the BIJ

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[14] These are: Al-Qaeda (30 terrorist attacks over the period under investigation); Al-Qaeda in Iraq (637); Al-Qaeda in Saudi Arabia (1); Al-Qaeda in Yemen (12); Al-Qaeda in the Arab Peninsula (907); Al-Qaeda in the Indian Subcontinent (14); Al-Qaeda in the Islamic Maghreb (248).

as 'leader', 'commander', 'senior figure' or similar are considered leaders. This coding rule plausibly considers as drone hits, strikes on some individuals whose status as leader was exaggerated in the media after they have been hit. Despite this, the second and third lag of *hit* remain individually statistically significant, although coefficients on *hit* are no longer jointly statistically significant. Although the observed effect is somewhat weakened, which may be unsurprising if the alternative coding rule counts as 'hits' strikes on some individuals who may in reality not have a leading role within the terrorist organization, we can still observe an increase in the number of terrorist attacks after a drone hit.

The Appendix section B.2 explores whether the lack of statistical significance of individual coefficients on lags (and leads) of *hit* in the main results can be ascribed to a small sample size. Simulations suggest that the sample size would have to be radically expanded to make a meaningful difference to the main results.

The Appendix section B.5 furthermore shows that results are robust to: varying the number of leads and lags, restricting the analysis to periods within 6 months of a hit or a miss, using a group-time trend instead of period fixed effects, using a negative binomial model, using Discroll-Kraay standard errors, dropping two small terrorist groups, including all terrorist groups that have committed more than one attack in Afghanistan or Pakistan in the sample, and restricting the period under analysis to periods prior to Pakistan acquiring its own drone capability. Results are also robust to using alternative counterfactuals that are less subject to measurement error. To mitigate concerns that results are driven by trends over time specific to world regions terrorist groups are active in, the Appendix section B.3 also shows results from region-group-month level regressions, including region-fixed effects, region-group fixed effects and region-period fixed effects respectively. Results are somewhat sensitive to using HAC instead of Newey-West standard errors, but calculating the main test statistic using randomization inference leaves results qualitatively unchanged (Appendix section B.4.

6 Theoretical mechanisms

This section explores which theoretical mechanisms most plausibly produce the main results, by testing the hypotheses derived from theoretical models of problems of control, capacity, backlash and signaling. Most evidence found favours the problems of control mechanism, although there is also some evidence in favour of signaling. Table 1 provides an overview of hypotheses and evidence found.

6.1 Timing, target and type of terrorist attacks

The timing, target and type of terrorist attacks is most clearly consistent with problems of control. I find no evidence for the capacity mechanism, and only weak evidence for the signaling mechanism.

First, consider the *capacity* mechanism: there is no evidence that terrorist groups, in response to a drone strike hitting their leader, substitute a small number of high-capacity attacks with a large number of low-capacity attacks (H2.1). Table 6 suggests that a drone hit on a terrorist leader has a very limited to no effect on the percentage of 'successful' terrorist attacks, i.e. those in which the planned attack type took place and was not foiled (column 1). Similarly, no effect can be detected on the mean number of victims per terrorist attack (column 2). Table 6 also provides no evidence that terrorist groups are concentrating their attacks in Pakistan at the expense of attacks in Afghanistan and the rest of the world (excluding Western Europe, the US and Australia) after a drone hit on their leader. In fact, the main results are driven by terrorist attacks in the rest of the world (column 5)[15]. Although it would be interesting to investigate the effect of a drone hit on terrorist attacks in 'the West', there have been only eight such attacks over the research period, making this impossible.

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[15] The strong jump in terrorist attacks in Pakistan in the third month after a successful drone strike and subsequent decline in the fourth month (column 3) are artifacts of outliers: dropping only three outlying observations causes all coefficients in column 3 of Table 6 to become statistically insignificant.

Table 6: Types of terrorist attacks (1)

VARIABLES	(1) % success	(2) mean # vics.	(3) Pak.	(4) Afgh.	(5) ROW	(6) Infight
t	0.0179	-0.0858	-0.0811	-1.225	2.636*	0.0294
	(0.100)	(2.172)	(0.589)	(3.877)	(1.590)	(0.0839)
t+1	0.0173	0.425	-0.0392	-0.0357	1.527	-0.0788
	(0.100)	(2.167)	(0.587)	(3.937)	(1.613)	(0.0837)
t+2	0.0540	1.159	-0.712	1.303	3.025*	0.179**
	(0.100)	(2.164)	(0.586)	(3.898)	(1.601)	(0.0836)
t+3	0.0130	-3.170	1.888***	2.531	5.213***	0.354***
	(0.100)	(2.167)	(0.586)	(3.888)	(1.596)	(0.0834)
t+4	-0.0328	0.529	-1.827***	3.432	1.574	0.0458
	(0.101)	(2.165)	(0.584)	(3.960)	(1.627)	(0.0839)
t+5	-0.185*	-1.626	-0.304	1.887	0.566	0.0172
	(0.0988)	(2.140)	(0.577)	(3.851)	(1.583)	(0.0828)
t+6	0.0526	-3.220	0.447	2.779	5.691***	-0.0942
	(0.102)	(2.215)	(0.597)	(3.890)	(1.603)	(0.0853)
Observations	1,577	1,577	1,577	1,577	1,577	1,577
R-squared	0.674	0.180	0.800	0.547	0.520	0.223
Group FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Prob > F lags hit	0.5473	0.4815	0.0000	0.9693	0.0000	0.0004
Prob > F leads hit	0.8737	0.2678	0.2355	0.9709	0.1167	0.0000
Prob > F lags attempt	0.1124	0.0831	0.0000	0.9833	0.1320	0.1236
Prob > F leads attempt	0.4062	0.9810	0.0002	0.9999	0.0913	0.2916
Control mean	0.7582	3.9494	4.4752	0.8812	5.7030	0.1089

Newey-West standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table 7 illustrates that the increase in the overall number of terrorist attacks is driven by attacks against private and civilian targets (columns 1 and 2), but that there is no evidence that terrorist groups substitute attacks against ‘softer’ targets for attacks against ‘hard’ targets. There is no decline the number of terrorist attacks against military targets (column

Table 7: Types of terrorist attacks (2)

VARIABLES	(1) Private	(2) Civilian	(3) Military	(4) US vic.	(5) Claimed	(6) Unclaimed
t	1.347	1.329	1.457	0.0496	3.572	-2.204
	(1.284)	(4.122)	(2.796)	(0.123)	(2.497)	(1.979)
t+1	-0.153	1.437	1.305	-0.125	1.823	-0.313
	(1.298)	(4.182)	(2.840)	(0.124)	(2.532)	(2.001)
t+2	-0.944	3.496	4.361	0.151	0.597	3.015
	(1.289)	(4.144)	(2.812)	(0.124)	(2.510)	(1.987)
t+3	3.134**	9.800**	4.518	0.0614	7.309***	2.378
	(1.286)	(4.134)	(2.806)	(0.123)	(2.503)	(1.983)
t+4	0.573	3.152	2.730	0.128	1.182	1.911
	(1.306)	(4.206)	(2.857)	(0.124)	(2.544)	(2.015)
t+5	1.292	2.035	1.961	-0.0396	1.620	0.577
	(1.272)	(4.093)	(2.778)	(0.122)	(2.479)	(1.963)
t+6	2.384*	8.901**	5.059*	-0.0339	3.378	5.580***
	(1.292)	(4.141)	(2.807)	(0.125)	(2.512)	(1.992)
Observations	1,577	1,577	1,577	1,577	1,577	1,577
R-squared	0.532	0.556	0.450	0.313	0.473	0.569
Group FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Prob > F lags hit	0.0081	0.0078	0.2516	0.5342	0.0029	0.0143
Prob > F leads hit	0.6657	0.6790	0.2530	0.0254	0.7123	0.0341
Prob > F lags attempt	0.4514	0.3213	0.8701	0.3099	0.0119	0.6586
Prob > F leads attempt	0.4948	0.9959	0.9483	0.0000	0.7613	0.4731
Control mean	3.7723	11.0594	3.8713	0.0990	5.0990	5.9307

Newey-West standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

3) or attacks with US casualties or injured (column 4)[16]. Taking all these results together, I find no evidence for the capacity mechanism.

Considering the *signaling* mechanism, terrorist organizations do not obviously commit more attacks that send a strong signal shortly after their leader was hit by a drone strike (H4.1). The timing of the increase in terrorist attacks is not obviously consistent with the

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[16] The coefficient on the leads of *hit* are jointly statistically significant in this specification, but a plot of the coefficients reveals a downward trend in the number of terrorist attacks with a US victim prior to a drone hit compared to a drone miss. Hence, there is no evidence that the probability of a drone hit is driven by an increasing number of attacks on US citizens.

signaling mechanism: statistically significant increases in the number of terrorist attacks are only observed from three months after the drone hit onwards. Rather than an increase in terrorist attacks on military and US targets, attack types that would send a strong signal, the main results are driven by an increase in attacks on private and civilian targets.

Consistent with the signaling mechanism however, Column 5 of Table 7 does show a statistically significant increase in the number of claimed terrorist attacks in month three after a drone hit compared to after a drone miss. Coefficients are jointly statistically significant. This increase may be partially due to terrorist groups claiming certain attacks which they would not have claimed in a counterfactual world where the drone missed. It has been observed that terrorist groups claim attacks as revenge for a drone hit on their leader, whereas these attacks were already planned prior to the drone strike[17] or where no links between the attacker and the group could be established[18]. Table 4 also suggests that after a drone hit, the duration to the first claimed attack is shortened, while the duration to the first unclaimed attack is lengthened. In sum, I find some evidence consistent with the signaling mechanism, although this does not necessarily explain the timing and target of terrorist attacks, or a general increase in attacks.

Finally, I find evidence that a drone hit decreases the level of control terrorist leaders have over their operatives (H1.1). Consistent with the idea that terrorist operatives may have a greater preference for indiscriminate violence than the leader, the increase in terrorist attacks after a drone hit on a leader is driven by attacks against private and civilian targets. Column 6 of Table 7 also shows that the number of unclaimed terrorist attacks increases significantly, particularly in the sixth month, after a drone hit[19]. Finally, a drone hit is associated with an increase in infighting, violence by one terrorist group against another (H1.2a). These results should be treated with some caution for two reasons. First, infighting is rare, there are only forty instances of infighting in 26 time periods. Second, in this specification, leads of *hit*

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[17] E.g. BIJ Ob46

[18] E.g. BIJ Ob11

[19] The leads of *hit* being jointly statistically significant in column 6 is some cause for concern. However, given that this is true for one model among many, this could be due to multiple testing.

are also strongly jointly statistically significant. However, the Appendix section B.6 shows that this is driven by a single coefficient, and not necessarily by consistently differing trends between a hit and a miss prior to the drone strike.

6.2 Effect of drone strikes killing civilians

There is no evidence that drones strikes killing civilians are associated with an increase in terrorist attacks, as the *backlash* mechanism would suggest.

Even if drone strikes cause backlash, this would not necessarily explain the differing trends in terrorist attacks when comparing drone hits and misses *on a leader*. Recall from Table 2 that hits do not kill statistically significantly more civilians than misses. There is also no evidence that terrorist organizations specifically use drone strikes on terrorist leaders in their recruitment propaganda (Ludvigsen, 2018).

Nevertheless, I test whether drone strikes killing civilians are associated with an increase in terrorist attacks. To do so, I estimate two variations on equation 1 and 2. The first variation replaces hit_{it} with the number of civilian casualties from drone strikes targeting group i in month t and $attempt_{it}$ with the total number of casualties from drone strikes in month t on group i. The second variation replaces hit_{it} with an indicator that equals one if some drone strike in month t targeting terrorist group i instead killed only civilians[20], and $attempt_{it}$ with an indicator for any drone strike in month t on group i. BIJ provides maximum and minimum casualty estimates. Table 8 shows results from maximum casualty estimates, but similar results are obtained when using minimum casualty estimates (not shown).

Table 8 provides no evidence that drone strikes hitting only civilians, or done strikes hitting many civilians, are associated with an increase in terrorist attacks, compared to other drone strikes (H3.1). If anything, it shows a *decrease* in the number of terrorist attacks, both

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[20] If the maximum number of civilian casualties is larger than or equal to the minimum total number of casualties from a drone strike (for maximum civilian casualty estimates), or if the maximum number of civilian casualties is equal to the maximum total number of casualties (for minimum civilian casualty estimates).

Table 8: Drone strikes with civilian casualties

VARIABLES	(1) Terr. att.	(2) Terr. att.	(3) Affil. att.	(4) Affil. att.
t	-0.299***	0.0118	-0.0384**	-0.931***
	(0.0941)	(1.551)	(0.0183)	(0.358)
t+1	-0.260***	-3.261**	-0.0334*	-0.584*
	(0.0944)	(1.556)	(0.0183)	(0.344)
t+2	-0.325***	-2.779*	-0.0384**	-1.126***
	(0.0940)	(1.622)	(0.0186)	(0.358)
t+3	-0.305***	-3.603**	-0.0256	-0.581*
	(0.0934)	(1.591)	(0.0183)	(0.347)
t+4	-0.245**	-1.251	-0.0171	-0.717**
	(0.0967)	(1.563)	(0.0194)	(0.349)
t+5	-0.172*	-2.631*	-0.0257	-0.851**
	(0.0980)	(1.581)	(0.0198)	(0.353)
t+6	-0.194**	-1.018	-0.0390**	-0.991**
	(0.0944)	(1.724)	(0.0186)	(0.408)
Observations	1,577	1,577	8,640	8,640
R-squared	0.592	0.566	0.403	0.402
Indep. var.	# civilians	only civilians	# civilians	only civilians
Control	# casualties	drone strike	# casualties	drone strike
Model	Gr-mnth	Gr-mnth	Affil.-mnth	Affil.-mnth
Group FE	YES	YES	NO	NO
Period FE	YES	YES	YES	YES
Affiliate FE	NO	NO	YES	YES
Prob > F lags	0.0216	0.1489		
Prob > F leads	0.0003	0.0003		
Prob > F lags parent			0.1827	0.0566
Prob > F leads parent			0.6380	0.0282
Prob > F lags affiliate			0.0084	0.0327
Prob > F leads affiliate			0.0004	0.0001

Newey-West standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

by the terrorist group itself and by its affiliates – using specification 2. The sign on virtually all coefficients is negative, although coefficients on the lags of the dependent variable of interest are not jointly statistically significant in each instance.

This study by no means convincingly shows that drone strikes causing civilian casualties decrease terrorist violence. In three out of four specifications shown, the leads of the dependent variable are jointly statistically significant. As this provides evidence that the parallel trends assumption is violated, these results should be interpreted with due caution. The sole purpose of this exercise is to show the lack of evidence in favour of the backlash mechanism.

6.3 Affiliate groups and splintering

Affiliates of a terrorist group commit an increasing number of terrorist attacks after a drone strike that hit, compared to missed, the parent group's leader. This increase, given an analysis of the types of terrorist attacks that drive it, could be consistent with the *problems of control* and *signaling* mechanisms. Consistent with the *problems of control* mechanism, drone hits are related to a proxy for terrorist group splintering.

Table 9 investigates the impact of a drone hit on a terrorist group leader, compared to a miss, on terrorist attacks committed by other terrorist groups affiliated with the group struck. It presents results at the group-month level, and at the affiliate-month level, following specification 2. Only lags of the variable of interest are presented to promote readability. Results are presented for affiliates categorized according to the Mapping Militants project ('Stanford'), splinter groups as per to my coding and an aggregation of both.

Column 1 and 4 show that a drone hit on a parent group is associated with an increase in terrorist attacks by affiliates of that group. All but one coefficient on the lag of *hit* is individually statistically significant, and coefficients are jointly statistically significant at the 5% level or stricter[21]. This effect is substantial in size: estimates in column 1 suggest that a drone hit on a terrorist group leader is associated with an additional 177 terrorist attacks by affiliates of that group globally over the next six months, over an average of 281 terrorist attacks by those affiliates after a drone miss. Effect size increases to 195 additional terrorist attacks if branches of Al-Qaida are considered independent affiliates (not shown). There is no evidence that drone strikes targeting but missing the parent group's leader affect affiliates: coefficients on leads and lags of *attempt* are jointly statistically insignificant.

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[21] There are some concerns that the parallel trends assumption in the specifications presented in columns 3 and 4 has been violated; leads of *hit* are also statistically significant, although only at the 10% level.

Table 9: Effect of drone strikes on attacks by affiliates

VARIABLES	(1) Affil. att.	(2) Affil. att. excl. AQ	(3) Splintering	(4) Affil. att.	(5) Affil. att. excl. ISIS
t	26.11**	3.069	-0.0717	1.601*	0.859
	(12.64)	(11.95)	(0.0447)	(0.862)	(0.655)
t+1	18.64	5.052	-0.0862*	0.786	0.224
	(12.90)	(12.23)	(0.0445)	(0.875)	(0.663)
t+2	31.10**	19.18	-0.0662	1.926**	0.979
	(12.75)	(12.06)	(0.0446)	(0.880)	(0.665)
t+3	31.20**	3.821	0.0870*	2.217**	1.192*
	(12.70)	(11.98)	(0.0445)	(0.892)	(0.673)
t+4	40.40***	17.00	0.0719	3.133***	2.054***
	(13.00)	(12.14)	(0.0446)	(0.929)	(0.699)
t+5	24.82**	17.13	0.154***	2.165**	1.153*
	(12.61)	(11.88)	(0.0441)	(0.896)	(0.677)
t+6	30.77**	27.39**	0.0128	2.765***	1.634**
	(12.67)	(12.56)	(0.0456)	(0.838)	(0.635)
Observations	1,577	1,445	1,577	7,776	7,632
R-squared	0.592	0.551	0.219	0.406	0.491
Model	Gr.-mnth	Gr.-mnth	Gr.-mnth	Affil.-mnth	Affil.-mnth
Group FE	YES	YES	YES	NO	NO
Period FE	YES	YES	YES	YES	YES
Affiliate FE	NO	NO	NO	YES	YES
Prob > F lags hit	0.0303	0.0477	0.0003		
Prob > F leads hit	0.1354	0.9179	0.4756		
Prob > F lags attempt	0.1270	0.5899	0.0001		
Prob > F leads attempt	0.4837	0.9784	0.3639		
Control mean	46.9010	46.9010	0.0594	2.0428	1.7575
Prob > F lags parent hit				0.0061	0.0290
Prob > F leads parent hit				0.0752	0.0639
Prob > F lags parent attempt				0.3316	0.2684
Prob > F leads parent attempt				0.8495	0.6894
Prob > F lags affil. hit				0.0421	0.0031
Prob > F leads affil. hit				0.4969	0.1735

Newey-West standard errors in parentheses
* $p<0.1$ ** $p<0.05$ *** $p<0.01$

These results are strongly influenced, but not exclusively driven, by Al-Qaida, the terrorist group with the most affiliates. Column 2 of Table 9 presents results excluding Al-Qaida.

Coefficients on *hit* are still jointly statistically significant at the 5% level, although coefficients decrease in size and only the coefficient on the sixth lag retains statistical significance. Results are robust to excluding the Islamic State (ISIS) from the dataset (column 5) and are driven by Stanford affiliates, rather than by splinter groups (not shown).

I proceed to analyze which type(s) of terrorist attacks drive the increase in affiliate group violence after a drone hit on their parent group. The tables showing these results are relegated to the Appendix section C.1 to save space. The increase in affiliate violence is driven by terrorist attacks across the board, including attacks against military, civilian, private and US targets. This is consistent with both the problems of control mechanism (H1.3) and the signaling mechanism (H4.2), although the signaling mechanism cannot necessarily explain the increase in attacks against private and civilian targets. There is no evidence that drone hits against a parent group diminish affiliate capacity (H2.1): I find no evidence for a substitution effect.

Returning to the results in Table 9, a drone hit on a parent group is associated with a proxy for group splintering, consistent with the problems of control mechanism (H1.2b). Splinter groups are more likely to commit the first terrorist attack recorded by GTD after a drone hit on the parent group's leader, compared to after a miss (column 2). Coefficients are individually statistically significant for the third and fifth lag of *hit* and jointly statistically significant at the 1% level. If the first attack by these small groups in Afghanistan and Pakistan is a credible indicator for splintering of the parent group, terrorist groups are more likely to splinter after a drone hit on their leader.

6.4 Interaction effects

Finally, I explore whether the effect of a drone hit on terrorist attacks is stronger for particular terrorist groups or for particular leaders. This provides some evidence in favour of hypotheses derived from the *problems of control* mechanism (H1.4), but no evidence in favour of the *signaling* mechanism (H4.3).

Results on interaction effects, displayed in Table 10, should be interpreted with some caution: given the limited number of drone strikes targeting a terrorist leader and limited number of groups, statistical power to detect any interaction effects may be lacking.

Keeping this in mind, the first three columns of Table 10 explore the hypothesis that the effect of a drone hit on a terrorist leader is greater for terrorist groups that rely more strongly on central ties. This would be consistent with the problems of control mechanism. I employ a classification by Staniland (2014) , in which integrated and vanguard terrorist groups rely on strong central ties. Staniland considers the Taliban an integrated group (p140). Al-Qaida is not explicitly classified, but its strategy of making alliances closely resembles Staniland's description of a vanguard group (p44-46). No other groups subject to drone hits and misses on their leaders are classified by Staniland as having strong central ties[22]. Column 1 reveals that the effect of a drone hit on terrorist attacks is indeed stronger for these two organizations. This is mainly driven by the one integrated organization (column 2), although coefficients on the interaction term between drone hit and an indicator for Al-Qaida, the only vanguard organization, are also all positive (column 3).

The final columns of Table 10 explore the final hypotheses. Results in these columns do not show any evidence that the effect of a drone hit is stronger for more prominent leaders (H4.3), as measured by whether they are 'first in command' according to the Stanford project (column 5), or whether there is an outstanding reward for information regarding them (column 4). If anything, the effect is weaker for more prominent leaders, judging by the sign of the coefficient on the interaction terms, failing to provide support for the signaling mechanism. Lastly, column 6 of Table 10 provides some very tentative support for the hypothesis that the effect of a drone hit is stronger for strikes up to the first hit, and thereby some support for the problems of control mechanism. Coefficients on the fourth to sixth lag of the interaction term are positive and of substantial size compared to their

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[22] TTP is explicitly classified as a Parochial group (p.6), the Stanford mapping militants project describes Harkat-ul-Jihad-al-Islami as consisting of "small, autonomous cells", not suggesting strong central ties and the Haqqani network is described by Staniland as a group with "strong social ties' (p.138).

Table 10: Heterogeneous effects

VARIABLES	(1) Terr. att.	(2) Terr. att.	(3) Terr. att.	(4) Terr. att.	(5) Terr. att.	(6) Terr. att.
t	-2.390	1.274	-1.938	2.772	3.269	4.830
	(5.123)	(4.147)	(4.959)	(5.191)	(4.769)	(5.858)
t+1	-1.703	0.621	0.241	1.139	1.039	2.822
	(5.237)	(4.207)	(5.054)	(5.275)	(4.812)	(5.824)
t+2	-3.279	1.157	1.288	4.144	1.718	0.0133
	(5.195)	(4.178)	(5.001)	(5.256)	(4.697)	(5.722)
t+3	3.753	6.585	8.547*	8.006	8.987*	9.726*
	(5.194)	(4.176)	(4.979)	(5.189)	(4.721)	(5.801)
t+4	-3.707	-1.851	3.556	6.119	3.392	-1.441
	(5.255)	(4.249)	(5.036)	(5.427)	(4.862)	(6.022)
t+5	-2.131	-1.433	2.260	4.919	2.417	-1.356
	(5.128)	(4.137)	(4.926)	(5.479)	(4.823)	(6.093)
t+6	-3.448	3.057	5.024	10.39*	11.84**	4.593
	(5.441)	(4.201)	(5.183)	(5.892)	(4.967)	(5.986)
Interaction	13.43	17.19	10.07	0.759	-12.77	-6.948
	(8.684)	(15.87)	(9.473)	(8.861)	(12.65)	(8.592)
t+1	10.29	17.14	5.367	5.075	-0.192	-3.306
	(8.873)	(15.88)	(9.677)	(9.029)	(12.24)	(8.644)
t+2	20.62**	48.02***	9.434	-1.518	6.654	7.056
	(8.893)	(15.90)	(9.777)	(9.293)	(12.27)	(8.866)
t+3	20.41**	52.15***	7.861	3.925	-2.634	-0.682
	(8.983)	(15.94)	(9.941)	(9.154)	(11.50)	(8.633)
t+4	27.15***	70.92***	5.405	-7.906	-5.443	12.13
	(9.084)	(15.95)	(10.04)	(9.261)	(11.57)	(8.766)
t+5	18.76**	52.46***	1.221	-4.956	3.876	9.677
	(8.869)	(15.92)	(9.848)	(9.034)	(10.96)	(8.886)
t+6	33.70***	72.02***	9.791	-1.293	-9.699	10.09
	(8.618)	(15.94)	(9.197)	(8.940)	(10.96)	(8.755)
Observations	1,577	1,577	1,577	1,577	1,577	1,577
R-squared	0.580	0.590	0.564	0.563	0.559	0.562
Interaction variable	central ties	intregated	vanguard	reward	1st in comm.	1st hit/miss
Group FE	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES
Prob > F lags hit	0.4974	0.0745	0.4190	0.4408	0.0099	0.0187
Prob > F leads hit	0.9931	0.8656	0.9756	0.5409	0.5273	0.9322
Prob > F lags inter.	0.0017	0.0000	0.8101	0.4825	0.3810	0.2854
Prob > F leads inter.	0.0828	0.0196	0.4210	0.4908	0.9531	0.9726
Control mean	11.0792	11.0792	11.0792	11.0792	11.0792	11.0792

Newey-West standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

non-interacted counterparts. They are not individually or jointly statistically significant however.

7 Conclusion

Exploiting a natural experiment provided by drone strikes hitting and missing terrorist leaders in FATA, Pakistan, this paper investigates how drone strikes killing terrorist leaders – and undermining control within terrorist organizations – affect terrorist attacks. It suggests that such counterterrorism policies might backfire. Results suggest that a drone strike hitting a terrorist organization's leader is associated with 29 additional terrorist attacks globally by the organization itself in the next 6 months, as well as 177 additional attacks by its affiliates. The timing, type and target of these attacks, as well as results on splintering, infighting, affiliates and interaction effects, suggest that problems of control (collective action and principal-agent problems internal to the terrorist organization) are the most likely theoretical mechanism explaining this effect.

Two caveats to these results are in order. First, this paper is only able to capture the medium-term effect (six to twelve months) of targeted leader killing. It has been suggested that terrorist organizations, specifically Al-Qaida, are in the process of disintegration partially because their leaders have been consistently killed or captured, and that increased violence may be the organization's "death throws" (Cronin 2006). Although I cannot exclude the possibility that this may happen in the future, the number of attacks by the terrorist organizations studied in this paper currently shows no sign of decreasing. In fact, the number of attacks has increased over eight-fold between 2004 and 2015. Secondly, this paper investigates the effect of drone hits relative to drone misses. It cannot comment on the effect of the *threat* of drone strikes, i.e. the number of terrorist attacks in the current state of the world, relative to a counterfactual world in which terrorist leaders were never targeted by drone. Hence, it can comment on potential effects of increasing the accuracy of drones (more ‘hits’ and fewer ‘misses’), but these results do not directly translate into an assessment of the effectiveness of the use of drones in general.

Results do suggest that successful drone strikes undermine control within terrorist groups. This has important policy implications beyond counterterrorism, in the arenas of law and diplomacy. Legal scholars suggest that the lawfulness of drone strikes under International Humanitarian Law (IHL) depends on an armed group’s level of internal organization (Heyns et al., 2016). For IHL to apply to drone strikes, they must take place in the context of a Non-International Armed Conflict. The level of organization of parties to the conflict, including the existence of a command structure, is one of two criteria used to determine whether a situation is thus classified (Heyns et al., 2016). The results presented in this paper suggest that drone strikes, by virtue of their own ‘success’ in killing leaders and undermining terrorist command structure, may contribute to making themselves unlawful.

Undermining leaders’ control over a terrorist organization also implies that these leaders are less able to enforce adherence to any peace agreement they sign. Peace agreements between the Pakistani government and terrorist groups are common: Staniland et al. (2018) document 24 individual peace deals.[23] Anecdotal evidence suggests that the signing of such a peace agreement is often followed by the establishment of splinter groups which ‘spoil’ the peace agreement by executing or threatening attacks.[24] Terrorist leaders appear unable to enforce adherence to these peace agreements within their own organization; a problem of control that this paper suggests is aggravated by drone strikes.

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[23] Unfortunately, these peace agreements are not common enough to quantitatively investigate the impact of drone hits versus drone misses on peace duration.

[24] Dawn, “TTP’s splinter group opposes talks with govt”, 15 February 2014.

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Appendix

A Data

A.1 Terrorist groups included in dataset (as classified by BIJ)

Table A.1

Group	Subgroups[25]	Start month[26]
Al-Qaida	AQ in Iraq	
	AQ in the Arab Peninsula	
	AQ Indian Subcontinent	
	Abu Kasha's group	
	Islamic Army of Great Britain	
	Lashkar al Zil	
Al-Badr		
East Turkestan Islamic Movement		
Haqqani Network	Maulvi Ihsanullah's faction	
Harkat-ul-Jihad al-Islami		
Islamic Movement of Uzbekistan (IMU)		
Islamic Jihad Union		
Jund al Khilafah		August 2011
Lashkar-e-Islam		
Punjabi Taliban		
Taliban	Hezb-i-Islami	
	Maulvi Nazir's faction	
	SWAT Taliban	
Taliban (Pakistan)		
Tehrik-e-Taliban Pakistani (TTP)	Khan Said's faction	December 2007
	Hafiz Gul Bahadur's faction	
	Jamaat e Islami Azad Kashmir	
	Sajna faction	

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[25] This table does not give a comprehensive overview of subgroups of these terrorist groups, merely of those subgroups that are named in the BIJ data.

[26] If after January 2014.

A.2 Codebook targeted leader killing

Coding Instructions

targettype

1=vehicle
2=building
3=both a vehicle and a building
9=unknown/other

Record the physical object hit by the strike, according to BIJ.

targetnamed

0=no
1=yes

Code 1 if AT LEAST ONE of the following is satisfied:

1. Report includes a NAMED individual classified by BIJ as "leader", "commander", "senior figure" or similar of a militant group, who, or a location associated with whom, is named by BIJ as "target" of a drone strike, potential or otherwise, or is mentioned as (falsely) claimed to have died in or as a result of the strike by any source.
2. BIJ identifies as a target of the strike, potential or otherwise, OR as having died in or as a result of the strike
    a. Individuals (allegedly) associated with a NAMED militant group, OR
    b. (alleged) militants (allegedly) associated with a NAMED individual, identified implicitly or explicitly as leader or similar of a militant group, OR
    c. a location associated with a NAMED militant group.

Code 0 otherwise.

IF 0: leave all remaining fields blank
IF 1: for EACH UNIQUE NAMED militant group under (2.) or associated with individual(s) under (1.) AND EACH UNIQUE NAMED individual NOT associated with a named militant group under (1.) or (2.) fill in the remaining fields.

NOTE: see page 2 for known named militant groups

group?HVTtarget

0=no
1=yes

FOR EACH UNIQUE named militant group or named individual not associated with a militant group
Code 1 if ALL of the following are satisfied

1. A named individual OR a gathering of more than two unnamed individuals,
2. Classified by BIJ as "leader(s)", "commander(s)", "senior figure(s) or similar of a militant group
3. Was either
    a. Named by BIJ as "target" of the drone strike, potential or otherwise
    b. Mentioned as (falsely) claimed to have died in or as a result of the strike by any source.

Code 0 otherwise

group?HVTdied

0=no
1=yes
9=unknown

Blank if group?HVTtarget=0

FOR EACH UNIQUE named militant group or named individual not associated with a militant group

Code 1 if ANY of the individuals recorded under group?HVTname have died in, or as a result of injuries incurred during, the drone strike.
Code 9 if BIJ mentions the death of ALL individuals recorded under group?HVTname is uncertain and/or if the BIJ cites conflicting reports on the death of ALL individuals recorded under group?HVTname.
Code 0 if otherwise.

group?HVTname

Text field (codes available)

Blank if group?HVTtarget=0 AND group?militant is EITHER 2, 3, OR 4 not involving a location associated with a named leader.

FOR EACH UNIQUE militant group or named individual not associated with a militant group

Record name(s) of HVT(s) under group?HVTtarget and group?militant IF group?militant=1 OR group?militant=4 and it involves a location associated with a named leader, separated by ; and including any aliases in brackets ( ).

Record ‘gathering’ if group?HVTtarget=1 because the report involved a gathering of more than two unnamed individuals.

group?militant

1=Militants associated with HVT
2=Named militants
3=Unnamed militants
4=Location associated with militants

Blank if group?HVTtarget=1

FOR EACH UNIQUE named militant group or named individual not associated with a militant group
record the LOWEST code applicable. Code:

1. If BIJ identifies as a target of the strike, potential or otherwise, OR as having died in or as a result of the strike, one or more individuals identified as (alleged) militant(s) AND associated with, or alleged to be associated with, a NAMED individual (or “Named individual’s group”) identified implicitly or explicitly as leader or similar of a militant group.
2. If BIJ identifies as a target of the strike, potential or otherwise, OR as having died in or as a result of the strike, one or more individual(s) BY NAME AND as militant(s) or alleged militant(s) associated with the named group.
3. If BIJ identifies as a target of the strike, potential or otherwise, OR as having died in or as a result of the strike, one or more UNNAMED individual(s) as (alleged) militant(s) associated with the named group.
4. If BIJ records that the location that was struck is (allegedly) associated with the named militant group or a named individual classified as “leader”, “commander” “senior figure” or similar.

group?name

Text field, see spelling below

FOR EACH UNIQUE militant group, record name of:

1. the militant group the HVT is associated with if group?HVTtarget=1, OR group?militant=1 OR group?militant=4 and this involves a location associated with an HVT.
2. the militant group militants are associated with if group?militant=2 OR group?militant=3
3. the militant group the location struck is associated with if group?militant=4 AND this does NOT involve a location associated with a an HVT.

Record ‘unknown’ if group?HVTtarget=1 OR group?militant=1 AND the HVT is NOT associated with a militant group.

AQ: Al Qaeda
Haqqani: Haqqani network
LeI: Lashkar-e-Islam
IMU: Islamic Movement of Uzbekistan
Afghan Taliban: Afghan Taliban
TTP: Pakistani Taliban, Tehrik-e-Taliban Pakistani, Local Taliban
Taliban: Taliban, unspecified

Foreigner: including “Arab”, “non-local” or individuals of a specific nationality not Pakistani, Afghani, Uzbek or Punjabi.
NOT TO BE CODED SIMULTANESOULY WITH AQ
Punjabi: Punjabi militants
Uzbeks: Uzbeks, Uzbek militants.
NOT TO BE CODED SIMULTANEOUSLY WITH IMU

A.3 Terrorist leaders included in dataset

Table A.2

Leader name	Group	Subgroup	# attempts	# hits
Abu Mus'ab al-Zarqawi	Al-Qaida	AQI	0	0
Abu Yahya al-Libi	Al-Qaida		2	1
Ahmad Farouq	Al-Qaida	AQIS	3	1
Amran Ali Siddiqi	Al-Qaida	AQIS	1	1
Atiyah adb al-Rahman	Al-Qaida		3	1
Ayman al-Zawahiri	Al-Qaida		2	0
Badruddin Haqqani	Haqqani network		2	1
Baitullah Mehsud	TTP		3	1
Hafiz Gul Bahadur	TTP		2	0
Hakimullah Mehsud	TTP		5	1
Jalaluddin Haqqani	Haqqani network		0	0
Maulana Faqir Muhammed	TTP		1	0
Maulvi Ahmad Jan	Haqqani network		1	1
Maulvi Nazir[27]	Taliban	Maulvi Nazir group	2	1
Muhammad Ilywas Kashmiri	Harkat-ul-Jihad		5	1
Mustafa Abu al-Yazid	AQ		1	1
Nasser al-Wuhayshi	AQ	AQAP	1	0
Qari Hussain	TTP		6	1
Qarri Imran	AQ	AQIS	1	1
Sangeen Sadran	Haqqani network		3	1
Sirajuddin Haqqani	Haqqani network		1	0
Wali ur Rehman Mehsud	TTP		1	1
TOTAL			46	15

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[27] It should be noted that major attacks by the Maulvi Nazir faction as identified by the Stanford project are all coded as having been perpetrated by the 'Taliban' by the GTD. Hence, this faction is classified as Taliban, even though it was briefly merged with the TTP (Crenshaw, 2012)

A.4 Splinter groups included in dataset

Table A.3

Affiliate name	Parent group name	Source
Abdullah Azzam Brigades	AQ	https://www.trackingterrorism.org/group/abdullah-azzam-brigades-aab
Abu Hafs Katibatul al-Ghurba al-Mujah	AQ	https://www.trackingterrorism.org/group/katibat-al-ghuraba-al-turkistan-kgt-al-qaeda-aqc
Ahle Sunnat Wal Jamaat	AQ	http://www.bbc.co.uk/news/world-asia-17322095
Al-Fatah	None	https://www.trackingterrorism.org/group/al-fatah
Al-Jihad (Pakistan)	Not found	
Al-Mansoorian	AQ	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/79
Al-Qaida	AQ	
Al-Qaida in the Indian Subcontinent	AQIS	
Amr Bil Maroof Wa Nahi Anil Munkir	AQ	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/445
Ansar Al-Mujahideen (Pakistan)	TTP	http://www.thefridaytimes.com/tft/ptis-peace-paradox/
Ansar Wa Mohajir (Pakistan)	TTP	https://speekout.wordpress.com/category/ansar-wa-mohajir/
Ansarul Islam (Pakistan)	None	https://www.rferl.org/a/pakistan-ansar-ul-islam-taliban-ttp/24886662.html
Baba Ladla Gang	None	https://www.dawn.com/news/1312260
Baloch Liberation Army (BLA)	None	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/297
Baloch Liberation Front (BLF)	None	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/297
Baloch Liberation Tigers (BLT)	None	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/297
Baloch Militant Defense Army	Not found	
Baloch Mussalah Diffah Tanzim (BMDT)	TTP	https://www.trackingterrorism.org/group/balochistan-musalla-difa-tanzeem-bmdt-haq-na-tawar
Baloch National Liberation Front	None	
Baloch Nationalists	Not found	

Continuation of Table A.3

Affiliate name	Parent group name	Source
Baloch Republican Army (BRA)	None	
Baloch Republican Guards (BRG)	None	https://www.app.com.pk/14-activists-of-banned-outfit-in-balochistan-surrender/
Baloch Waja Liberation Army (BWLA)	None	
Baloch Young Tigers (BYT)	Not found	
Balochistan Liberation United Front	None	
Balochistan National Army	None	https://www.trackingterrorism.org/group/baluchistan-national-army
Bhittani tribe	Not found	
Free Balochistan Army (FBA)	Not found	
Gholam Yahya Akbar	Taliban	https://www.longwarjournal.org/archives/2009/02/coalition_strik
Gunmen	Not found	
Hafiz Gul Bahadur Group	TTP	
Haji Fateh	None	http://www.xactrisk.com/international-security-update.html
Halqa-e-Mehsud	TTP	
Haqqani Network	Haqqani	
Harkatul Jihad-e-Islami	Harkat-Ul-Jihad	
Hizb al-Tahrir al-Islami (HT)	None	https://www.globalsecurity.org/military/world/para/hizb-ut-tahrir.htm
Hizb-I-Islami	Taliban; AQ	http://www.understandingwar.org/hizb-i-islami-gulbuddin-hig
Imam al-Bukhari Brigade	Taliban	https://www.longwarjournal.org/archives/2016/07/foreign-jihadists-advertise-role-in-latakia-fighting.php
Islambouli Brigades of al-Qaida	AQ	https://books.google.co.uk/books?id=_PXpFxKRsHgC&pg=PA6 Qaeda&source=bl&ots=mE81OUofTb&sig=SkZB2bIgy5EV61g0 Qaeda&f=false
Islami Jamiat-e-Talaba (IJT)	AQ; TTP	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/101?highlight=IJT

Continuation of Table A.3

Affiliate name	Parent group name	Source
Islamic Movement of Uzbekistan (IMU)	IMU	
Jaish al-Muslimin	Taliban	https://reliefweb.int/report/afghanistan/baag-afghanistan-monthly-review-oct-2004
Jaish al-Umar (JaU)	Not found	
Jaish as-Saiyouf (Army of Swords)	Not found	
Jaish Usama	TTP	https://nation.com.pk/05-Mar-2014/not-bound-to-follow-ceasefire-jaish-e-usama
Jaish-e-Islam	None	https://jamestown.org/program/a-profile-of-militant-groups-in-bajaur-tribal-agency/
Jaish-e-Khorasan (JeK)	AQ	https://www.linkedin.com/pulse/rise-islamic-state-terror-its-climax-september-2014-hassan-ali/
Jaish-e-Mohammad	AQ; Taliban	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/95
Jamaat Tauhid Wal Jihad (Pakistan)	AQ	https://ctc.usma.edu/militant-imagery-project/0068/
Jamaat-E-Islami (India/Pakistan)	None	
Jamaat-ul-Ahrar	TTP	Dawn
Jeay Sindh Qaumi Mahaz (JSQM)	None	https://tribune.com.pk/story/354308/pakistan-day-jsqm-leader-demands-freedom-for-sindh-and-balochistan/
Jundallah (Pakistan)	TTP	Dawn
Khatm-e-Nabuwat (KeN)	None	https://www.rabwah.net/ahrar-khatmenabuwat-terrorist-organizations/
Khorasan Chapter of the Islamic State	TTP; Taliban	https://thediplomat.com/2015/05/islamic-state-and-jihadi-realignments-in-khorasan/
Khorasan jihadi group	AQ	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/21?highlight=khorasan
Lashkar-e-Balochistan	None	https://www.trackingterrorism.org/group/lashkar-e-balochistan
Lashkar-e-Islam (Pakistan)	Lashkar-e-Islam	
Lashkar-e-Jarrar	Not found	
Lashkar-e-Jhangvi	None	
Lashkar-e-Taiba (LeT)	AQ	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/79
Mahaz Fedai Tahrik Islami Afghanistan	Taliban	Dawn
Mahsud Tribe	Not found	

Continuation of Table A.3

Affiliate name	Parent group name	Source
Majlis-e-Askari	TTP	https://therearenosunglasses.wordpress.com/2017/05/25/us-drone-strike-in-khost-kills-3-ttpisis-taliban-while-pak-army-hangs-2-more-same-group/
Majlis-e-Lashkari	TTP	https://therearenosunglasses.wordpress.com/2017/05/25/us-drone-strike-in-khost-kills-3-ttpisis-taliban-while-pak-army-hangs-2-more-same-group/
Militants	Not found	
Mujahideen Ansar	TTP	http://www.thefridaytimes.com/tft/ptis-peace-paradox/
Mullah Dadullah Front	Taliban	https://www.trackingterrorism.org/group/dadullah-front
Muslim extremists	Not found	
Muslim Fundamentalists	Not found	
Mutahida Majlis-e-Amal	None	https://www.geo.tv/latest/166882-muttahida-majlis-e-amal-restored
Muttahida Qami Movement (MQM)	None	
New People's Army (NPA)	None	
Orakzai Freedom Movement	TTP	https://books.google.co.uk/books?id=8TZDDwAAQBAJ&pg=PT
Pakistani People's Party (PPP)	None	
People's Amn Committee	None	
Punjabi Taliban	Punjabi Taliban	
Qari Kamran Group	TTP	https://www.trackingterrorism.org/group/qari-kamran-group
Separatists	Not found	
Sindh Liberation Front	None	
Sindh Revolutionary Army	None	
Sindhu Desh Liberation Army (SDLA)	None	

Continuation of Table A.3

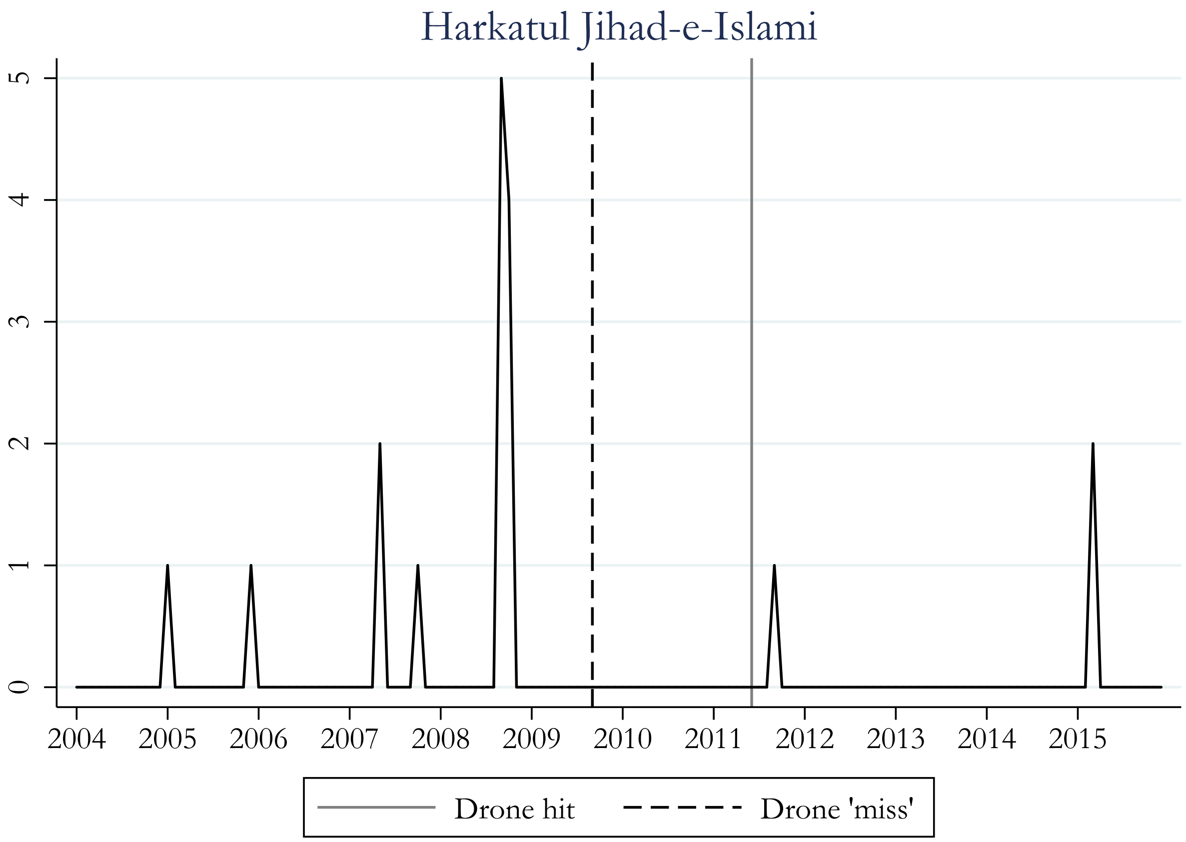
Affiliate name	Parent group name	Source
Sindhudesh Revolutionary Army (SRA)	None	
Sipah-e-Sahaba/Pakistan (SSP)	None	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/147
Sipah-I-Mohammed	None	http://www.satp.org/satporgtp/countries/pakistan/terroristoutfi
Sirri Powz	Not found	
Sunni Muslim extremists	Not found	
Taliban	Taliban	
Taliban (Pakistan)	Local Taliban	
Tanzeem al-Islami al-Furqan	None	https://www.trackingterrorism.org/group/tanzeem-ul-islami-ul-furqan-tif
Tawheedul Islam	Not found	
Tehrik-e-Khilafat	TTP	http://www.dailymail.co.uk/news/article-2686009/Pakistani-terror-group-jihadi-group-defect-ISIS-outside-Middle-East-leader-al-Baghdadis-influence-grows.html
Tehrik-e-Nafaz-e-Shariat-e-Mohammadi	TTP	http://web.stanford.edu/group/mappingmilitants/cgi-bin/groups/view/411
Tehrik-e-Nifaz-e-Aman Balochistan	None	http://thebalochistanpoint.com/taliban-in-balochistan/
Tehrik-e-Taliban Islami (TTI)	TTP	https://in.reuters.com/article/idINIndia-58032520110701
Tehrik-e-Tuhafaz (Pakistan)	None	https://www.catholicforlife.com/tag/tehreek-e-tuhafaz/
Tehrik-i-Taliban Pakistan (TTP)	TTP	
Tela Mohammed	Not found	
Tribesmen	Not found	
United Baloch Army (UBA)	None	http://www.dopel.org/UBA.htm
Unknown	Not found	
Uzair Baloch Gang	None	https://www.dawn.com/news/1326325
Zehri Youth Force (ZYF)	Not found	

B Further results and robustness checks

B.1 Descriptive results for groups not included in main text

Below are graphs depicting raw data on terrorist attacks, and drone hits and misses on terrorist leaders, for those terrorist groups that experienced at least one hit and one miss and that are not included in the main text.

Figure B.1: Descriptive relationship: Harkatul Jihad-e-Islami



B.2 Simulations of expanded sample size

By expanding the sample using simulated data, this section explores whether the lack of statistical significance of the coefficients on individual lags (or leads) of *hit* is due to a small

Figure B.2: Descriptive relationship: Haqqani Network

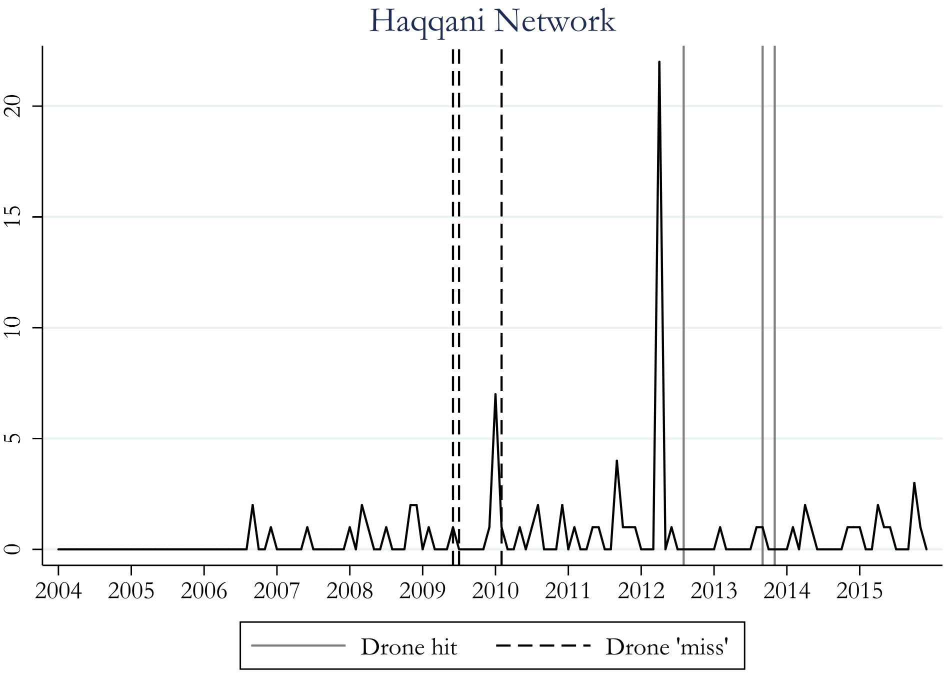
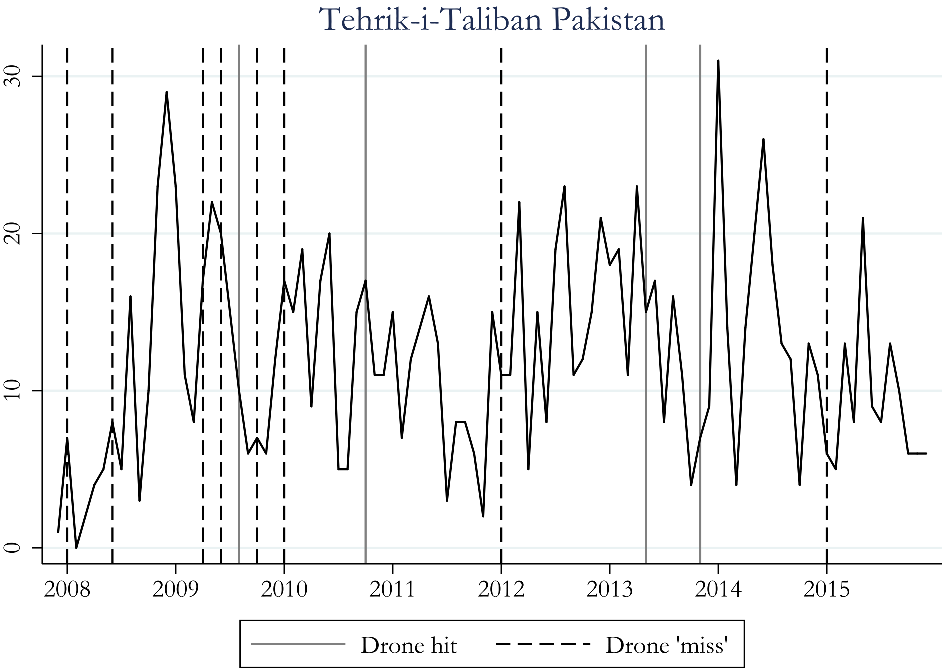
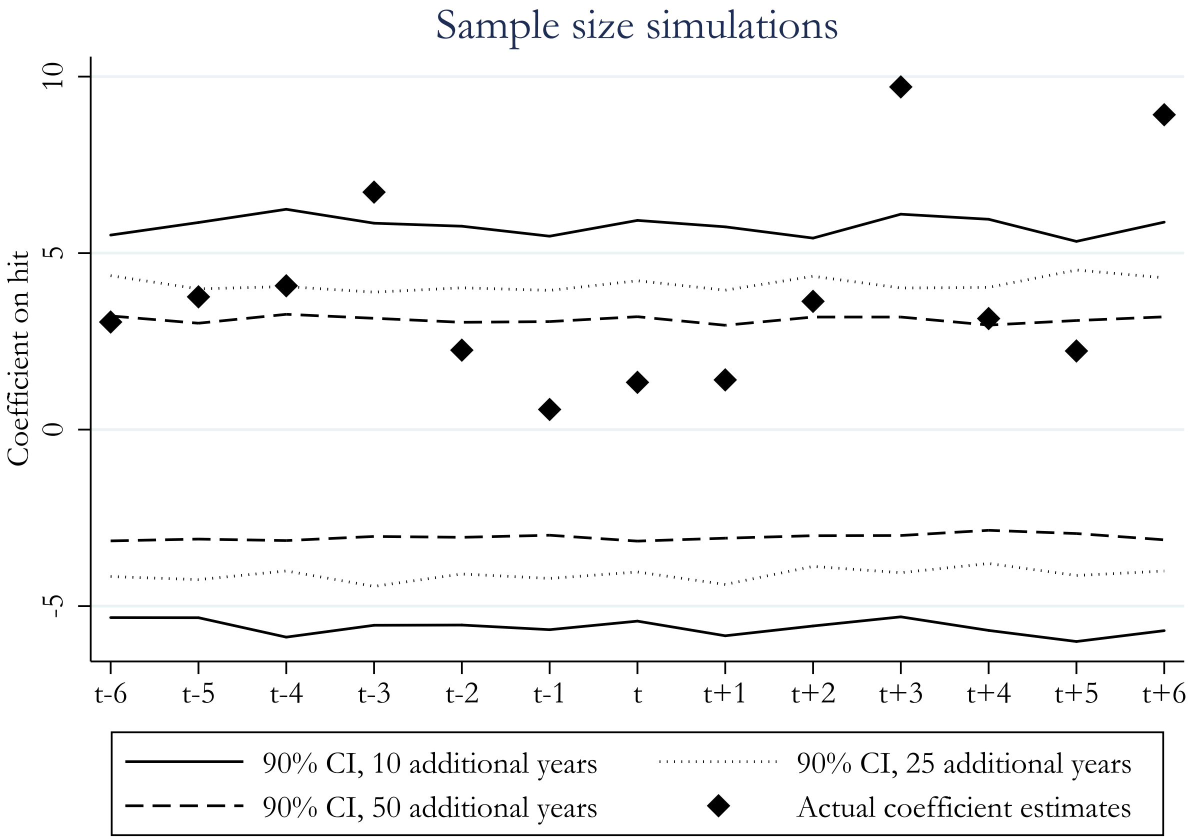


Figure B.3: Descriptive relationship: TTP



sample size. The main results, in which only two lags and none of the leads carry statistically significant coefficients, are based on 12 years of data, and 45 hits and misses on terrorist leaders.

Figure B.4: Sample size simulations



To expand the dataset, I add additional years to the end of the dataset, in five-year increments. Data on terrorist attacks, and drone hits and misses on terrorist leaders for all periods is drawn randomly based on the actual group-specific distribution of these variables. Data on terrorist attacks is drawn from a negative binomial distribution, where parameters r and p differ by terrorist group and are estimated using the actual data. The negative binomial distribution is chosen because it outperforms the Poisson distribution in a likelihood-ratio test for ten of the thirteen groups, and because there is no evidence that a zero-inflated negative binomial distribution outperforms the negative binomial distribution for any of the groups. Data on drone hits and misses is drawn from a binomial distribution, where n equals one and p equals the actual group-specific probability of a drone hit or miss on a terrorist leader respectively.

Draws are repeated one thousand times for each sample size, and specification 1 is run on each simulated dataset. The 5th and 95th percentile of the resulting thousand coefficients demarcate the simulated 90% confidence interval for a given sample size. Figure 8 displays these 90% confidence intervals, together with the main results, the actual coefficient estimates obtained when running specification 1 on the original sample.

Simulations suggest that the sample size would have to be radically expanded to make a meaningful difference to the statistical significance of individual coefficients. Only after expanding the sample with fifty additional simulated years, more than quintupling the original dataset in size, do more coefficients on lags of *hit* gain statistical significance at the 10% level. A similar observation holds for the leads of *hit*, although a single lead gains statistical significance after adding ten additional simulated years to the dataset. Even when radically expanding the dataset, simulations never indicate an immediate (i.e. in the same month, or the month immediately following) effect of a drone hit on a terrorist leader compared to a drone miss. Nor do results of any of the simulations indicate a divergence in trends between a hit and a miss in the two months immediately preceding the drone strike.

B.3 Alternative econometric specifications

Table B.1 investigates the robustness of the main results (reproduced in column 1) to the use of alternative econometric specifications.

Table B.1: Alternative econometric specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				<7 mnths				
	Baseline	Only lags	Only leads	from attempt	Baseline	Baseline	Baseline	nbreg
VARIABLES	Terr.att.	Terr.att.	Terr.att.	Terr.att.	Terr.att.	Terr.att.	Terr.att.	Terr.att.
t	1.339	1.744		1.304	-0.153	1.339	1.339	0.00779
	(4.129)	(4.129)		(4.210)	(2.810)	(2.803)	(3.160)	(0.163)
t+1	1.409	1.253		1.366	-1.468	1.409	1.409	-0.0871
	(4.189)	(4.327)		(4.266)	(2.817)	(3.203)	(3.176)	(0.280)
t+2	3.634	3.588		3.597	1.123	3.634	3.634	0.145
	(4.151)	(4.384)		(4.231)	(2.806)	(3.595)	(3.508)	(0.195)
t+3	9.709**	9.529**		9.644**	6.449**	9.709**	9.709**	0.693
	(4.141)	(4.244)		(4.221)	(2.805)	(4.147)	(4.538)	(0.445)
t+4	3.146	2.809		3.075	0.825	3.146	3.146	-0.0774
	(4.213)	(4.363)		(4.290)	(2.824)	(4.865)	(4.385)	(0.138)
t+5	2.228	1.602		2.137	0.0569	2.228	2.228	-0.230
	(4.100)	(4.315)		(4.177)	(2.762)	(3.593)	(2.947)	(0.178)
t+6	8.921**	6.585		8.764**	7.471***	8.921	8.921*	0.312
	(4.149)	(4.108)		(4.229)	(2.793)	(5.481)	(4.619)	(0.320)
Observations	1,577	1,655	1,655	1,368	1,577	1,577	1,577	1,577
R-squared	0.556	0.557	0.535	0.591	0.766	0.556	0.556	
Includes 6 leads	YES	NO	YES	YES	YES	YES	YES	YES
Group FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	NO	YES	YES	YES
Group-Month trend	NO	NO	NO	NO	YES	NO	NO	NO
Standard errors	N. West	N. West	N. West	N. West	N. West	HAC	Drisc.-Kr.	Clust.
Prob > F lags hit	0.0101	0.0221		0.0154	0.0018	0.2162	0.0677	0.0000
Prob > F leads hit	0.6772		0.6506	0.7132	0.7396	0.7282	0.7803	0.6368
Prob > F lags attempt	0.3475	0.4560		0.3613	0.1525	0.6403	0.7122	0.0729
Prob > F leads attempt	0.9958		0.9828	0.9975	0.9745	0.9735	0.9577	0.0000
Control mean	11.0792	11.0792	11.0792	11.0792	11.0792	11.0792	11.0792	11.0792

Standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

Table B.2: Alternative counterfactuals and further robustness

VARIABLES	(1) Baseline Terr.att.	(2) Cntrfac: drone strike Terr.att.	(3) Cntrfac: leader named Terr.att.	(4) Only < Sept. 2015 Terr.att.	(5) Drop 2 small gr. Terr.att.	(6) Region-Gr.-mnth Terr.att.	(7) Region-Gr.-mnth Terr.att.	(8) Region-Gr.-mnth Terr.att.
t	1.339	2.496	2.803	1.339	2.924	0.0262	0.0262	0.0262
	(4.129)	(3.035)	(3.276)	(4.129)	(5.473)	(1.263)	(0.945)	(1.283)
t+1	1.409	2.068	2.871	1.409	3.969	0.375	0.375	0.375
	(4.189)	(3.091)	(3.361)	(4.189)	(5.573)	(1.267)	(0.947)	(1.287)
t+2	3.634	6.043**	7.464**	3.634	7.792	0.999	0.999	0.999
	(4.151)	(3.071)	(3.356)	(4.151)	(5.539)	(1.229)	(0.926)	(1.249)
t+3	9.709**	8.127***	10.18***	9.709**	14.42***	1.870	1.870**	1.870
	(4.141)	(3.074)	(3.360)	(4.141)	(5.566)	(1.262)	(0.948)	(1.282)
t+4	3.146	4.481	5.364	3.146	8.808	0.233	0.233	0.233
	(4.213)	(3.145)	(3.381)	(4.213)	(5.690)	(1.332)	(0.989)	(1.354)
t+5	2.228	0.909	1.113	2.228	5.969	-0.221	-0.221	-0.221
	(4.100)	(3.211)	(3.462)	(4.100)	(5.356)	(1.318)	(0.979)	(1.340)
t+6	8.921**	7.252**	8.357**	8.921**	16.72***	1.950	1.950*	1.950
	(4.149)	(3.184)	(3.436)	(4.149)	(5.259)	(1.400)	(1.054)	(1.423)
Observations	1,577	1,577	1,577	1,577	1,313	6,308	6,308	6,308
R-squared	0.556	0.559	0.567	0.556	0.569	0.171	0.536	0.198
Group FE	YES	YES	YES	YES	YES	YES	NO	YES
Period FE	YES	YES	YES	YES	YES	YES	YES	NO
Region FE	NO	NO	NO	NO	NO	YES	NO	NO
Region-group FE	NO	NO	NO	NO	NO	NO	YES	NO
Region-period FE	NO	NO	NO	NO	NO	NO	NO	YES
Prob > F lags hit	0.0101	0.0077	0.0025	0.0101	0.0013	0.0424	0.00755	0.0464
Prob > F leads hit	0.6772	0.2845	0.0879	0.677	0.2125	0.269	0.125	0.282
Prob > F lags attempt	0.3475			0.347	0.2419	0.595	0.460	0.606
Prob > F leads attempt	0.9958			0.996	0.9856	0.948	0.908	0.951
Control mean	11.0792	11.0792	11.0792	11.08	11.0792	3.153	3.153	3.153

Newey-West standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

To investigate whether the joint statistical significance of the coefficients on the lags *hit* is an artefact of the inclusion of the leads of *hit*, column 2 presents the main results excluding all lead variables. Main results are unaffected. Similarly, the lack of joint statistical significance of the coefficients on the leads of *hit* does not depend on the inclusion of the lags of *hit* (column 3). Column 4 restricts the analysis to periods within 6 months of a drone attempt on the terrorist leader of some group. Again, results are unaffected. The model in column 5 includes linear group-time trends instead of period-fixed effects, giving results very similar to the main results. As column 6 shows, results are somewhat sensitive to using HAC instead of Newey-West standard errors: although the third lag of *hit* is still statistically significant at the 5% level, the coefficients on lags are no longer jointly statistically significant. Main results are robust to using Driscoll-Kraay standard errors (column 8).

Column 7 displays the results obtained when running specification 1 on an expanded sample, adding all terrorist organizations that committed more than one terrorist attack in Afghanistan or Pakistan over the research period. This specification employs HAC standard errors, as adding these observations introduces strong heteroskedasticity. Results resemble the main results closely. However, similar to previous results employing HAC standard errors, lags of *hit* are no longer jointly statistically significant.

Since the number of terrorist attacks can be considered count data, column 9 estimates specification 1 using a negative binomial instead of a linear probability model. None of the resulting individual coefficients on lags of *hit* are statistically significant. However, they are strongly jointly statistically significant (p-value < 0.0000).

Table B.2 presents a final set of robustness checks. Drone misses are measured with error: a leader may have been targeted by a particular drone strike, but this may be unobserved by the media or the BIJ. Hence one may be concerned that the main results are an artefact of this measurement error. Therefore, columns 2 and 3 investigate alternative counterfactuals for a drone hit that may be more easily observed. In column 2 any drone strike not killing a terrorist leader is taken as a counterfactual. In column 3, any drone strike in which a leader is named, but not necessarily targeted is considered a counterfactual. These include drone strikes targeting militants closely associated with the leader, locations associated with the terrorist leader – commonly a known residence – or family members of the terrorist leader. Coefficient estimates on *hit* are similar to those obtained in the baseline model (column 1), and they are strongly jointly statistically significant (1% level). These are not the preferred specifications however, as it becomes more difficult to substantiate the parallel trends assumption. In column 3 leads of *hit* are jointly statistically significant, albeit only at the 10% level. Perhaps unsurprisingly, groups that have their militants but not their leaders (or individuals or locations associated with their leaders rather than their leaders themselves) targeted may already commit an increasing number of terrorist attacks prior to a drone strike.

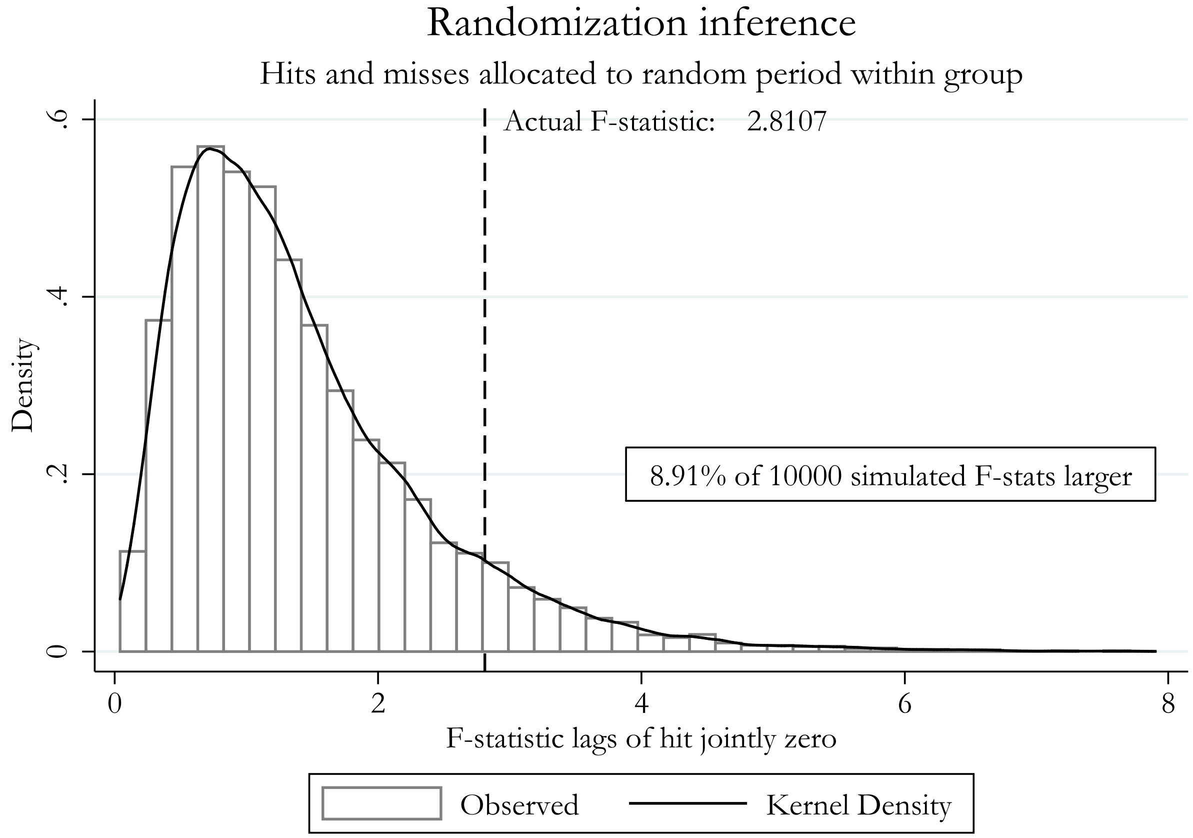
Results are unaffected when excluding periods after September 2015, the month in which the Pakistani military acquired its own weaponized drones (Column 4).

Some may be concerned that the probability of a hit on a terrorist leader conditional on an attempt is different for the leaders of large compared to small terrorist groups and that these small groups would somehow drive the main results. However, main results are robust to excluding two groups which commit substantially fewer attacks, the Haqqani network and Harkat-ul-Jihad-al-Islami (column 5).

Up to this point, the dependent variable in all regressions is an aggregation of all terrorist attacks committed by a group globally. One might worry about the existence of region-time specific factors (for instance holidays or other occasions which may be a target of terrorist groups) that could be correlated to level of effort to hit leaders of groups active in these regions. One might have similar worries about group-region specific factors, such as differential ability of groups to commit terrorist attacks in different regions. Therefore, the final three columns of Table B.2 re-estimates the baseline model at the group-region-month level, distinguishing four regions (Western Europe, the US and Australia, Asia, Middle East and North Africa). Models include region-fixed effects (column 6), region-time fixed effects (column 7) and region-group fixed effects (column 8) respectively. Estimates for these three models are extremely similar, as there is limited variation across regions between groups (many groups commit terrorist attacks only in a single region) and limited variation over time across regions (two regions do not experience any terrorist attacks in most time periods). In all three models, the size of the coefficients decreases, as these now represent the impact of a drone hit per month, group and region, and they are not individually statistically significant in columns 6 and 8. However, coefficients on lags of *hit* are jointly statistically significant in each of the three models.

B.4 Randomization inference

Figure B.5: Results from randomization inference

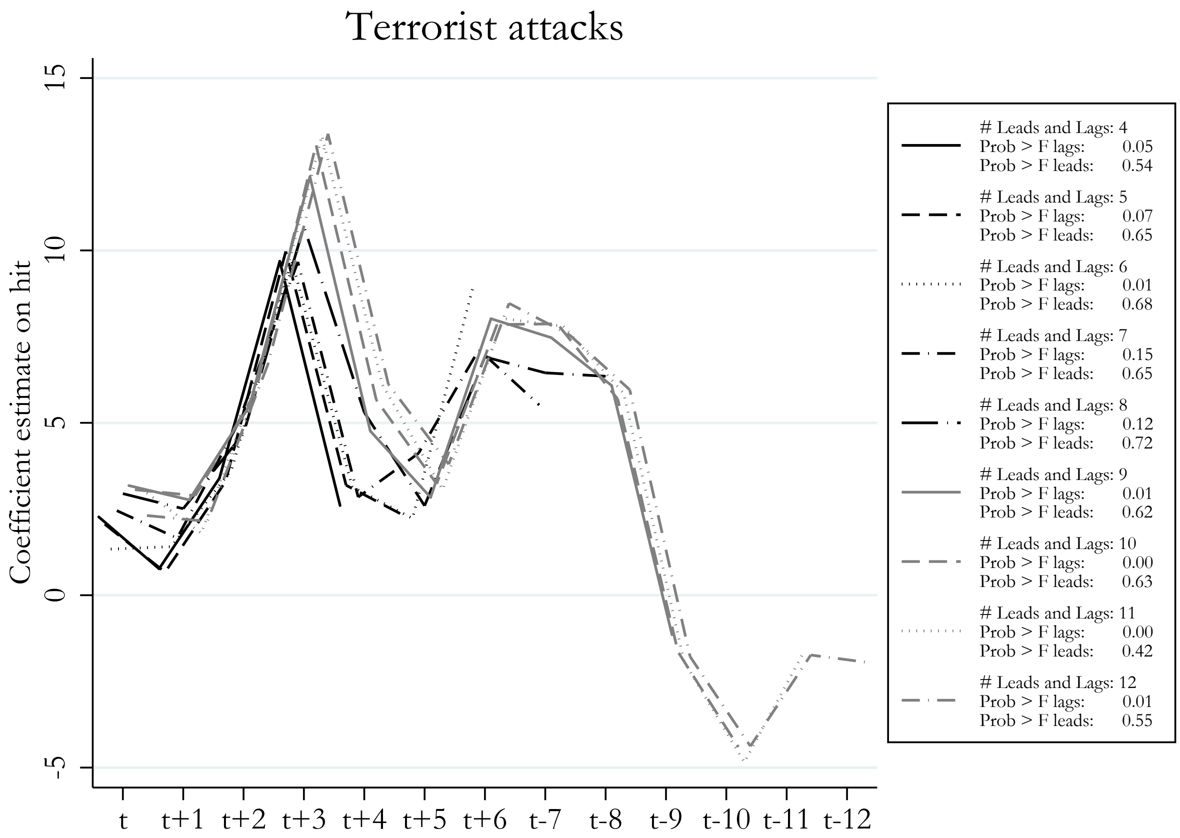


The empirical strategy in the main paper can be considered a quasi-experiment with a small number of clusters (i.e. terrorist groups), an outcome variable with a non-normal distribution (i.e. terrorist attacks) and several treatment coefficients (i.e. lags of *hit*). Under these circumstances, we may worry that either outliers or multiple testing can lead to false conclusions regarding the statistical significance of the main results (Young, 2017)). Figure B.5 therefore presents the results from randomization inference. Within each terrorist group, I allocate the number of drone hits and misses found in the data randomly to some time period and calculate the F-statistic for the joint significance of the lags of *hit* in specification (1). Doing this repeatedly gives an indication of how exceptional the main results are in a universe of 10,000 possible random assignments of the 'treatment'. I find an F-statistic greater or larger than the one observed for the main results in 8.91% of random assignments. This test statistic suggests coefficients on the lags of *hit* are jointly statistically significant, albeit only at the 10% level.

B.5 Alternative numbers of leads and lags

Figure B.6 illustrates that main results are not an artefact of choosing six as the particular number of leads and lags of the variables of interest to include. The figure plots the coefficient estimates on the lags of *hit* in specification 1, varying the number of leads and lags of *hit* and *attempt* included between four and twelve. It also shows the results of an F-test for joint significance of all lags and leads of *hit* respectively. Coefficient estimates are similar across the nine models. The leads of *hit* are jointly insignificant in each case: none of the models suggest that the parallel trends assumption has been violated. In all but two of the models, the lags of *hit* are jointly statistically significant at conventional levels. Apart from those two exceptions, each model presented suggests the number of terrorist attacks increases after a drone hit on a terrorist leader compared to after a drone miss.

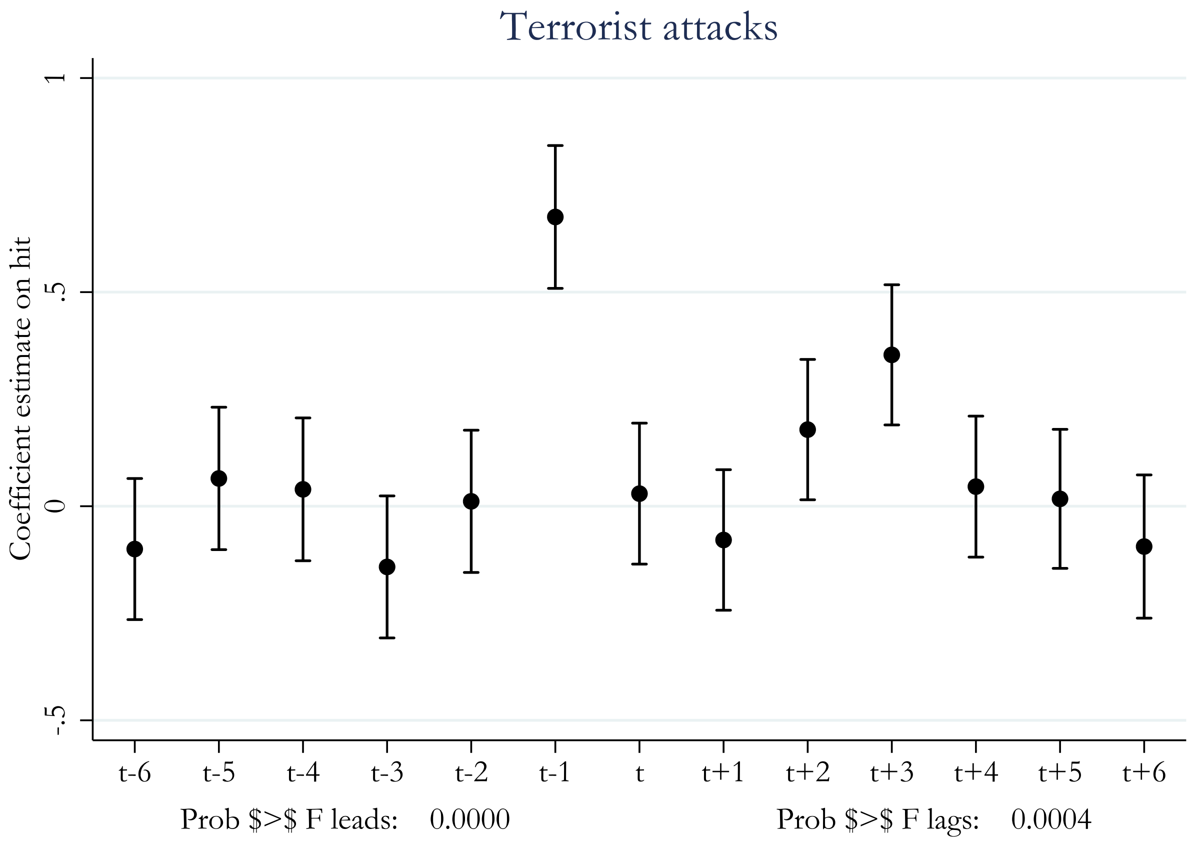
Figure B.6: Alternative numbers of leads and lags



B.6 Graph of results on infighting

Figure B.7 shows graphically the results on infighting presented in section 6.1 of the main text. It shows that the leads of *hit* are strongly jointly statistically significant, but that this is driven by the first lead of *hit*. Closer examination reveals that this is not an artefact of a single outlier. Therefore, results on infighting should be treated with some caution. However, there is no evidence that trends in infighting differ between a hit and a miss prior to a drone strike for any other time period.

Figure B.7: Infighting



C Drone hits on parent groups and affiliate attacks

C.1 Analysis by attack type

The increase in terrorist attacks by affiliates, following a drone strike killing the leader of their parent group, that is observed in the main text is driven by an increase in attack types across the board. Table C.1, showing results at the group-month level, and Table C.2, showing results at the affiliate-month level, suggest that a drone hit is associate with an increase in terrorist attacks on military, private, and civilian targets, and terrorist attacks with a US citizen killed our wounded. There is little evidence that a drone hit on the parent group decreases affiliate capacity: the percentage of 'successful' terrorist attacks by affiliates does not decrease significantly following a drone hit, nor does the mean number of victims per attack. A number of coefficients on *hit* enter the group-month level regression with the mean number of victims per attack as dependent variable significantly, but those coefficients are not jointly statistically significant (column 2 of Table C.1).

Table C.1: Type of affiliate attack (group-month level)

VARIABLES	(1) % success Affil.att.	(2) mean # vics. Affil.att.	(3) US vic. Affil.att.	(4) Civilian Affil.att.	(5) Private Affil.att.	(6) Military Affil.att.
t	-0.253	3.219*	0.248	25.92**	8.227	15.70**
	(0.879)	(1.721)	(0.201)	(12.59)	(5.016)	(6.835)
t+1	0.948	-0.950	0.773***	18.71	8.706*	10.20
	(0.881)	(1.720)	(0.203)	(12.84)	(5.119)	(6.964)
t+2	0.790	2.456	0.0306	31.26**	14.25***	14.79**
	(0.879)	(1.716)	(0.202)	(12.69)	(5.061)	(6.886)
t+3	1.280	-0.641	0.547***	30.88**	12.42**	18.82***
	(0.880)	(1.718)	(0.202)	(12.65)	(5.046)	(6.864)
t+4	0.402	0.724	0.198	40.40***	12.76**	21.52***
	(0.884)	(1.715)	(0.203)	(12.94)	(5.157)	(7.012)
t+5	-0.206	-2.907*	0.541***	24.80**	7.327	12.97*
	(0.863)	(1.690)	(0.199)	(12.55)	(5.002)	(6.805)
t+6	0.728	-3.683**	0.0556	30.82**	10.87**	15.40**
	(0.886)	(1.749)	(0.204)	(12.62)	(5.033)	(6.849)
Observations	1,577	1,577	1,577	1,577	1,577	1,577
R-squared	0.406	0.439	0.461	0.592	0.560	0.552
Model	Gr.-mnth	Gr.-mnth	Gr.-mnth	Gr.-mnth	Gr.-mnth	Gr.-mnth
Group FE	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES
Prob > F lags hit	0.6556	0.1409	0.0010	0.0273	0.0543	0.0607
Prob > F leads hit	0.0180	0.1366	0.1348	0.1328	0.1884	0.0193
Prob > F lags attempt	0.6030	0.4995	0.1710	0.1215	0.5005	0.0433
Prob > F leads attempt	0.8360	0.2501	0.4050	0.4817	0.5797	0.8658
Control mean	0.9817	7.3329	0.5149	46.6436	18.1584	19.3564

Newey-West standard errors in parentheses
* p<0.1 ** p<0.05 *** p<0.01

Table C.2: Type of affiliate attack (affiliate-month level)

VARIABLES	(1) % success Affil.att.	(2) mean # vics. Affil.att.	(3) US vic. Affil.att.	(4) Civilian Affil.att.	(5) Private Affil.att.	(6) Military Affil.att.
t	0.0246	0.507	0.0156	1.567*	0.587*	1.066**
	(0.0265)	(0.398)	(0.0165)	(0.858)	(0.351)	(0.475)
t+1	0.0228	0.235	0.0581***	0.779	0.438	0.560
	(0.0266)	(0.398)	(0.0165)	(0.872)	(0.356)	(0.481)
t+2	-0.00983	0.291	0.0125	1.933**	0.832**	0.909*
	(0.0266)	(0.397)	(0.0165)	(0.876)	(0.358)	(0.484)
t+3	0.0189	0.252	0.0536***	2.186**	0.793**	1.298***
	(0.0268)	(0.399)	(0.0167)	(0.889)	(0.363)	(0.490)
t+4	0.0510*	0.303	0.0238	3.135***	1.115***	1.630***
	(0.0272)	(0.400)	(0.0169)	(0.925)	(0.377)	(0.510)
t+5	-0.00410	-0.398	0.0398**	2.164**	0.629*	1.182**
	(0.0268)	(0.397)	(0.0166)	(0.892)	(0.364)	(0.492)
t+6	0.0367	-0.537	-0.00377	2.756***	1.094***	1.458***
	(0.0259)	(0.390)	(0.0161)	(0.834)	(0.340)	(0.461)
Observations	7,776	7,776	7,776	7,776	7,776	7,776
R-squared	0.436	0.111	0.262	0.407	0.341	0.368
Model	Affil.-mnth	Affil.-mnth	Affil.-mnth	Affil.-mnth	Affil.-mnth	Affil.-mnth
Group FE	NO	NO	NO	NO	NO	NO
Period FE	YES	YES	YES	YES	YES	YES
Affiliate FE	YES	YES	YES	YES	YES	YES
Prob > F lags parent hit	0.2819	0.7653	0.0000	0.4935	0.0876	0.6728
Prob > F leads parent hit	0.2819	0.7653	0.0000	0.4935	0.0876	0.6728
Prob > F lags parent attempt	0.9444	0.8290	0.2729	0.3287	0.5774	0.2186
Prob > F leads parent attempt	0.5002	0.1196	0.6808	0.8486	0.5104	0.9074
Prob > F lags affil. hit	0.7013	0.2413	0.0000	0.0382	0.1352	0.0028
Prob > F leads affil. hit	0.2819	0.7653	0.0000	0.4935	0.0876	0.6728
Control mean	0.1695	1.0313	0.0209	2.0341	0.7530	0.8649

Newey-West standard errors in parentheses

* $p<0.1$ ** $p<0.05$ *** $p<0.01$