Drones, Surveillance, and Violence: Theory and Evidence from a US Drone Program

Asfandyar Mir* Dylan Moore†

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Abstract

We investigate the impact of the US drone program in Pakistan on insurgent violence. Using novel details about US-Pakistan counterterrorism cooperation and geocoded violence data, we show that the program was associated with monthly reductions of around 9-13 insurgent attacks and 51-86 casualties in the area affected by the program. This change was sizable as in the year before the program the affected area experienced around 21 attacks and 100 casualties per month. Additional quantitative and qualitative evidence suggests that this drop is attributable to the drone program. However, the damage caused in strikes during the program cannot fully account for the reduction. Instead, *anticipatory effects* induced by the drone program played a prominent role in subduing violence. These effects stemmed from the insurgents' perception of the risk of being targeted in drone strikes; their efforts to avoid targeting severely compromised their movement and communication abilities, in addition to eroding within-group trust. These findings contrast with prominent perspectives on air-power, counterinsurgency, and US counterterrorism, suggesting select drone deployments can be an effective tool of counterinsurgency and counterterrorism.

*Corresponding Author: Postdoctoral Fellow, CISAC, Stanford University, alimir07@stanford.edu. For helpful comments, the authors would like to thank Christopher Clary, Martha Crenshaw, C. Christine Fair, James Fearon, Andrea Gilli, Mauro Gilli, Gemma Staton-Hagan, Sana Jaffrey, Ethan B. Kapstein, Sameer Lalwani, John Mearsheimer, Robert Pape, MJ Reese, Jacob Shapiro, Paul Staniland, Monica Toft, Kevin Weng, Jeremy Weinstein, Amy Zegart, the editors of ISQ, numerous anonymous reviewers, and participants of seminars at the 2018 Annual Meeting of American Political Science Association, CISAC Social Science Seminar, Empirical Studies of Conflict Lab Meeting, Stanford Security Working Group, University of Chicago Program on International Security Policy, and the Stimson Center. Asfandyar Mir thanks University of Chicago Committee on Southern Asia Studies and the Social Science Division for financial support for data collection and fieldwork. All remaining errors are those of the authors alone.

†PhD Student, University of Michigan, dtmoore@umich.edu

Introduction

Drones are central to US counterinsurgency and counterterrorism strategies across Africa, Middle East, and South Asia. Other powerful states are also heavily investing in drones (Zegart 2015; Horowitz, Kreps, and Fuhrmann 2016; Fuhrmann and Horowitz 2017). Motivated by this salience, scholars have examined the effects of drone strikes on insurgent violence, patterns of insurgent violence, propaganda output, interest in *jihadi* literature, and radicalization patterns (Smith and Walsh 2013; Abrahms and Potter 2015; Nielsen 2016; Johnston and Sarbahi 2016; Shah 2018). Yet, disagreement persists about effectiveness of drones against asymmetric threats. While some scholars argue that drones can provide states with important advantages (Byman 2013; Horowitz, Kreps, and Fuhrmann 2016; Mir 2018), many question their efficacy for counterinsurgency and counterterrorism (Kilcullen and Exum 2009; Boyle 2013; Jordan 2014; Hazelton 2017; Pape 2017). A separate literature on conventional air-power shows that air strikes against insurgents are counterproductive in the local battlefield (Kocher, Pepinsky, and Kalyvas 2011; Dell and Querubin 2017).

This study contributes to the growing literature on drones by assessing the impact of a *drone program* on insurgent violence. Specifically, it tests the program implemented by the US government in select regions of Pakistan's insurgency-affected Federally Administered Tribal Areas (FATA) beginning in 2008. Drawing on novel details obtained from interviews with key officials, we posit that the program was enabled by continuous aerial surveillance, wide-ranging communication interception, abundance of analysts for processing technical/human intelligence gains, and unilateral targeting authority. US counterterrorism operators believe that such capabilities are essential to successful operations in insurgent safe havens and weak states.[1] Given this, we fill an important gap in the literature by investigating a program achieving such capabilities, especially as its impact as a coherent whole might differ from the sum of its parts.

Our analysis relies on the fact that, under the terms of a covert agreement between the US and Pakistani governments, the capabilities of the program were restricted to a "flight box" over the Waziristan region. Within that area, beginning in January 2008, the US government retained independent authority to undertake strikes as well as large-scale surveillance. Using newly geocoded data on violence in

1. Regarding the importance continuous of aerial surveillance and communication interception, see: Task Force (2013, 12) and Flynn, Juergens, and Cantrell (2008). On the role of intelligence analysts, see: Lin-Greenberg (2018). On the value of devolved targeting authority, see Savage and Schmitt (2017). On synergy between such capabilities, see: Shultz (2017).

Pakistan, we compare the evolution of insurgent violence before and after the launch of the US drone program inside North Waziristan to that elsewhere in FATA. We find that the program corresponds with a reduction in violence on the order of 9 to 13 insurgent attacks per month and 51 to 86 casualties per month. If this change is attributable to the program, it suggests a sizable effect; in the year before implementation, the region experienced 21 attacks and resultant 100 casualties in an average month. We clarify the assumptions under which our data are consistent with a negative causal impact of the program on insurgent violence and evaluate their plausibility in light of both qualitative and quantitative evidence.

Our key contribution is investigating the impact of the drone program holistically whereas previous empirical work on air-power and drones has focused on the effect of individual strikes. For example, Johnston and Sarbahi (2016) show that drone strikes in Pakistan were correlated with short-run reductions in violence. We provide suggestive evidence that this approach may substantially underestimate the impact of US counterterrorism in Pakistan: Only about 25% of the negative association between the drone program and insurgent violence which we document can be explained by the aggregated effects of individual strikes. To our knowledge, this is the first empirical finding in the literature suggestive of an important role of capabilities like surveillance that enable strikes in counterinsurgency and counterterrorism operations.

We explain our findings as resulting from insurgent degradation under the drone program. The security studies literature largely focuses on the killing of leaders and rank-and-file to explain consequences of targeting—which we call *kinetic* effects. Although such kinetic effects are clearly important to diminishing targeted groups, we argue that our empirical findings are best understood as the result of both kinetic and *anticipatory* effects. Targeting programs which leverage large-scale surveillance and rapid exploitation of intelligence—as the program in Pakistan did—can substantially increase insurgents' perception of the risk associated with activities they believe might precipitate strikes. The resulting changes in insurgent behavior to avoid targeting constitute anticipatory effects. They include three major changes in insurgent life: restricted movement, constrained communication, and compromised intra-group trust. We contend that these changes prevented formidable armed groups like Al-Qaeda and the Pakistan Taliban from meaningfully adapting to the drone program. Novel qualitative evidence, including some testimonies of members of Al-Qaeda and the Pakistan Taliban, support this view.

1 Theoretical Perspectives

We conceptualize a drone program as a campaign which seeks to identify and swiftly target insurgents using sustained aerial surveillance, advanced communication interception, intelligence analysts, and devolved targeting authority. Such a program can plausibly shape an important feature of insurgent politics: violence. Below, we synthesize and extend existing theoretical work to predict the effect of a program on insurgent violence.

1.1 Drone Program as an Antagonist to Violence

We locate the drone program's ability to undermine an insurgency in its particular tactical, technological, and organizational capabilities.[2] Consider the US government's ideal drone deployment. Such deployments utilize intelligence, surveillance and reconnaissance (ISR) drones—often combined with precise weapons delivery platforms—to monitor the civilian population and generate leads on the insurgency (Flynn, Juergens, and Cantrell 2008; Task Force 2013). In addition, communication interception is an important complement to such platforms. The US government uses a variety of technical tools to identify the location of communication devices, and determine the content being communicated between them (Arkin 2015). One such technology is *Gilgamesh* – which "is attached to unmanned Predator and even larger Reaper drones, where it performs a very specific task in "signals intelligence," seeking out the faintest and most fleeting of buried digits emanating from the contemporary netherworld" (Arkin 2015). This type of technological surveillance is often combined with human intelligence derived from interrogations of insurgents, networks of paid spies, and informants available to local partners (McChrystal 2013, 199).

The US government's select drone deployments are able to exploit leads from surveillance sources to generate actionable information, and quickly act upon that information. They achieve this by drawing on plentiful analysis and collation paraphernalia to follow up on leads (Lin-Greenberg 2018). Select deployments are also empowered to undertake targeting by extensive legal and political authority and rapidly deployable striking platforms. If engaged in surveillance, platforms like the MQ-1 Predator and MQ-9 Reaper can be readily re-purposed for precise targeting (Task Force 2013, 12-16).

We claim the combined effect of these capabilities can reduce insurgent violence through two mech-

2. Not all drone deployments are accompanied by such capabilities. See Task Force (2013, 12-16)

anisms: *kinetic* effects and *anticipatory* effects.[3] Kinetic effects consist of damage to insurgent organizations directly caused by drone strikes such as leadership decapitation, rank-and-file attrition, lost capabilities, and casualties of civilian supporters. Such effects have been extensively examined in studies of air-power, counterinsurgency, and leadership decapitation (Pape 1996; Jordan 2009; Johnston 2012; Price 2012; Long 2014; Johnston and Sarbahi 2016). A drone program which swiftly exploits intelligence generated by surveillance is likely to generate extensive kinetic effects, which can reduce insurgent violence.

In addition to kinetic effects, anticipatory effects undermine insurgency violence by inducing changes to their perception of the risk of being targeted rather than by physical damage in strikes. This mechanism has received less attention in debates on air-power, counterinsurgency, and drones. Scholars of population-centric counterinsurgency focus more on variation in civilian support and less on sources of insurgent organizational fragmentation (Berman, Shapiro, and Felter 2011; Berman and Matanock 2015; Shaver and Shapiro, Forthcoming). Within existing work on drones, Johnston and Sarbahi (2016) and Byman (2013) discuss ideas pertaining to anticipatory effects. Johnston and Sarbahi (2016, 206), for example, argue that "...drone strikes in an area represent a meaningful indication of an increased security risk to militants." However, they do not elaborate on how such a mechanism might undermine an insurgency.

Under a drone deployment with the surveillance and targeting capabilities described above, we believe insurgents are likely to anticipate being targeted and adjust their behavior accordingly. Although any campaign by state forces might produce such effects, a drone program's sustained surveillance and swiftly executed strikes may produce especially high levels of perceived risk of targeting. Insurgents may feel compelled to significantly adjust their organizational practices to mitigate the threat posed by a drone program, inducing changes in the way they move, communicate, and interact within their group in a bid to avoid targeting. If insurgents feel that their movements may produce detectable patterns that precipitate strikes they may reduce activities such as patrolling, picketing, or organizing sabotage in the open in a bid to avoid detection. Communication involving radios or mobile and satellite phones may prove difficult to maintain once insurgents come to realize that interception of communication devices can provide cues about their locations. Intra-group trust may break down altogether; leaders and rank-and-file may exercise increased caution in all interactions—even within their own ranks—due to concerns of infiltration.

Our first hypotheses are motivated by both the kinetic and anticipatory mechanisms:

3. For a theoretical discussion of the sources of such effects, see: Mir (2018)

Hypothesis 1a *All else being equal, violence decreases during the operation of the drone program*

Hypothesis 1b *All else being equal, individual drone strikes will be followed by a reduction in violence*

Hypothesis 1b follows from our discussion of the kinetic effects of the drone program. We expect most individual drone strikes to inflict some form of kinetic damage on insurgent organizations, thereby having the potential to reduce violence. As this hypothesis has been examined in the literature , we primarily focus on hypothesis 1a which can be motivated by both mechanisms (Johnston and Sarbahi 2016; Abrahms and Potter 2015). Regarding kinetic effects, note that if individual strikes reduce violence in the short-run a program involving the repeated execution of strikes will reduce violence for at least as long as it is active. Furthermore, some individual strikes may produce kinetic damage that persists well into the future. In addition, the anticipatory effects mechanism may separately undermine violence once insurgents become aware of heightened surveillance and its efficacy in targeting. It may also amplify damage due to the kinetic effects and limit insurgents' ability to recover from such damage.

1.2 Drone Program as a Catalyst for Violence

There are potential countervailing forces which may offset the kinetic and anticipatory effects of a drone program. For example, groups may find ways to adapt to the existence of the program. This suggests the following alternative hypotheses:

Hypothesis 2a *All else being equal, violence does not change during the operation of the drone program*

Hypothesis 2b *All else being equal, violence decreases during the early stages of the drone program but reverts (partially or completely) towards pre-program levels in the long-run*

Prospects of successful adaptation may depend on a targeted group's intrinsic *type*. An important literature on civil war posits that outcomes of targeting insurgent groups are conditioned by the group's characteristics. Scholars argue that some armed groups possess attributes like social bases, quality recruits, institutionalization, networks, and prior experiences of selective violence that make them both resilient and dynamic (Weinstein 2006; Staniland 2014; Long 2014; Jordan 2014; Finkel 2015; Toft and Zhukov 2015). We might expect such groups to quickly recover when harmed and overtime learn how to operate effectively despite the program.

Another countervailing force stems from civilian behavior. The literature on counterinsurgency and civil war suggests that civilian behavior is of strategic importance in wartime (Kalyvas 2006; Berman and

Matanock 2015). This literature views civilians as central conduits of information in irregular warfare, affording the side they collaborate with an informational advantage and in turn an advantage in undertaking violence (Berman, Shapiro, and Felter 2011). Some scholars argue that attaining civilian cooperation is a function of levels of security, service provision, and collateral damage (Berman, Shapiro, and Felter 2011; Condra and Shapiro 2012; Kocher, Pepinsky, and Kalyvas 2011). If the drone program harms the civilian population—as many analytical accounts of US drone deployments suggest—we might expect it to increase civilian support in favor of the insurgency. In turn, this may diminish the effectiveness of the program. This provides another motivation for hypotheses 2a and 2b.[4]

Civilians might also join combat in response to victimization by political actors (Lichbach and Gurr 1981; Goodwin 2001; Wood 2003). Wood (2003, 235) provides an influential elaboration of this logic, arguing that victimized civilians may join the insurgency as a way to express their agency. An important body of scholarly work, press accounts, and human rights reports suggest that drones increase sympathy for insurgents by triggering sentiments of revenge in the civilian population (Clinic and NYU School of Law 2012; Lamb, Woods, and Yusufzai 2012; International 2013; Boyle 2013; Cronin 2013).[5] This mechanism provides further support for hypotheses 2a and 2b, as well as an additional hypothesis:

Hypothesis 3 *All else being equal, violence increases during the operation of the drone program*

2 US Drone Program in Pakistan: Background

We examine the impact of drones by studying the conflict in Pakistan's tribal region—the Federally Administered Tribal Areas (FATA)—involving Al-Qaeda and the Pakistan Taliban from 2003 to 2011. After 9/11, a coalition of Al-Qaeda and local armed groups took root in the region and sought to overturn the Pakistani state through irregular warfare. The conflict offers a unique opportunity to analyze the effects of a *drone program*, launched by the US government in one district of the FATA: North Waziristan

4. See Investigative Journalism (2017) on civilian casualties. The US government concedes 117 civilian deaths from 2009 to 2016. See: Director of National Intelligence (2016)

5. Tahir (2015) makes a powerful argument that practice and criteria of drone strikes is akin to colonial collective punishment practices. Shah (2018) challenges the view that drone strikes increase radicalization at the local level. Fair (2014) and Fair, Kaltenthaler, and Miller (2015) suggest that to the extent anti-Americanism exists in Pakistan it is not due to drone strikes alone.

Agency.[6] In this section, we summarize important details on the program using evidence gathered from multi-sourced interviews, including with critical officials in the US and Pakistani governments. As the campaign in Pakistan unfolded under United States Code Title 50, which substantially restricts the release of official records, interview data was the most viable way to obtain this information.[7]

In January 2008, the US government launched a targeting program enabled by pervasive surveillance of the North Waziristan Agency. According to a senior US official from the period, the campaign involved daily aerial surveillance along with "full-motion video" analysis, communication interception sensors, and a sizable bureaucracy of analysts dedicated to deriving actionable information from available leads.[8] A former Pakistani official from the Counterterrorism (CT) division of the ISI who coordinated the drone program with the US government noted that these capabilities were realized following a January meeting between General Pervez Musharraf, President of Pakistan, and US intelligence chiefs Michael Hayden, Director CIA, and Michael McConnell, Director National Intelligence.[9] At this meeting, Musharraf approved an expanded counterterrorism campaign in the tribal areas, apparently motivated by a desire to retain US support while confronting pressure from domestic political actors calling for his resignation in the aftermath of the December 27, 2007 killing of Pakistani politician Benazir Bhutto. A Pakistani intelligence official from the period noted that "Musharraf was under tremendous pressure at the time" and the "...American delegation's visit right after Benazir Bhutto's death gave them the pretext to press General Musharraf on drone strikes being the way forward."[10]

Following the meeting, Pakistani military negotiators led by General Ashfaq Kayani—and including representatives of Pakistan's nuclear bureaucracy, the Strategic Plans Division—finalized the parameters

6. Drone operations also occurred in South Wazirstan Agency but we exclude it from our analysis for reasons discussed below. For politics of the conflict in FATA, see: Staniland, Mir, and Lalwani (2018)

7. This draws on 66 interviews conducted under University of Chicago IRB protocol no: IRB 16-0234. Identities of respondents withheld for reasons of safety. FOIA requests submitted to Director National Intelligence (DF-2016-00300), CIA (F-2017-01836), and US CENTCOM/Air Force Central Command (USCENTCOM 17-0486) have yet to yield information.

8. This official, uniquely positioned to comment on US counterterrorism campaigning, emphasized that the US campaign in Pakistan was exceptional in the scale of available resources and associated capabilities in the period from 2008 to 2014; on follow-up questions seeking clarification and comparison, the official noted that to her/his knowledge, not even half of similar capabilities were realized in Yemen, at least until 2014.

9. Interview Islamabad, Pakistan, 2016. Broad account confirmed in interviews with US officials.

10. Interview retired ISI Official, 2016

of an improved intelligence sharing arrangement. The foundation for this arrangement was provided by a 2004 agreement between the Pakistani and US governments permitting limited US drone deployment within FATA. Back then, operations were confined to two demarcated "flight boxes"—depicted in figure 1—and required advance authorization from Pakistani authorities.[11]

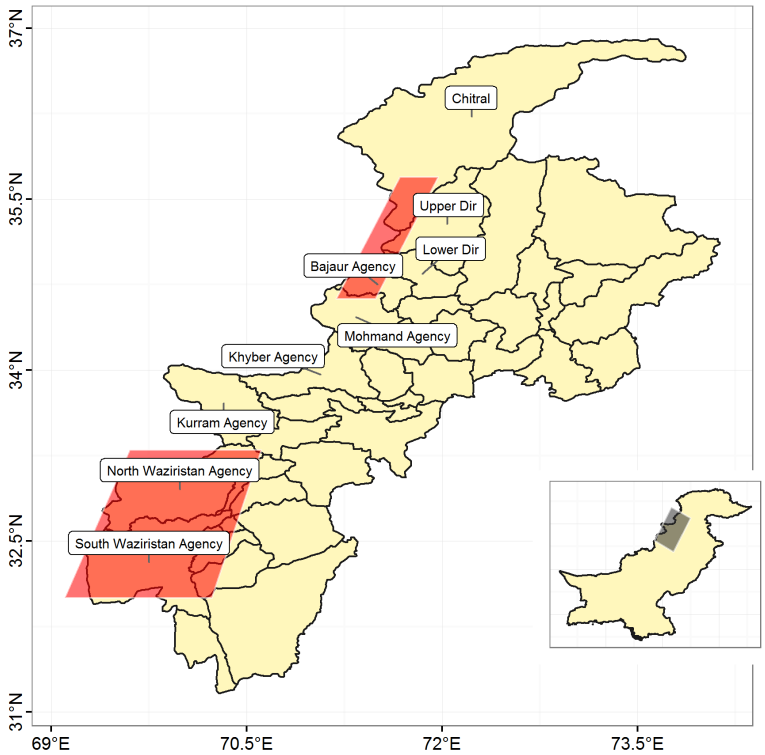


Figure 1: Map of FATA. Insert shows map of Pakistan. The shaded areas were first demarcated as flight boxes in 2004. In 2008, the program was implemented in the southern box; the northern box was de-activated at this time. These boundaries are estimates adapted from a map hand-marked by a Pakistani intelligence official privy to the demarcation. Two US officials confirmed these boundaries.

The new agreement in 2008 allowed continuous reconnaissance and kinetic targeting within only the southern box, covering the Waziristan regions. Pakistani military negotiators denied US requests to extend the box over Waziristan and revoked the northern box—covering Bajaur Agency—to minimize the risk of public backlash US presence in Pakistan might bring.[12] Both in 2004 and 2008, Pakistani negotiators worried that the US government might use unrestrained surveillance capacity to spy on proximate sites of Pakistan's nuclear program, offices of ISI detachments suspected to be aiding the Haqqani

11. Flight boxes have been previously discussed by Mazzetti (2013, 108).

12. In addition to Bajaur, the northern flight box included parts of Dir and Chitral, which fall outside FATA. Interviews with Pakistani military negotiators from the time (2004) suggest that the US wanted to monitor Chitral due to suspicions about Osama-bin-Laden's presence there. Thus, to allow a coherent corridor, Pakistani negotiators extended the box as far as Chitral.

Network, and "other facilities"—most likely camps of militants backed by Pakistani intelligence.[13]

Under the 2008 pact, the US government could unilaterally undertake surveillance and drone strikes throughout the Waziristan agencies. Figure 2 depicts the temporal distribution of (known) drone strikes occurring in North Waziristan Agency between 2003 and 2011.[14] Pakistan additionally committed to intensifying human intelligence operations conducted in conjunction with the CIA's forward bases in the towns of Bannu, Mir Ali, and Mirmashah. Furthermore, US access to the region's population records and communication infrastructure was enhanced, which included stepped up help with interception of radio and land-line communication.[15]

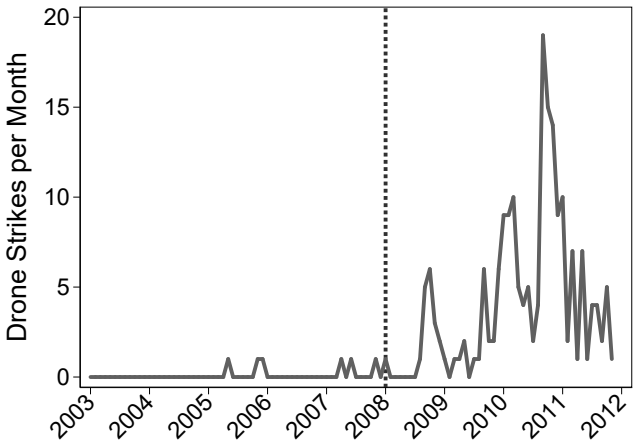


Figure 2: Total monthly drone strikes recorded by the Bureau of Investigative Journalism in North Waziristan Agency. The dotted line marks beginning of the drone program in January 2008.

The US government appears to have respected the constraints of the flight box. Key Pakistani officials from the period stated that, barring occasional transgressions and pre-authorized activity, drone surveillance and strikes were limited to the agreed upon areas. The sanctity and importance of the box to US officials is made plausible by their attempts to negotiate its expansion; doing so as early as February 2008 and once again in 2010.[16] They also sought the addition of a box covering areas of Baluchistan province.

13. A US government official from the period confirmed that Pakistani negotiators raised some of these concerns.

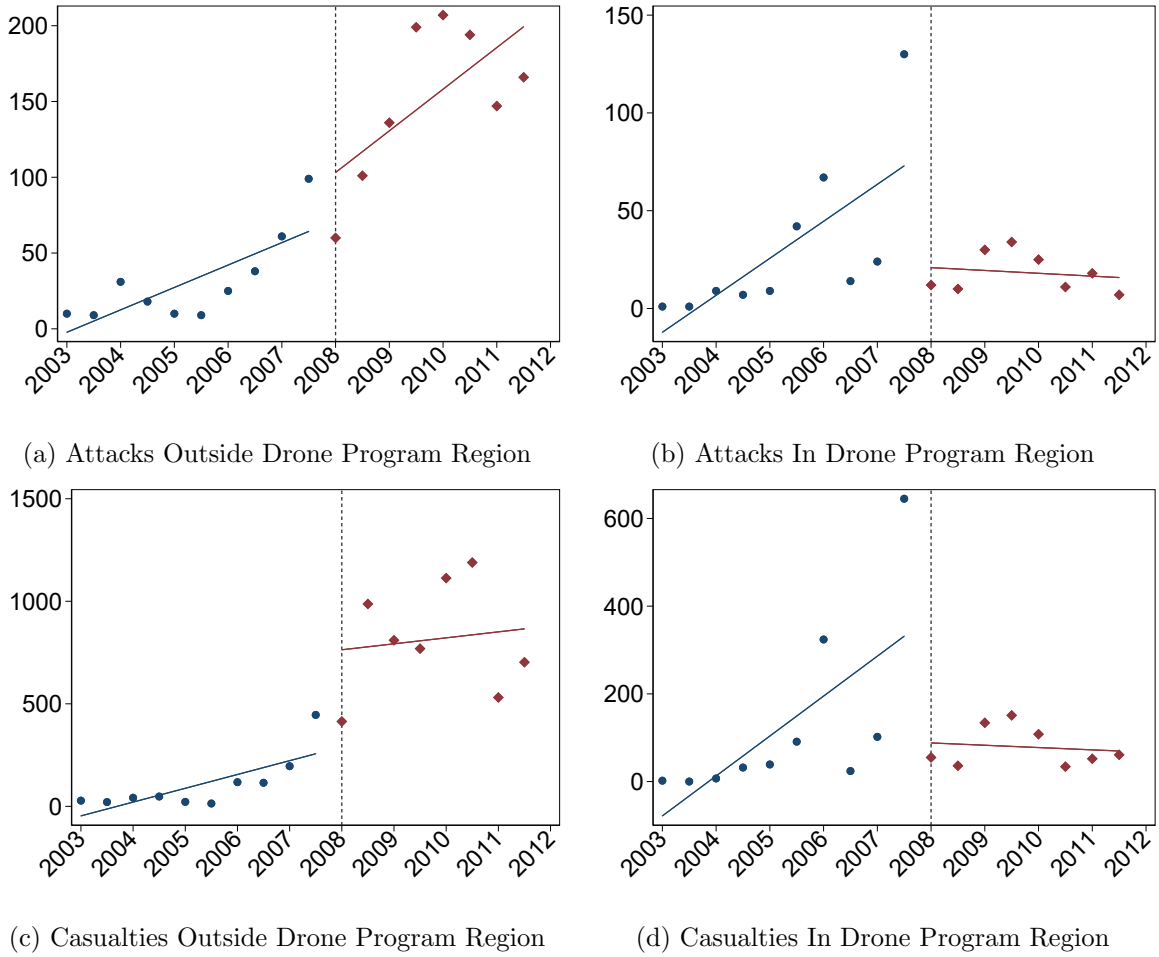
14. BIJ reports less than 20 strikes outside Wazirstan agencies between 2008 and 2011.

15. See details of NSA's signal interception operations center operated with ISI in Islamabad, called the Combined SIGINT Operations Center, in support of operations in Waziristan: SIGINT Liasion Officer (2006). In 2008, Pakistani support for such centers surged. Also on availability of bulk Pakistani cellular call records to the NSA, and their use for locating targets: Development (2012)

16. Interview US Government Official, 2016

3 Empirical Strategy

Our empirical strategy is a simple one: we compare trends in violence in North Waziristan Agency to those in areas of FATA outside the flight box before and after the introduction of the drone program. Figure 3 provides a basic presentation of this information, depicting measures of total insurgent attacks and resultant casualties for each half-year of the study period within North Waziristan Agency and within areas of FATA outside the Waziristan flight box (Kurram, Khyber, Bajaur, Mohmand, and Orakzai Agencies).



(a) Attacks Outside Drone Program Region

(b) Attacks In Drone Program Region

(c) Casualties Outside Drone Program Region

(d) Casualties In Drone Program Region

Figure 3: These graphs depict our measures of insurgent violence within and outside of North Waziristan in each half year of our study period alongside linear trends fit before and after the program commenced. The dotted lines mark the beginning of the drone program.

The figure shows an upwards trend throughout FATA in the period prior to the program's initiation. After January 2008, this growth continued in the areas unaffected by the program—if perhaps at a somewhat slower rate—but appears to have stopped or even reversed in North Waziristan. This pattern is the primary empirical finding of this paper. If one attributes this break in trend to the program—assuming that, in its absence, violence in North Wazirstan would have followed a trend similar to that

in the rest of FATA—it follows that the program had a large negative impact on violence in that region.

We consider several approaches to quantifying the correlation described above. We also discuss the assumptions under which the estimated correlations are consistent with a causal effect, assessing their plausibility in light of available quantitative and qualitative evidence. Ultimately, we conclude there is substantial support for the hypothesis that the US drone program in Pakistan had a negative impact on insurgent violence.

3.1 Study Area and Period

Our study examines the period from January 2003 to November 2011 in a sample of 32 *tehsils*—a granular political jurisdiction—in FATA. The nine tehsils of North Waziristan form our *treatment region* while the 23 tehsils of Bajaur, Khyber, Mohmand, Orakzai and Kurram agencies form our *control region*. We exclude South Waziristan Agency from our analysis because we remain uncertain about the nature of the program as implemented there. Dozens of interviews with Pakistani intelligence and military officials, civilians, journalists, and members of Al-Qaeda and the Pakistan Taliban suggested that while drone surveillance was ubiquitous in North Waziristan during the program, it was far more intermittent in South Waziristan. With the onset of Operation Rah-e-Nijat—a major Pakistani counterinsurgency campaign in October 2009—respondents noted that the already intermittent surveillance grew even more infrequent (Yusufzai 2009).[17] Figure 4 visualizes our sample geographically.

3.2 Data

Our dependent variables are derived from a dataset compiled by the BFRS project containing information on reported incidents of political violence occurring within the FATA between January 2002 to November 2011 (Mesquita et al. 2014, 8).[18] We geocode these incidents in order to construct tehsil-month level measures of insurgent attacks and resultant casualties.[19] We exclude all incidents unlikely to be related to insurgent violence: drone strikes and attacks perpetrated by Pakistani security forces, any foreign security forces, student groups, religious parties, unions, civil society groups, political parties or Pakistani

17. In unreported results, we verified that our findings are robust to including this region.

18. The analysis reported is robust to a different dataset on political violence in Pakistan at the district level from 2007 to 2014. See supplement.

19. Casualties are here defined as civilian and military deaths and injuries. Insurgent casualties are excluded.

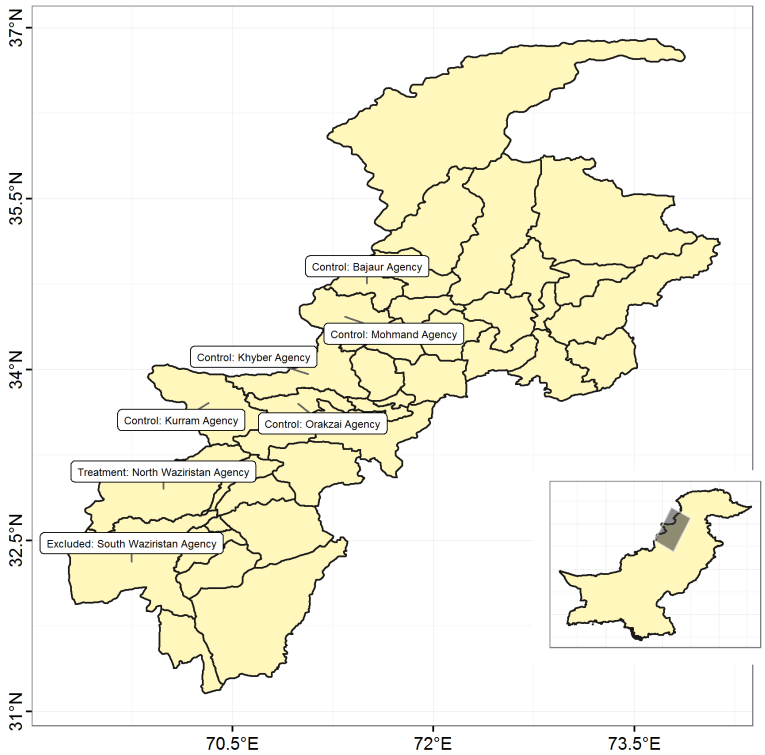


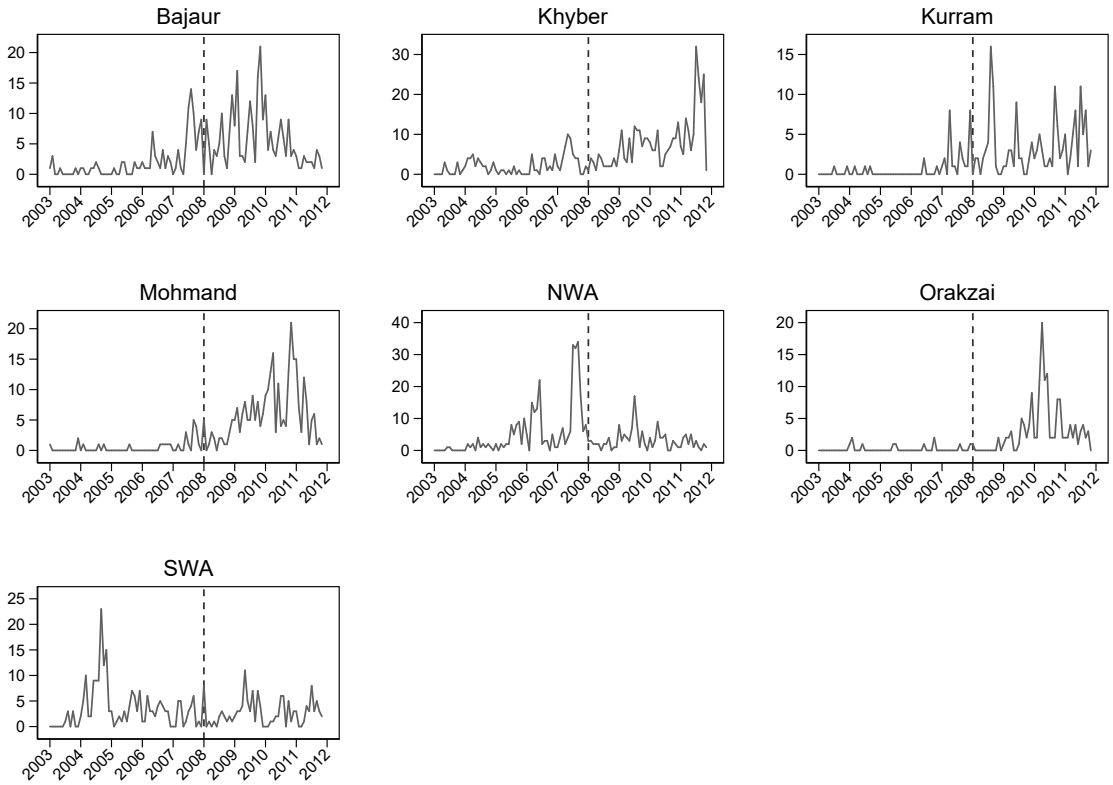
Figure 4: Map of FATA. Insert shows map of Pakistan.

intelligence agencies.[20] Figure 5 displays our measures of monthly attacks and casualties in each district of FATA.

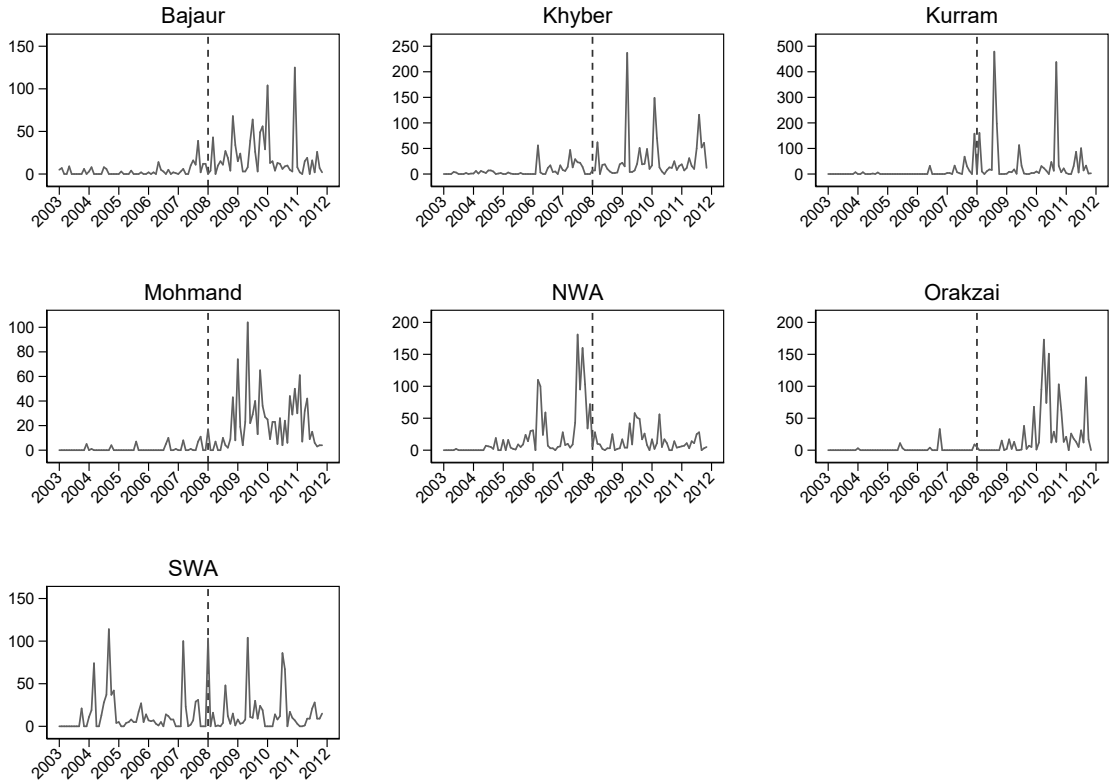
Employing tehsil-month-level observations in our regression analyses permits examining spatial variation in violence at a finer level than previous empirical studies of violence in Pakistan. These were constrained to district-level analysis. However, it is important to note that the drone program appears to have been assigned at the level of district, not tehsil. Thus, the primary advantage of our tehsil-level analysis is that it permits the use of tehsil-specific control variables.[21]

Table 1 displays instructive descriptive statistics on the period before the drone program commenced.[22] There were meaningful similarities but also important differences between tehsils subjected to the drone program and those which were not. This might be explained in part by the non-random assignment of the drone program but even with random assignment at the district level, large differences would not be anomalous in such a small sample of districts.[23]

20. For details, see supplement.
21. Conceivably, it might yield improved statistical inference but, as we discuss later, this is in doubt.
22. The supplement discusses data sources.
23. We discuss this issue further in 4.1.1.



(a) Number of Insurgent Attacks by Month and District



(b) Number of Casualties by Month and District

Figure 5: The dotted lines mark the beginning of the drone program.

Table 1: Balance Table Pre-Drone Program

	Mean (Tehsils NWA)	Mean (Other Tehsils)	Difference
Incidents	0.56	0.21	-0.36
Casualties	2.34	0.70	-1.64
Peace Deal	0.23	0.06	-0.18
Military Operations	0.03	0.01	-0.02
Population per Tehsil	40138.44	93296.17	53157.73
Male per Tehsil	21381.22	48096.41	26715.19
Female per Tehsil	18757.11	45199.76	26442.65
Education Spending (in Rs) per Tehsil	112.05	97.41	-14.65
Health Spending (in Rs) per Tehsil	63.89	44.58	-19.31
Agriculture Spending (in Rs) per Tehsil	24.87	21.17	-3.70
Wheat Produce per Tehsil	7.18	19.56	12.38
Annual Registration per Tehsil	19794.00	18818.28	-975.72
Total Registered Population per Tehsil	74735.80	96695.64	21959.84
Prop Registered Population per Tehsil	2.26	1.13	-1.12
Valid Votes Cast per 100k	7917.04	9231.59	1314.55
Reject Votes Cast per 100k	80.00	175.89	95.89
Registered Voters Cast per 100k	26698.70	38843.70	12145.00

This table displays pre-program sample means for a number of variables both inside and outside North Waziristan Agency, as well as differences in these means between these two regions. For the first four variables, we present means of tehsil-month-level varaibles from 2003-2007. The remaining variables are measured at the district-level at a single pre-program time period and we present district-level means weighted by the number of tehsils per district.

4 Regression-based Results

In this section, we use standard panel methods to estimate the magnitude of the correlation between the drone program and levels of violence. All our regression specifications conform to the following structure:

$$Y_{it} = \delta(treat_t \cdot nwa_i) + \alpha_i + \theta_t + \boldsymbol{\beta X_{it}} + \tau_i \cdot t + \varepsilon_{it} \tag{1}$$

where Y_{it} is the outcome variable. $treat_t$ is a variable indicating whether time period t (a month) occurs in 2008 or later. nwa_i is a binary variable indicating whether tehsil i is in North Waziristan Agency. Our base specification includes this interaction term along with vectors of tehsil fixed effects (α_i) and month-year fixed effects (θ_t), which account for differences in levels of violence which are tehsil-specific but time-invariant and vice versa. Other specifications also include tehsil-specific linear time trends (τ_i) and additional control variables (X_{it}).

It seems likely the error terms in this specification will exhibit serial correlation, raising concerns of downwardly biased standard errors and consequent over-rejection of the true null hypotheses (Bertrand, Duflo, and Mullainathan 2004). To address this we present standard errors clustered by tehsil. We also employ the wild bootstrap approach proposed by Cameron, Gelbach, and Miller (2008), which may be

more reliable given our small number of clusters (32).[24] Ultimately, both strategies are imperfect, for reasons discussed in the supplement.

Tables 2 and 3 present regression results with the number of insurgent attacks and the number of resultant casualties per tehsil per month as dependent variables. These estimates of δ simply capture the correlation between our outcome variables and the drone program in space and time after partialling out the influence of fixed effects and additional control variables. Connecting these correlations to the program's impact requires additional assumptions, which we discuss alongside the results below.

Column 1 in each table presents estimates from the base specification, which imply that the US drone program's implementation was accompanied by an average reduction of approximately one attack and 5.7 casualties per tehsil per month. Both estimates are statistically significant and substantively large; over the pre-program period, tehsils in North Waziristan saw an average of 0.56 attacks and 2.34 casualties per month.[25]

Table 2: Incident Results

	(1) Attacks	(2) Attacks	(3) Attacks	(4) Attacks
treat·nwa	-1.039*	-1.420*	-1.408*	-1.469*
	(0.259)	(0.583)	(0.564)	(0.596)
MO			0.898	
			(0.443)	
Peace			-0.150	
			(0.197)	
Obamareview			0.382	0.142
			(0.271)	(0.272)
Haqqani			0.601	0.927
			(0.524)	(0.703)
Observations	3638	3638	3531	3531
WB p-value	0.00200	0.0240	0.0280	0.0300
Year FE	X	X	X	X
Tehsil FE	X	X	X	X
Time Trends		X	X	X
Controls			X	X
Hetero. Ctrls				X

Standard errors in parentheses. WB stands for wild bootstrap.
* $p < 0.05$

When applied for causal inference, this specification implements a simple difference-in-differences design. Interpreting our estimates as pertaining to treatment effects requires a so-called parallel trends

24. We use 1000 bootstrap replications to implement this method.
25. And 1.4 attacks and 6.9 casualties per month in 2007, the final year before the program.

Table 3: Casualty Results

	(1) Casualties	(2) Casualties	(3) Casualties	(4) Casualties
treat·nwa	-5.698*	-8.735*	-8.958*	-9.670*
	(1.406)	(2.161)	(2.047)	(2.203)
MO			4.806*	
			(2.074)	
Peace			-1.027	
			(1.048)	
Obamareview			4.662	4.997
			(2.758)	(3.162)
Haqqani			-1.786	-0.637
			(1.390)	(1.468)
Observations	3638	3638	3531	3531
WB p-value	0.00200	0.00200	0.00200	0.00200
Year FE	X	X	X	X
Tehsil FE	X	X	X	X
Time Trends		X	X	X
Controls			X	X
Hetero. Ctrls				X

Standard errors in parentheses. WB stands for wild bootstrap.
* $p < 0.05$

assumption. In our context, this means assuming that the post-2008 change in expected monthly attacks and casualties per tehsil outside North Waziristan Agency is identical to that which would have obtained for a counterfactual North Waziristan Agency unexposed to the program. Notice, however, that figure 5 seems to suggest that variation in violence prior to 2008 did not follow a parallel trend of this kind, increasing at a much faster rate in North Waziristan Agency than other districts. Given this, there is reason to doubt it would have done so after 2008 absent the program. In section 5, we present formal evidence of a departure from parallel trends in the pre-treatment period cautioning against a straightforward causal interpretation of our estimates.

Column 2 displays an estimate from a specification which adds tehsil-specific linear time trends. This is a common technique for addressing concerns about non-parallel trends which alters the assumptions needed for causal interpretation of estimates of δ, instead requiring parallel trends in deviations from the time trends.[26] This specification yields negative estimates of δ larger in magnitude than the base specification.

Next, we consider the impact of adding additional control variables. Particularly relevant controls are those pertaining to peace deals and military operations. $Peace_{it}$ and MO_{it} are tehsil-month-level

26. See Mora and Reggio (2017) for a more precise characterization.

variables indicating whether—within tehsil i during month t—any peace deal was active or sizable declared Pakistani military action was underway respectively. Both variables were sourced from publicly available news reports.[27]

We also include controls for two other factors potentially relevant to the dynamics of violence in the region during this period. The first is motivated by the role of the famous Haqqani Network, a North Waziristan based Afghan armed group that began to openly oppose violence against the Pakistani state on June 23, 2006 (Khan 2006). Field research suggests that the group's cadres were concentrated near Jalal Haqqani's base in the town of Dande-e-Darpakhel in Miramshah, a tehsil of North Waziristan, as well as other areas of Miramshah and the neighboring tehsil of Ghulam Khan. We attempt to account for the group's adjustment in priorities using the variable $Haqqani_{it}$, an indicator equal to one for all observations in Miramshah and Ghulam Khan after June 2006 and zero at all other times and places. We similarly attempt to account for increased NATO/ISAF supplies passing through Pakistan after President Obama's "Af-Pak" review in March 2009 which potentially attracted insurgent violence along the supply routes passing from two tehsils in FATA's Khyber Agency, Landi Kotal and Jamrud.[28] We code a tehsil-month variable $ObamaReview_{it}$ as equal to one for observations in Landi Kotal and Jamrud tehsils later than February 2009 and zero elsewhere.

The third and fourth columns of the tables report coefficient estimates from specifications that include these control variables in addition to linear time trends. They differ in that the former uses just the two indicator variables described above to control for military operations and peace deals while the latter includes interactions between these and tehsil indicators permitting tehsil-specific influences by these factors. The resulting estimates are quite similar to those from the time trend specification.

The inclusion of most of these controls can be motivated by the possibility that the weakened parallel trends assumption needed for a causal interpretation of the linear time trend specification—discussed above—is satisfied after conditioning on these variables. The $ObamaReview_{it}$ variable, by contrast, is motivated by concern that the changes in violence that accompanied the heightened NATO supply line activity are not informative about the counterfactual path of violence in North Waziristan and should not be ignored when estimating the drone program's impact.

However, we want to emphasize that peace deals and military activity are likely endogenous to the introduction of the program, which may have substituted for Pakistani state activity of this kind.

27. See supplement for coding protocol.

28. Woodward (2011) provides a detailed discussion of the "Af-Pak" review.

The causal interpretation of the corresponding estimates—if warranted—differs from that accompanying specifications without these controls. At best, these estimates of δ measure the drone program's impact *holding military operations and peace deals constant.*[29] That is to say, the assumed counterfactual is one in which Pakistani state activity in post-2008 North Waziristan would have been the same as that actually observed. This may not be the most policy-relevant counterfactual.

4.1 Alternative Interpretations

Here, we discuss two alternatives to a causal interpretation of the regression-based results reported until now.

4.1.1 Mean Reversion

One concern is that our results may simply reflect mean reversion following anomalous spikes in violence in the North Waziristan Agency between 2005 and 2007. This concern arises in many program evaluation exercises when there is reason to suspect that treatment was endogenously assigned. Evidence from field work suggests that this was not the case with the drone program.

We introduced details of the flight box negotiation process in section 2. While motivated by strategic considerations, the final geography and time period of imposition was shaped by considerations unrelated to the insurgency including General Musharraf's regime survival concerns, Pakistani government's concerns of US spying on the country's nuclear program, and concerns of public backlash. In addition to the evidence already discussed, we attempted to ascertain whether negotiations were influenced by or a response to the spike in violence in the North Waziristan Agency in the second half of 2007. Pakistani officials from the period explicitly denied this. A Pakistani official coordinating the counterterror campaign with the US government noted: "If you recall, we were in deep national crisis at that time. Benazir Bhutto was killed on the 27th[of December, 2007]. Elections were due soon. North Waziristan was far from a priority for either General Musharraf or [Chief of Army Staff] General Kayani."[30] In a notable interview for the study, a general officer in-charge of Pakistani ground forces in the tribal areas from 2007 to 2010 denied the program launch was linked to the surge in violence, adding that he protested drone use in his area of operations.[31]

29. This is a variant of the so-called "bad control" problem (Angrist and Pischke 2008).
30. Interview Islamabad, Pakistan, 2016
31. Interview Islamabad, Pakistan, 2016

In light of this evidence, we contend that the complex political process, which shaped the location of the flight box and in turn the drone program, was largely exogenous to insurgent violence in the FATA. However, in our context, this is not enough to ensure the parallel trends assumption holds. Because the program appears to have been assigned at the district level, there remains substantial risk that the post-2008 changes in violence in areas outside the flight box would differ from those within the box purely by chance. The pre-program departure from parallel trends that we document in the next section provides strong evidence that this was the case.

Thus, mean reversion remains worthy of serious consideration even under exogenous program assignment. However, we note that the intermittent spikes in violence exhibited in North Waziristan between 2005 and 2007 are similar in character to patterns of violence observed elsewhere in FATA after—and in some cases, before—the program's commencement. In the next section, we discuss qualitative evidence supporting the perspective that these pre-program patterns of violence in North Waziristan were not outliers and should have been expected to continue absent the drone deployment.

4.2 Displacement

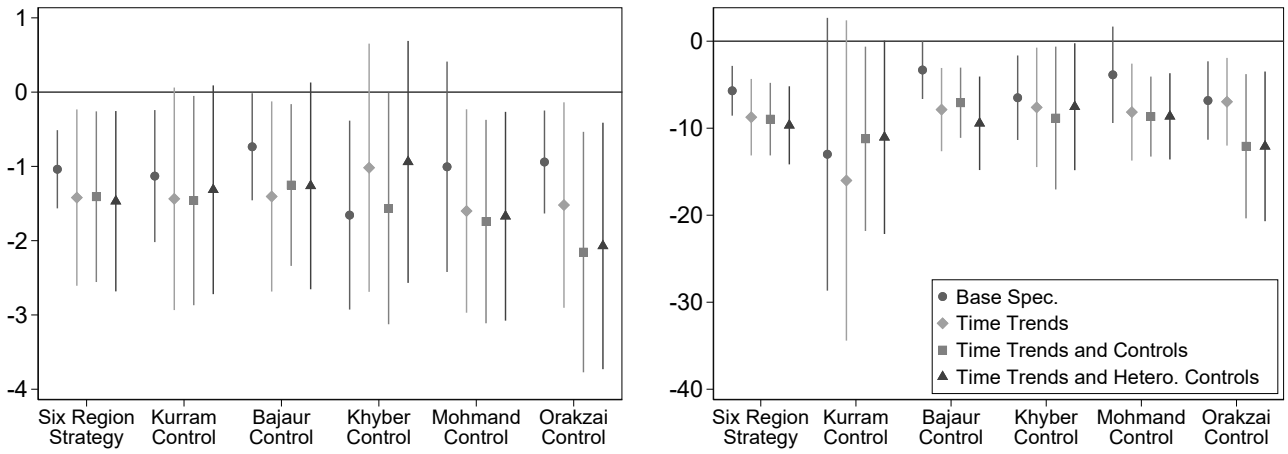
Another concern is that the drone program might have induced insurgent leadership and manpower to move to areas outside the flight box, leading to displacement of violence to other parts of FATA. This would undermine a strictly causal interpretation of our findings.

If there were displacement effects, we would expect them to be strongest in Orakzai and Kurram, the districts closest to North Waziristan Agency. Figure 5 shows that violence in Orakzai was minimal before 2008, consistent with a story of violence displacement. In Kurram, observed increases in violence post-2008 period are consistent with a pattern of growth that predates the program.

By contrast, Bajaur and Mohmand Agencies seem the least likely to experience contamination from the drone program since they are not contiguous to North Waziristan. Furthermore, significant geographical barriers between them. Furthermore, all major travel routes to Bajaur and Mohmand Agency from North Waziristan Agency pass through Peshawar and Kohat, urban areas with strong Pakistani state presence. As such, the post-treatment increase in violence that is observed in these districts should assuage this concern to some degree.

We compliment this informal analysis with empirical robustness checks. We re-run the regressions discussed in the previous section on five restricted samples, each containing only one of our control

districts: Bajaur, Khyber, Kurram, Mohmand, and Orakzai.[32] Figures 6 graphically present the resulting point estimates of δ and accompanying confidence intervals.[33] The estimates are broadly similar to those based on our full sample, though not always as statistically significant. We interpret the similarity of coefficient estimates as evidence that our findings are not driven by spillover effects.



(a) Incidents Results

(b) Casualties Results

Figure 6: These figures display estimates of the coefficient δ from all four versions of specification (1) for each choice of control region we consider along with confidence intervals (accounting for tehsil-level clustering).

In addition, we found no qualitative evidence supporting the displacement hypothesis. Interviewed members of the Pakistan Taliban noted that select cadres from the North Waziristan Agency left for Karachi, parts of Afghanistan, and South Waziristan Agency in 2012/2013, but not to the other tribal districts which are part of our study.[34]

Note that the causal interpretations of these new estimates rely on different parallel trends assumptions than those in our original analysis. In the base specifications for example, the post-program change in expected monthly violence per tehsil in the single included control district is assumed to be exactly the same as that for counterfactual North Waziristan. The stability of the estimates thus demonstrates the robustness of our results to mild variations in the particular assumptions made about counterfactual violence in North Waziristan.

32. That is to say, the sample for each regression includes only tehsils from North Waziristan and one district unaffected by the program.

33. Results from tables 2 and 3 are included for comparison.

34. Interviews Pakistan 2016/2017.

5 Addressing Non-Parallel Trends

In this section, we first formally document non-parallel trends in pre-2008 violence levels between our treatment and control regions. We then discuss possible reasons for this and investigate what can be inferred from observed patterns of violence in FATA in spite of this problem in light of available qualitative evidence on the nature of the processes generating this violence.

5.1 Event Study

Here, we use an event study to more explicitly track the differential trends in violence that underly the correlation between the drone program and violence. This method offers one way to formally test for a departure from parallel trends in the pre-program period and a lens through which to discuss causal inference in the absence of a parallel trends assumption.[35]

Let $H(t)$ be a function which maps a given month t from our study period into the half-year containing it. A half-year is the either the first or last six months of a given year; for example, January-June 2002. Further, suppose we label each half-year sequentially with an integer such that the final half-year before the drone program was implemented (July-December 2007) is labeled zero.[36]

Then our event-study specification can be written:

$$Y_{it} = \sum_{j=-9}^{-1} \delta_j(\mathcal{I}\{H(t) = j\} \cdot nwa_i) + \sum_{j=1}^{8} \delta_j(\mathcal{I}\{H(t) = j\} \cdot nwa_i) + \alpha_i + \theta_t + \varepsilon_{it} \tag{2}$$

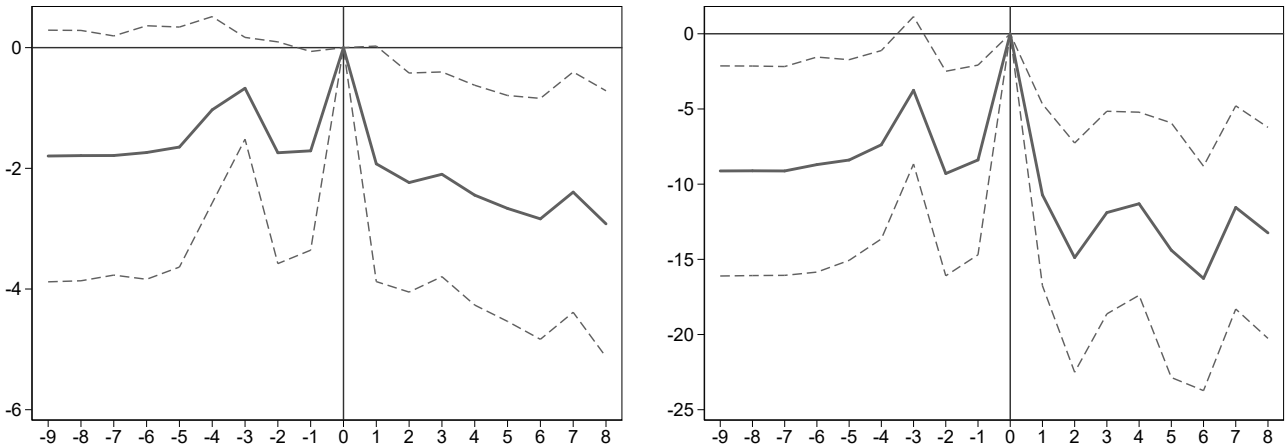
where i denotes tehsil and t denotes month.

This equation is similar to (1) but it includes interactions between an indicator for whether a tehsil is in North Waziristan Agency and dummy variables for each half-year in our sample except July-December 2007 rather than a single interaction term with a post-2008 indicator. Each coefficient δ_j on these interaction terms measures the expected difference monthly violence per tehsil between North Waziristan Agency and the control district during half-year j, less the value of that same difference in the half-year prior to start of drone program ($j = 0$).[37] Figure 7 displays estimates of these δ_j coefficients for each

35. Event study strategies of this kind are increasingly employed in the applied microeconomics literature. See Alsan and Wanamaker (2018) for a recent application.

36. By way of example, this implies that $H(\text{March 2008}) = 2$ and $H(\text{August 2006}) = -2$.

37. Our use of half-year rather than month dummies in constructing the interaction terms—while ad



(a) Incidents Event Study

(b) Casualties Event Study

Figure 7: Solid lines depict estimated event study coefficients and dotted lines depict confidence intervals (accounting for tehsil-level clustering). Half-year relative to July-December 2007 is on the x-axis.

$j \neq 0$. Let us call these the *event study coefficients*.

Our estimates of δ_j for $j < 0$ can be used to test for pre-program parallel trends. If the parallel trends assumption held in that period, these coefficients would be zero, since the difference in expected levels of violence between tehsils inside and outside North Waziristan would have been constant. For both outcome variables our estimates of these coefficients are large and negative, reflecting the fact the differences in average violence earlier in the pre-program period were smaller than in the latter half of 2007. The estimates reflect a noisy trend of increasing differences between the tehsils within the flight box and those elsewhere in FATA as the program start date approached. Although most are not independently statistically significant, F-tests of the null hypothesis that all pre-program event study coefficients are zero give p-values of 0.005 with insurgent attacks as the dependent variable and 0.01 with casualties as the dependent variable. This constitutes strong evidence of non-parallel trends in the pre-program period warranting skepticism regarding the causal interpretation of estimates from our base specification.[38]

Post-2008 event study coefficients ($j > 0$) are also all negative, larger in magnitude than any of

hoc—was motivated by a desire to increase statistical power in the hopes of more reliably detecting instances where these coefficients are non-zero. Alternative constructions yield qualitatively similar results, with estimates tending (unsurprisingly) to grow noisier and confidence intervals wider as temporal granularity of the interaction terms increases.

38. As noted previously, the requisite parallel trends assumption is different for results from our other specifications, so this test does not directly speak to their merits.

the pre-program estimates and mostly statistically significant. For the attacks dependent variable they become increasingly negative over time; for the casualties dependent variable they decline more rapidly and remain stable thereafter. This indicates that the difference in levels of violence shrank after the introduction of the program and remained at that reduced level for the duration of the program, perhaps even reducing further with time. Under the parallel trends assumption these estimates would be unbiased estimates of the program's average treatment effect in each half-year period following it's introduction. Substantively, this requires assuming that violence would have continued to increase in the North Waziristan Agency absent the program, albeit at a reduced rate relative to the growth in the late pre-program period. Since we have already cast doubt on the parallel trends assumption, it is worth considering what alternative assumptions might imply about the causal effect of the program.

Suppose that violence in the North Waziristan Agency would have remained at pre-program levels in the absence of the US drone program. Although this would imply that estimates from our base specification overstate the program's impact, the empirical patterns would still imply a negative effect. To see this, refer back to figure 5a and note that our results are not only driven by increasing violence outside the flight box after 2008 but also by the absence within North Waziristan of the large spikes in violence observed during 2006 and 2007 after the commencement of the drone program. A negative causal effect of the program can only be ruled out if one thinks it likely that this observed decline in violence would have occurred anyway—or been more severe—absent the program. We contend that available quantitative and qualitative evidence suggests continued growth or stagnation at pre-program levels are the most plausible counterfactual paths for violence in North Waziristan Agency. The growth of violence in that region prior to 2008 was driven by political dynamics similar to those underlying increases in violence in other districts of FATA before and during the program: the strength of local organizations within the Pakistan Taliban umbrella committed to overturning the Pakistani state.

Leading up to 2008, Taliban forces in North Waiziristan—led by Baitullah Mehsud—increasingly saw sustained attacks against the local state presence as a tool for maximizing control over territory and maintaining the safety of their sprawling infrastructure in Waziristan.[39] Military bases, convoys, civilian administration, and the Political Agent's offices were all targeted. Fighting was especially intense around Pakistani military forts and encampments and during the militarys attempts at transporting soldiers and supplies in a drill called the road opening day (ROD).[40] After January 2008, this trend reversed.

39. Interview Peshawar, 2016

40. The October 2007 Battle of Mir Ali was triggered by a Taliban assault on a military convoy during a routine ROD.

The North Waziristan Taliban factions and their Al-Qaeda affiliates mostly stopped attacking forward bases and offices of the Pakistani military and intelligence agencies, such as those in Mir Ali, Data Khel, Ghulam Khan, and Miramshah. Besides low-level targeting of suspected civilian informants, the period did not see any sustained attempt by these insurgent groups at large-scale violence targeting these military installations. This change was plausibly the result of the drone program compromising the capacity of these organizations to mount such assaults. We support this point with additional qualitative evidence in section 6.

Bajaur Agency provides a telling qualitative sketch of one possible counterfactual scenario for North Waziristan.[41] As in North Waziristan, this region had a local Taliban faction—led by Maulvi Faqir Muhammed—which was active in the pre-program period. With the help of select teams of Al-Qaeda fighters based in areas such as Damadola, Khar, and Nawagai, Taliban forces interdicted the agency's major lines of communication, compelling the Pakistani paramilitary group Bajaur Scouts to scale back their deployments. A former Political Agent of Bajaur Agency noted that the Pakistani state had largely lost its "writ" to the Al-Qaeda-backed Taliban forces by early 2007.[42] Significantly, in contrast to North Waziristan, there was no break in the Bajaur Taliban's subversive activity after the drone program began. Until late 2008, Maulvi Faqir frequently rallied his forces, sometimes in conventional military formations. In an audacious August 2008 assault, he captured the Agency headquarter in Khar.[43] After induction of new Pakistani military forces and aviation assets—which precipitated battles in the towns of Loe Sum, Nawagai, and Khar as part of Operation Sher-Dil—the insurgency experienced some losses.[44] Many insurgent units moved to the neighboring Afghanistan province of Kunar but a sizable number of Faqir's sabotage units remained in Bajaur.[45] Those across the border in Kunar frequently returned for sabotage in Bajaur, including interdicting convoys.[46] They also launched counterattacks and offensives to extend their perimeter of territorial influence.[47] According to one Pakistani official who had purview over both

41. One reason Bajaur makes for a telling comparison is that—as show in figure 1—the 2004 flight boxes included parts of Bajaur. This suggests that, like North Waziristan, Bajaur was of strategic interest to the US and that Pakistan was initially willing to permit limited drone deployments there—though this had changed by 2008.
42. Interview Pakistan 2016
43. Interview Pakistan 2016.
44. Interview Bajaur Agency 2017.
45. Interview Bajaur Agency 2017.
46. For example, a US Special Operations convoy involved in training Pakistani paramilitary was interdicted and bombed in February 2010 on the border between Lower Dir and Bajaur Agency.
47. For example, a counteroffensive was launched in the Batwar area of Bajaur in September 2012.

Bajaur and North Waziristan, the forces of Maulvi Faqir operated with relatively more freedom and latitude than the factions in North Waziristan; select tribal elites aligned with the Taliban presented a similar perspective.

5.2 Modifiable Areal Unit Problem

It should be noted that the departure from parallel trends documented above might not have been obvious when looking at figure 6.[48] In these graphs, the pre-2008 patterns of violence in and outside North Waziristan appear much more similar. This difference results from a change in the unit of analysis. The dependent variables in that figure are monthly totals of attacks and casualties inside and outside North Waziristan whereas the dependent variables in our regressions are instead tehsil-level totals. Because our sample contains the 9 tehsils inside North Waziristan and 23 outside the flight box, even if the parallel trends assumption were satisfied when comparing total violence in the control and treatment areas, it would not (in general) be satisfied when comparing average violence *per tehsil* between those areas. It is this latter parallel trends assumption that is needed for causal interpretation of estimates from our base specification.

This makes it clear that our application suffers from a variant of the modifiable areal unit problem.[49] The scale of our dependent variables is not invariant to changes in our choice of a spatial unit of aggregation. Consequently, the particular parallel trends assumption needed for causal interpretation of our panel regressions varies with this choice.[50] We can see no obvious reason to prefer any particular level of spatial aggregation over another a priori.

That said, the parallel trends assumption underlying a causal interpretation of our panel regressions is more conservative than that which would accompany an analysis based on aggregation of our data into two spatial units: inside and outside North Waziristan Agency. Since there are relatively more tehsils outside the flight box, our analysis implicitly lessened the magnitude of the post-program increase in violence in those areas, thus also lessening the implied counterfactual increase in violence in North Waziristan. Nonetheless, our choice of tehsil-level aggregation remains arbitrary.

48. We thank an anonymous reviewer for highlighting this discrepancy.
49. See Fotheringham and Wong (1991) for a discussion.
50. This problem is not unique to our paper, but affects any other difference-in-differences design using spatially aggregated count variables.

6 Probing Mechanisms

In this section, we probe the mechanisms mediating the negative association between the US drone program and insurgent violence documented above in two steps. First, we examine whether it can be explained by simply aggregating the local effects of individual drone strikes undertaken as part of the drone program. Next, we consider limited but valuable qualitative evidence pertinent to the program's anticipatory effects. This work is far from definitive but demonstrates the plausibility of both the kinetic and anticipatory mechanisms.

6.1 Decomposing Results

Our methodological approach in the preceding sections differs substantially from that employed in previous work on effects of drones. Johnston and Sarbahi (2016)—also investigating the US drone program in Pakistan—documented a negative correlation between drone strikes and insurgent violence occurring in the same district-week observation. As we have noted, the program's total effect need not be composed of simply the aggregation of short-run responses to individual strikes, especially if the surveillance dimension of the program led to anticipatory effects. In this section, we probe how much of the program-level correlation we document might be accounted for by the impact of individual drone strikes documented in the previous literature.

Table 4 presents the results. Columns (1) and (4) contain estimates from our base specification for incidents and casualties dependent variables respectively (for reference purposes).[51] In columns (2) and (5), we present results for a regression with month-year and tehsil fixed effects and a variable measuring the number of drone strikes occurring within a given month in the district a tehsil is located in. To be clear, although our observations are at the tehsil-month level, district-month level drone strike coding allows the effect of strikes to reach across an entire district. This specification is the most similar to what has been done in the previous literature.[52] These estimates document a statistically significant negative correlation between drone strikes and insurgent violence in a given month in the area in which the strikes occurred, consistent with Johnston and Sarbahi (2016).

Columns (3) and (6) display results from our baseline specification with the drone strikes variable

51. These estimates were previously presented in tables 2 and 3.

52. Our coding of drone strike variable is similar to that of Johnston and Sarbahi (2016) who code their drone strikes variable at the district-week level.

Table 4: Results Decomposition

	(1) Attacks	(2) Attacks	(3) Attacks	(4) Casualties	(5) Casualties	(6) Casualties
treat·nwa	-1.039*		-0.786*	-5.698*		-4.064*
	(0.259)		(0.195)	(1.406)		(0.966)
Strikes		-0.127*	-0.0646*		-0.740*	-0.418
		(0.0372)	(0.0283)		(0.281)	(0.276)
Observations	3638	3638	3638	3638	3638	3638
WB p-value (treat·nwa)	0.00200		0.00200	0.00200		0.00200
WB p-value (Strikes)		0.00200	0.00800		0.00200	0.106
Year FE	X	X	X	X	X	X
Tehsil FE	X	X	X	X	X	X

Standard errors in parentheses. WB stands for wild bootstrap.
* $p < 0.05$

added as a regressor. The estimates contain several interesting results. First, notice that the estimated coefficient on $treat \cdot nwa$ decreases in size significantly relative to the baseline specification for both incidents and casualties dependent variables. This suggests that the short-run effect of drone strikes may account for a portion of the total program impact. However, the estimates on $treat \cdot nwa$ are about 75% of their original size in both cases, suggesting that—as measured by a district-month-level variable—the immediate effects of drone strikes do not account for most of the correlation we have detected. This suggests that most of the correlation we have detected between the onset of the drone program and insurgent violence cannot be explained as simply the aggregation of the impact of many individual drone strikes—at least, not when measured by a district-month-level variable.

Comparing columns (3) and (6) to columns (2) and (4) also shows that introducing the $treat \cdot nwa$ variable almost halves the magnitude of the correlation between drone strikes and insurgent violence. This indicates that the correlations presented in columns (2) and (4) may partially reflect the effect of the drone program beyond the short-run effects of drone strikes (since most strikes took place in the North Waziristan Agency after the program began). Insofar as this is the case, previous work examining the impact of individual drone strikes, which included pre-drone program periods and districts outside the North Waziristan Agency in their analysis, may have suffered from a kind of omitted variable bias.

What best explains the isolated out effect of individual strikes and the sizable residual effect of the drone program? The isolated effect of strikes is plausibly best explained by kinetic effects; that is, the targeted groups experienced damage in the form of leadership decapitation and loss of personnel, which set back the operational capability of the group. This is consistent with the interpretation provided by Johnston and Sarbahi (2016). However, the explanation for the residual effect is less clear. There are three possibilities: pure kinetic effects; pure anticipatory effects; and a combination of kinetic and

anticipatory effects. We believe kinetic effects alone cannot plausibly explain the residual effect. A kinetic effects-based explanation would suggest that drone strikes did lasting damage to the capabilities of the targeted groups, which extended far beyond the month of the strike. This is not likely because Al-Qaeda and the Pakistan Taliban—the two main targets of the program—were relatively capable organizations, able to recover from losses under ordinary circumstances (Jordan 2014; Staniland 2014; Long 2014; Toft and Zhukov 2015). A more plausible account is one where kinetic effects interacted with anticipatory effects in first damaging and then constraining the recovery of these groups. A pure anticipatory effects story could also account for the residual association between the drone program and violence. Such an account would suggest that groups stayed continuously disorganized because of the sustained surveillance which induced high levels of perceived risk among insurgents.

6.2 Qualitative Evidence on Mechanisms

Here we draw on qualitative evidence to argue the importance of the mechanism of anticipatory effects of the drone program. An important caveat is that we do not claim the anticipatory effects mechanisms is the dominant driver of the drop in insurgent violence. Our purpose is to highlight its significance, given that it remains an understated mechanism. We draw on two sources of evidence: Interviews conducted in Pakistan, including with with members of Pakistan Taliban and Al-Qaeda, and correspondences between Osama Bin Laden and his subordinate commanders in the North Waziristan Agency, which were captured during the US raid on the Bin Laden compound in Abbotabad, Pakistan.[53]

Al-Qaeda and the Pakistan Taliban experienced considerable operational disruption because of the drone program. Until late 2007, the Pakistan Taliban, often with the guidance of Al-Qaeda's master trainers and its Pakistani factions, conducted sophisticated, manpower intensive assaults in the the North Waziristan Agency. As drones began to hover overhead frequently, the anticipatory effects set in, forcing the groups on the defensive. Members of Al-Qaeda and the Pakistan Taliban interviewed for the study noted that the surge in surveillance and the resulting anticipation of strikes became "inescapable," which substantially constrained operational coordination.[54] One Taliban operative noted: "Drones were an absolute headache for us and other *jihadi* groups [in the region] because there is no solution for them."[55]

53. For detailed process tracing of how the US drone war shaped trajectories of the targeted groups in North Waziristan, see Mir (2018).
54. Interview Pakistan 2017.
55. Interview Pakistan 2016.

The evidence is telling on the three theoretically expected challenges for the targeted groups: movement, communication, and trust. For example, as surveillance and targeting by drones intensified in early 2008, cadres of both Al-Qaeda and the Pakistan Taliban were compelled to give up activities that could identify them via overhead surveillance. While it did not eliminate all movement, leaders and cells struggled in moving around due to concern of being detected. Multiple members of the Taliban and Al-Qaeda noted that in order to evade intensified surveillance, they stopped moving in large groups. Some noted "strict standard procedures against moving in four-wheel vehicles."[56] Even "alternative means of movement—like by foot or motorbikes—became very high risk." This curtailed operational capacity of the "*marakiz* [units/centers] in Wazirisitan by 2009", according to one Pakistan Taliban leader.[57] Al-Qaeda leader Sheikh Atiya's letters to Bin Laden detail similar challenges: "...[W]e really worry because of our present security situation and the airstrikes really wore us down" (Justice 2015a, 12).

Al-Qaeda and the Taliban faced severe within group trust issues as the drone program set in.[58] Commanders felt that the US drone operation relied on local spies. They also thought the US government could exploit slip ups in operational security by less cautious/disciplined cadres. As early as 2008, senior and mid-level commanders of the groups began to regulate who they interacted with, limiting themselves to trustworthy and capable cadres.[59] This filtering of within group interaction brought principal-agent and intra-agent relationships under stress. In a letter to Bin Laden, Sheikh Atiya bemoaned the operational breakdown due to trust issues: "[W]e bought some quantities of ammunition and devised some simple plans. We are facing difficulties due to ...the abundance of spies operating in our areas" (Justice 2015b, 1). A Pakistan Taliban operative noted periods of intense distrust between top and mid-ranking leaders—including Hakimullah Mehsud and Wali-ur-Rehman Mehsud.[60] An Al-Qaeda operative noted: "Since the beginning of drone attacks, the jihadi organizations have suffered immense pain. The pain became worse because it could not be treated. It enhanced distrust within jihadist organizations and among their people. We knew that targeting by drones was not possible without a high quality spying network on the ground."[61]

Al-Qaeda and the Pakistan Taliban also found themselves handicapped in communication. Leaders and mid-level commanders of both groups radically reduced their use of intercept-able communication

56. Interview Pakistan 2016.
57. Interview Pakistan 2016.
58. Interviews Pakistan 2017.
59. On killings of suspected spies, see: Reese, Ruby, and Bauer (2017)
60. Interview Pakistan 2016.
61. Interview Pakistan 2017.

means. Sheikh Atiya wrote to Bin Laden that "...we [have] put a ban on communications except with a special permission" (Justice 2015b, 1). Multiple Taliban respondents noted dire challenges in use of messengers and technical means for communication from 2009 to 2014: "We were told to avoid communication devices, including wireless sets."[62]

7 Implications and Conclusion

This study explains and empirically demonstrates how a drone program can shape one key dimension of internal conflict: insurgent violence. Our work has implications for a number of scholarly and policy debates. We add to the debate on how transformative drones are for international relations (Stulberg 2007; Zenko 2013; Boyle 2015; Horowitz, Kreps, and Fuhrmann 2016; Zegart 2018). Existing scholarship provides valuable but limited conceptualization of the capabilities drones bring to the table, and how they are shaping the modern battlefield (Horowitz, Kreps, and Fuhrmann 2016). We contribute to this debate with extensive evidence on one type of deployment in asymmetric conflict: the combination of armed aerial drones with a pervasive surveillance regime, an extensive intelligence analysis bureaucracy, and broad targeting authority. Furthermore, our findings suggest that similarly well-resourced drone deployments may prove useful to states fighting insurgent organizations in other theaters.

Our findings also speak to empirical debates on the effects of drones. We complicate Johnston and Sarbahi (2016) who show that an average drone strike in Pakistan's tribal areas was associated with a short-run reduction in proximate violence. We show that, viewed in isolation, their findings underestimate the impact of US counterterrorism on insurgent violence in Pakistan. Our work also speaks directly to the view that drone strikes fuel insurgencies in the areas where they are carried out (Kilcullen and Exum 2009; Mazzetti and Shane 2013; Boyle 2013). If the strength of the Pakistani insurgency can be proxied by measured violence, we find evidence that the US drone program weakened it in the North Waziristan Agency.

Our findings contrast with the scholarly view that use of air-power against insurgents tends to be counterproductive (Pape 1996; Kocher, Pepinsky, and Kalyvas 2011; Dell and Querubin 2017). Much of this literature situates the ineffectiveness of air-power in the collateral damage caused by air strikes and the resulting increased support for the insurgency amongst the civilian population. Our work suggests—perhaps troublingly—that the US drone program in Pakistan undermined the insurgency *despite* harming

62. Interview Pakistan 2016.

civilians (Clinic and NYU School of Law 2012; Director of National Intelligence 2016; Investigative Journalism 2017). This suggests that the sustained kinetic and anticipatory effects of the program outweighed any countervailing effects, such as those due to increased civilian support for the insurgency. Relatedly, our study has implications for the population-centric model of counterinsurgency. This view argues that winning over civilians—through security and/or service provision—is critical for state forces to gain intelligence.[63] Our work implies that if states can build robust surveillance infrastructures, they can minimize the value of civilian collaboration to intelligence gathering.

Our analysis is highly policy-relevant. It speaks to a common view among counterterrorism operators about the importance of sustained aerial surveillance (Task Force 2013, 12-16). Our analysis provides some support for this intuition though we were unable to test it rigorously. Our findings also highlight the importance of local partner capacity and cooperation in enabling effective counterterrorism campaigns. The negotiation process between the US and Pakistani governments at the onset of the program shows that Pakistani capacity and cooperation was a key ingredient for realizing the capabilities of the program. Finally, we provide a basis to speculate on the popularly held notion that "drones create more terrorists" (Abbas 2013). Our evidence suggests two possibilities: either the drone program did not facilitate insurgent recruitment (by inciting feelings of revenge or sympathy), or insofar as it did, insurgent groups struggled to integrate these new recruits into their organizations. Our focus on anticipatory effects speaks primarily to the latter possibility. The crisis of in-group trust may have imposed constraints on the extent to which insurgents could benefit from the availability of recruits.

That said, caution is warranted regarding the external validity of our results. While we contribute new information on the secret counterterrorism pact between the US and Pakistani governments, much remains unknown about the composition of US-Pakistan intelligence sharing and US surveillance technologies central to the program. Such details are critical when considering the generalization of our results, especially for weak state contexts like Afghanistan and Yemen.

Finally, while our theoretical position attributes relatively less importance to civilian behaviors and preferences in shaping conflict processes, we do not condone harm to civilians by drone strikes. Our evidence and theoretical perspectives on program efficacy alone cannot justify the use of drones. We remain extremely concerned on the reported levels of civilian casualties in US drone campaigns including

63. See Nagl et al. (2008), Berman, Shapiro, and Felter (2011), Condra and Shapiro (2012), Berman and Matanock (2015), and Shaver and Shapiro (Forthcoming) on the importance of civilian collaboration for counterinsurgency.

the one in Pakistan. Our finding that strategic gains are possible even when civilians are harmed should be a call for an even greater focus on civilian protection. In the absence of functional incentives to protect civilians, we worry that states may be prone to civilian abuse.

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