The Impact of Drone Warfare on Suicide Bombings in Pakistan

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Abstract

Some analysts argue that US drone strikes targeting militants in the North Waziristan (NW) region of the erstwhile Federally Administered Tribal Areas (FATA) of Pakistan reduce militant activity. Others argue that these CIA-led strikes increase this activity. Cause and effect are difficult to disentangle because common underlying factors may drive both forms of violence. We use weather to identify a positive and large causal effect of drone strikes in NW on suicide attacks nationwide in Pakistan. Specifically, we use cloud cover and precipitation data for the NW, plus a dummy variable for a specific drone base closure, to instrument for drone strikes in the NW between July 2008 and the end of 2016 and identify a casual effect on suicide bombings in the whole country during this period. The idea is that drone strikes, but not suicide bombings, rely on good weather and appropriate air bases for their feasibility and effectiveness. We find that each drone strike causes, on average, at least 1 suicide bombing within the subsequent month, usually within a radius of 0 to 400 kilometers from the strike point. Strikes that eliminate militants' leadership provoke particularly large reactions. We characterize 27-33 percent of all suicide bombings from July 2008 through 2016 as reactions to drone strikes. These results are robust to a variety of alternative specifications and estimators.

1 Introduction

The United States, effectively, went to war against Al Qaeda and affiliated militants after the September 2001 attack. Along the way, the Bush administration reinstated a policy, which had been banned since 1976, of targeted assassinations by the US military and the Central Intelligence Agency (CIA) to eliminate overseas actors deemed to be hostile (Williams, 2010). The US also introduced unmanned aerial vehicles (UAVs), also known as drones, into this assassination campaign. Drones are widely viewed as attractive weapons because of their relatively low cost, surveillance capabilities, ability to strike precise GPS points while keeping operators safe from life-threatening risks.[1]

The Waziristan region of what was formerly known as the Federally Administered Tribal Areas (FATA) of Pakistan has been a focus for US drone activity with the CIA leading a hunt for Al Qaeda members and allies.[2] The database of the New America Foundation records 414 drone strikes in the FATA targeting a variety of militant groups.[3]

Recent scholarly literature is divided about the impact of the US drone program in Pakistan. Johnston (2012), Johnston and Sarbahi (2016) and Mir and Moore (2018) argue that drone strikes have tended to suppress militant violence while Jaeger and Siddique (2018), Mahmood and Jetter (2019) and Rigterink (2021) argue, broadly, that the strikes may have been counterproductive. We consider exactly this question of whether or not these strikes have been effective in deterring violence. Our main innovation is to use variation in cloud cover and precipitation plus the closure of a drone base to instrument for drone strikes, thereby addressing an endogeneity issue that plagues efforts to identify a causal relationship between drone strikes and militant violence.[4] A second contribution is that we account for

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[1] Military drones can stay airborne for over 24 hours and are cheaper than fighter jets. Predator and Reaper drones cost around $4.5 million and $22 million, respectively, whereas F-16's and F-35's cost $47 million and $148-$337 million, respectively. General David Deptula described drones as offering the promise "to project power without projecting vulnerability" (Gusterson, 2016).

[2] The FATA was a federally administered tribal area of Pakistan bordering Afghanistan and consisting of seven agencies (North Waziristan, South Waziristan, Kurram, Orakzai, Khyber, Mohmand and Bajuar) until it was officially merged with the Khyber Pakhtunkhwa province in 2018. The drone program in the region was almost entirely run by the CIA, a prime exception being the May 2016 killing of Taliban leader Mullah Akhtar Mohammad Mansour in Baluchistan which was carried out by the US military (Feffer, 2016).

[3] For more information see https://www.newamerica.org/in-depth/americas-counterterrorism-wars/pakistan/

[4] Mahmood and Jetter (2019) use wind speed in an instrumental variables approach that is similar in spirit to our

spatial heterogeneity in the distribution of suicide bombings. Third, we eliminate noise by focusing specifically on suicide bombings, the weapon of choice for the Islamist militants the CIA targets with its drone strikes.[5] We find that drone strikes cause at least one suicide attack, on average, within the ensuing month which is likely to occur within a 0-400 kilometer radius of the strike point. We calculate that roughly 27-33 percent of suicide bombings in Pakistan between July 2008 and the end of 2016 are attributable to drone strikes.

2 The US Drone Program in Pakistan

2.1 Background

Drones are not new to the battlefield. For example, Iran used primitive drones to fire rocket-propelled grenades during the Iran- Iraq war in the 1980's (Gusterson, 2016). But in the 21st century the US has mobilized its technologically sophisticated Predator and Reaper drones into campaigns that are unprecedented in their sheer scale and capabilities.[6]

The CIA's first drone strike in Pakistan killed Taliban leader Nek Muhammad in South Waziristan (Mazetti, 2013) in June of 2004 after fighting in Afghanistan had prompted some Taliban and Al Qaeda fighters to relocate to the FATA and use it as a launching pad for attacks in both Afghanistan and Pakistan (Shahzad, 2011). International pressure and militant bombing campaigns within Pakistan then led the Pakistani government to overcome its initial reluctance to expel militants from these areas (Aslam, 2011) and the CIA was allowed to initiate a parallel and complementary campaign to target militants in the region using combat drones. The drone campaign started slowly with 9 strikes during 2005-2007 but then picked up pace as the Bush administration dramatically increased to 36 strikes in

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use of cloud cover.

[5] Our focus on suicide attacks is meant to eliminate some noise that comes from lumping together various attack types. For example, drone strikes are unlikely to drive assassinations of leaders of competing ethnic groups.

[6] Predator drones, first developed in the 1990's, weigh just 1130 pounds, can fly up to 25,000 feet and as fast as 135 miles per hour. Predators can stay airborne for 24 hours and are normally equipped with two Hellfire missiles. Reaper drones are still higher in quality, attaining twice the top speed and altitude of the Predators and carrying more missile types (Gusterson, 2016).

2008.[7] The number of strikes then ballooned up to 122 in 2010 alone and remained high until falling back to just 10 in 2015 and progressing down to single digits by 2018.

The US maintains that drones decapitate militant organizations and disrupt their activities through precision strikes that do not put American lives at risk. Johnston and Sarbahi (2016), Mir and Moore (2018), Byman (2013) and Horowitz, Kreps and Fuhrmann (2016)) all make cases for drone programs broadly in these terms.[8] However, critics argue that drone strikes breach international law, especially in countries like Pakistan and Somalia that are not officially at war with the US. They also stress collateral effects such as civilian fatalities (Lamb, Woods and Yusufzai, 2012), mental trauma suffered by residents of areas targeted through drones (Stanford Law School and New York University School of Law, 2012) and injury to the legitimacy of the governments of countries where the US makes drone strikes (Boyle, 2013). Finally, several recent papers argue that drone strikes are counterproductive, blowing back into increased violence against the US and its allies (Feffer, 2016; Jaeger and Siddique, 2018; Mahmood and Jetter, 2019; Rigterink, 2021). Our paper focuses on potential blowback, specifically taking the form of suicide attacks that might be connected with drone strikes in Pakistan.

2.2 Descriptive Statistics on Drone Strikes and Suicide Bombings

The database of the New America Foundation, (Bergen, Sterman, & Salyk-Virk, 2021), shows a sharp rise and subsequent fall in drone-strike frequency under Obama (Table 2.1 & Figure 2.1) with a much smaller spike in civilian casualties (Table 2.1). Drone strikes under Obama appear to have been more precisely targeted on militants (Table 2.1), an outcome that Gusterson (2016) attributes to better technology, such as Reaper drones, and tighter protocols governing the strikes.[9] The database credits

[7] Williams (2010) argues that Bush's failure to seek Pakistani consent for the US drone programme in Pakistan fuelled a subsequent spike in suicide attacks. Interviews by Mir and Moore (2018) do suggest, however, that President Musharaf did secretly approve an increase in strike frequency in response to pressure following the assassination of former Prime Minister Benazir Bhutto. Of course, targeted organizations would not have been privy to such a secret agreement so Williams (2010) could still be right.

[8] The program had operated for about 10 years before it was officially acknowledged in 2012. Yet it was an open secret with then CIA Director Leon Panetta commenting back in 2009 that "Very frankly, it's the only game in town in terms of confronting or trying to disrupt the al Qaeda leadership" (Williams, 2010)

[9] Reapers can carry more precise and smarter missiles in addition to Hellfire missiles. The rules for drone strikes were also tightened in May 2013 under pressure from human rights groups and a few European countries.

the Bush era strikes with 0.35 militant leaders killed per strike compared to just 0.18 for the Obama period, but the Bush results come at the cost of 7-8 civilians killed per militant leader killed compared to around 2 for Obama. Gusterson (2016) suggests that the new Obama policy of "signature strikes," i.e., monitoring behavior of suspects who are then struck if their behavior is found to be consistent with militancy, can largely explain the differences between the Bush and Obama administrations where the former executed strikes based on pre-decided kill lists (Gusterson, 2016). The observation period of the signature strikes seems to have saved the lives of civilians while expanding targeting to include more low-ranking militants than had previously been the case. In addition to the moral advantages of better targeting, one might expect more precise strikes to be more effective at countering militant violence than less precise strikes are.

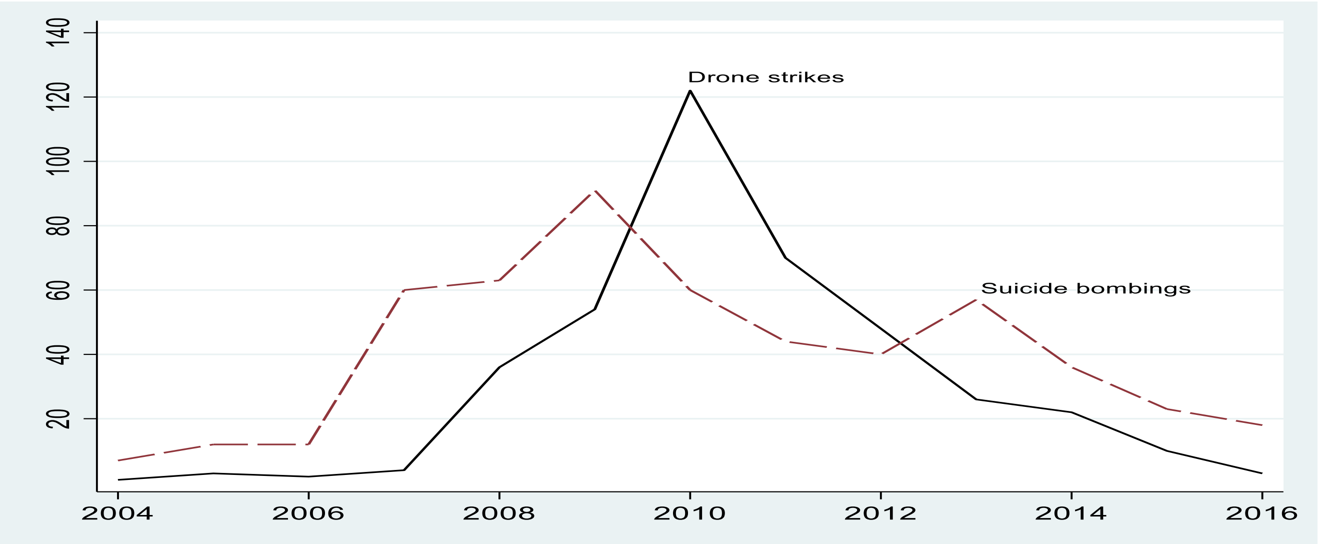
Table 2.1 Comparative Statistics of Drone Strikes

	Bush	**Obama**	**Trump**	**Total**
Total Strikes	48	353	13	414
Civilian Casualties	116-137	129-162	0-4	245-303
Militant Casualties	218-326	1659-2683	33-62	1910-3071
Unknown Casualties	65-77	146-249	0-2	211-328
Total Casualties	399-540	1934-3094	33-68	2366-3702
Civilian Casualties Per Strike (Min)	2.42	0.37	0.00	0.59
Civilian Casualties Per Strike (Max)	2.85	0.46	0.31	0.73
Militant Casualties Per Strike (Min)	4.54	4.70	2.54	4.61
Militant Casualties Per Strike (Max)	6.79	7.60	4.77	7.42
Total Casualties Per Strike (Min)	8.31	5.48	2.54	5.71
Total Casualties Per Strike (Max)	11.25	8.76	5.23	8.94

Data source: (Bergen, Sterman, & Salyk-Virk, 2021)

Suicide bombing trends track drone strike trends fairly well (Figure 2.1).

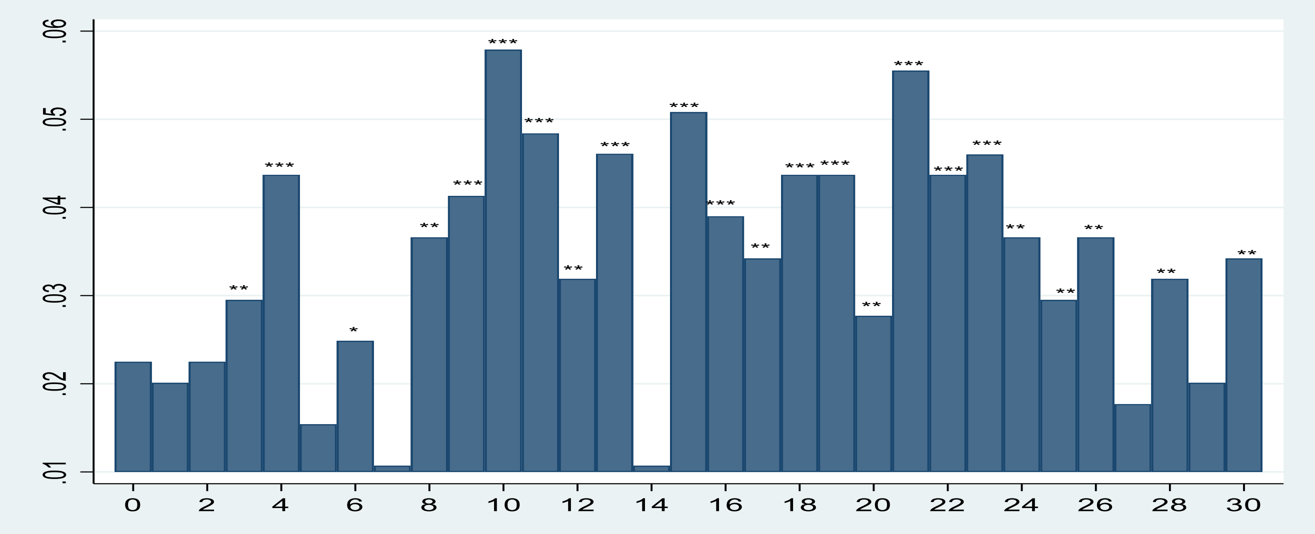
Figure 2.1 Trends in Drones Strikes and Suicide Bombings in Pakistan



Data sources: Drone Strikes: New American Foundation database on drone strikes in Pakistan. Suicide bombings: Chicago Project on Security and Threat, University of Chicago.

Moreover, following the methodology presented in Jaeger and Paserman (2008), Figure 2.2 shows average numbers of suicide bombings X days after drone-strike days minus the overall average of drone strikes per day over the whole period for all X between 1 and 31 days. We see elevated rates of suicide attacks throughout these drone-strike aftermaths with many statistically significant differences appearing three days after the drone strike. Saeed, Spagat and Overton (2019) show that these deviations sum roughly to 1, implying one extra suicide attack within a month of a drone strike. More conservatively, the sum of the statistically significant deviations is around 0.68. So drone strikes do appear to be associated with elevated suicide bombing rates although we cannot make a good causal claim based on this analysis.

Figure 2.2 Mean Deviations of Average Suicide Bombings Over 31 Days Following Drone Strikes



*The numbers of the Y axis represent deviations of the average number of suicide bombings on X days after drone strikes from the overall average number of suicide bombings. ***, ** and * indicate statistical significance at 1 %, 5 % and 10 % respectively. Data sources: Drone Strikes: New American Foundation database on drone strikes in Pakistan. Suicide bombings: Chicago Project on Security and Threat, University of Chicago.*

3 Literature and Hypotheses

The relevant literature divides along two distinct lines. The first divide is on the question of whether drone strikes deter or incite violence. The second divide is over methodology; some study local public opinion over drone strikes while others study the dynamics of strikes and militant violence.

Our paper focuses on the violent dynamics but here we pause briefly to consider the public opinion literature. A 2014 PEW survey found that 2 Pakistanis in 3 oppose drone strikes, suggesting rather strong opposition to the policy (Pew Research Center, 2014). [10] However, this survey did not cover the tribal areas where, plausibly, support for drone strikes aimed at ridding these areas of local violent actors could be much stronger than it is in the rest of the country. Nevertheless, a 2010 survey that covered tribal populations found that a whopping 90% of the population opposed US military operations in the region (Ballen, Bergen and Doherty, 2010). Shah (2018), on the other hand, criticized the PEW survey for its incomplete coverage and the Ballen, Bergen and Doherty (2010) survey for "social desirability

[10] See detailed survey at https://www.pewresearch.org/global/2014/08/27/a-less-gloomy-mood-in-pakistan/

bias," i.e., that respondents feared retaliation from militants if they failed to oppose drone strikes. Shah (2018) asked North Waziristan residents whether drone strikes created new militants and found that 71 percent of his respondents said that they did not while only 8 percent said that they did with the rest unsure. At first glance, the results of Shah (2018) seem to be in strong conflict with the previous survey work although many people can simultaneously oppose drone strikes while not believing that they incite people to join militant groups. Moreover, the sample of Shah (2018) appears to be rather biased towards sections of the tribal society such as tribal elders, maliks (official headmen), lawyers, reporters, officials, and students who are the sort of people targetted by the Taliban target and may, therefore, be more likely than the rest of the population to support drone strikes. Even so, the contrast between findings from tribal and non-tribal population samples in the Shah (2018) and (Pew Research Center, 2014) surveys, respectively, is striking. Silverman (2018) suggests that people in tribal areas may better understand the positive effects of drone strikes in their region than people living outside the region do and that knowledge of and support for drone strikes goes hand in hand. We make no attempt to resolve these disagreements here and simply note that average levels of public support for drone strikes are, at best, one factor among several in driving the dynamics of violence in Pakistan. It is, for example, possible that large numbers of Pakistanis are supportive of drone strikes while, simultaneously, a small sliver of society hates the strikes so passionately that they are driven into the arms of militant groups.

Johnston and Sarbahi (2016) and Mir and Moore (2018) operate within the violence dynamics branch of the literature, both finding that drone strikes deter militants' violence within the tribal areas and vicinity. Mir and Moore (2018) find that the whole drone program made a major contribution to deterring violence, with 75 percent of this violence-suppressing impact coming from the anticipatory effect of drone strikes which, they argue, changed the behavior of militants by, for example, restricting their movements and breaking down internal trust. In contrast, Johnston and Sarbahi (2016) focus, in contrast, on the effect of individual drone strikes which, they find, led to around a 5 percentage points decrease in the terrorist incidents. Both of these studies look for reactions only nearby to where drone strikes occur and not further afield in Pakistan. Yet Saeed and Syed (2016) find that militants emerge from a variety of geographical areas in Pakistan, not just the tribal ones. Thus, one might expect drone strikes to incite reactions throughout Pakistan, not just in the tribal areas where they occur. Indeed, Jaeger and Siddique (2018), consider reactions throughout Pakistan and find evidence of militant reaction within a week following drone strikes.

All of the above works on drone-militant dynamics relies on an assumption that drone strikes are exogenous events although there is good reason to question this assumption. First, Islamabad clandestinely coordinates the drone campaign with the CIA. Pakistani intelligence agencies serve up militants as CIA targets whom they know to have perpetrated violence within Pakistan.[11] Thus, there is a plausible channel of causation running from militant attacks to drone strikes, operating through Pakistani intelligence agencies and the CIA. Second, the activity of both militant violence and drone strikes can plausibly be affected by some common underlying factors such as group sizes of militant organizations and locations and episodes of infighting. Failure to account for these factors can cause correlations between the error terms in econometric models meant to explain militant violence and the drone strike variable used as an explanatory variable in these models.

Mahmood and Jetter (2019) address this endogeneity problem by using wind speed as an instrument for drone strikes. They find, in contrast to Johnston and Sarbahi (2016) and Mir and Moore (2018), that 1 drone strike generates roughly 4 terrorist attacks over the subsequent 7 days and that drone strikes explain around 16 percent of all terrorist incidents within Pakistan between 2006 and 2016. Rigterink (2021) uses success versus failure of attempts to assassinate top terrorist leaders with drone attacks as quasi-random outcomes to identify a causal effect of drone strike hits on subsequent terrorist attacks.

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[11] Pakistan has always officially denied its involvement in the drone program. However, there is ample evidence to suggest otherwise. Miller and Woodward (2013) quotes from CIA documents and Pakistan's diplomatic memos showing that Pakistani officials were regularly briefed about the drone strikes. On the 12th of February 2009, Dianne Feinstein, Chair of the Senate Intelligence Committee, acknowledged that drones were flying from an air base within Pakistan. Indeed, the *Times* later published images from Google Earth showing drones parked at Shamsi Airbase in Baluchistan, Pakistan, implicating the Pakistan military in the program (Page, 2009). President and former Army Chief Pervez Musharraf admitted in a 2013 CNN interview that Pakistan did consent to some drone strikes while Mir and Moore (2018) quotes officials from the US and Pakistan reporting that Musharraf offered the CIA a "flight box" over North Waziristan. Even Pakistan's civilian leadership had no qualms about the drone program; an August 2008 cable, published by Wikileaks, quotes the Prime Minister of Pakistan Yusuf Raza Gilani telling US Ambassador Anne Patterson that "I don't care if they do it as long as they get the right people. We'll protest in the National Assembly and then ignore it." For more see Mir and Moore (2018), Robertson and Botelho (2013), Mazetti (2013) and Miller and Woodward (2013)

Our work differs from Mahmood and Jetter (2019) in three main ways. First, we consider a range of potential instruments and find that cloud cover, precipitation and the date of a major drone base closure in Pakistan outperform wind speed as instruments for drone strikes. Second, we focus exclusively on suicide bombings which are the best documented and most lethal method of militant violence, particularly against targets such as military or foreign installations due to their international connections. Third, we also account for spatial variation in the distribution of suicide bombings carried out in response to drone strikes. The identification strategy of Rigterink (2021), hits versus misses, is entirely different from both ours and that of Mahmood and Jetter (2019) while our other differences from the latter paper also apply to the former one. Rigerink(2021) also considers other questions such as impacts on the types of terrorist attacks.

The above discussion shows that the existing evidence is mixed on whether drone strikes are effective in countering terrorism. One side of the argument maintains that drone strikes can disrupt and degrade terrorist networks and hence affect their ability to perpetrate violence (Johnston, 2012: Johnston and Sarbahi, 2016; Mir and Moore, 2018), leading to our first hypothesis:

Hypothesis 1A: *All else equal, drone strikes lead to a reduction in suicide bombing.*

On the other hand, patterns in suicide bombing following drone strikes in Pakistan are suggestive of blowback effect (Figure II: Jaeger and Siddique (2018): Mahmood and Jetter, 2019: Rigterink, 2021). The theoretical argument in support of these patterns is that drone strikes kill innocent people, not just the militants, and hence incite anger, national outrage and result in violence (Kilcullen and Exum, 2009, Feffer, 2016). This leads to our second hypothesis:

Hypothesis 1B: *All else equal, drone strikes lead to an increase in suicide bombing.*

In the next section, we outline the econometric methodology we use to test the causal impact of drone strikes on suicide bombings.

4 Econometric Methodology

We assess the impact of drone strikes on suicide bombing using regression analysis. However, the standard Ordinary Least Squares (OLS) approach, illustrated in equation (1) below, is inadequate due to endogeneity problems (Green, 2003):

$$SuicideBombing_t = \beta_0 + \beta_1 Drones_t + X_t^{`}\beta + \varepsilon_t \qquad (1)$$

where $X_t^{`}$ is a matrix of control variables and ε_t is an error term. Specifically, the error term in a regression of suicide bombings on drone strikes could be correlated with the drone-strike variable, rendering the OLS estimates to be biased.

Reasons for endogeneity problems abound. First, there is measurement error in part because we must extract our data from imperfect news stories. Second, there may be reverse causation whereby suicide bombings also cause drone strikes, in part because suicide attacks provide information on possible whereabouts of terrorist groups while also exerting pressure for responses. Third, both suicide bombings and drone strikes may be affected by common factors that are omitted from the regression. For instance, reports of infighting amongst militant groups could affect their capacity to carry out suicide bombings while at the same time increasing their visibility and, hence, vulnerability to drone strikes (Craig & Khan, 2014). Other factors such as the geographical locations of militant groups and their sizes and strengths might simultaneously affect both suicide bombings and drone strikes. Governments and militant groups are unlikely to share detailed information on such factors so they are unobservable and, therefore, not included in estimated models. OLS estimation of equation 1 can, therefore, lead to errors in the signs, magnitudes and p values of our estimates.

We use cloud cover, precipitation and a dummy for the closure of a drone base in Pakistan as instruments for drone strikes to counter the endogeneity issues. Weather conditions affect the flying and targeting capabilities of drones (Mahmood and Jetter, 2019; C., Wood, personal communication, March 02, 2019; J., Bronk, personal communication, March 06, 2019; W., Zwijnenburg, personal communication, March 07, 2019; United States Government Accountability Office, 2017; Gusterson, 2016; Whitlock, 2014; Fowler, 2014).[12] Drone operators gather evidence through live camera

[12] We corresponded with Chris Woods (Director Airwars), Justin Bronk (Research Fellow/Editor Royal United

surveillance (Gusterson, 2016).[13] Cloud cover and related conditions, such as rain, impede this camera-based surveillance and also hinder take-offs and landings.[14] Also, the missiles in use for Predator and Reaper drones during this our time period, such as the GBU-12 and the AGM-114 Hellfire, require clear lines of sight for targeting.[15] Hence cloud cover and rain, as measured through precipitation, are important factors which influence both visual monitoring and immediate combat capabilities for drones. At the same time, clouds and precipitation should not directly affect suicide attacks. Thus, these two weather variables appear to be excellent candidates for instruments, either alone or in combination. We also use a qualitatively different instrument in the form of a dummy variable for the closing of Shamsi airbase in Baluchistan province of Pakistan on November 26, 2011.[16] NATO had just accidentally killed 24 Pakistani soldiers at a checkpoint on the Pakistan-Afghan border and Pakistani officials felt pressure to take visible action against the US. Shamsi base was a workhorse facility for surveillance and combat drone missions at that time and its closure compromised drone operations without directly affecting suicide attacks.

Our first-stage model is:

$$Drones_t = \alpha_0 + \alpha_1(cloud\ cover * precipitation)_t + \alpha_2(Base\ Closure)_t + X_t'\alpha + \gamma_t \qquad (2)$$

Where X is a matrix of control variables and γ_t is the error term. The second-stage equation incorporates the predicted values for drones from the first stage model as an independent variable.

$$SuicideBombing_t = \beta_0 + \beta_1(Predicted\ Drones)_t + X_t^{`}\beta + \varepsilon_t \qquad (3)$$

Services Institute, Royal United Services Institute for Defense and Security Studies) and Wim Zwijnenburg (Program Leader Humanitarian Disarmament, PAX for Peace) and received valuable input about how weather conditions such as cloud cover affect targeting through these missiles.

[13] Other than the camera, the sensor ball also contains equipment for capturing mobile signals on the ground (Gusterson, 2016). See the BBC's report on how drones works at *https://www.bbc.co.uk/news/world-south-asia-10713898*

[14] According to United States Government Accountability Office, 20 percent of Predator B mission cancellations during the period 2013-2016 were due to these weather conditions (United States Government Accountability Office, 2017).

[15] GBU-12 and AGM-114 are semi-active laser homing missiles and cloud cover can cause beam distortion and attenuation for the spotting laser which the weapons home in on (C., Wood, personal communication, March 02, 2019; J., Bronk, personal communication, March 06, 2019; W., Zwijnenburg, personal communication, March 07, 2019).

[16] See Henderon, (2011) and Dawn, (2011) for more on the Shamsi airbase closure.

We employ Limited Information Maximum Likelihood (LIML), Generalized Method of Moments (GMM) and Two-Stage Least Square (2SLS) estimators for this final equation with each method offering some advantages. 2SLS is simple, intuitive and widely understood while GMM is suitable for over-identified models and LIML, which is asymptotically equivalent to 2SLS, outperforms 2SLS with weak instruments and also exhibits less bias than the other estimators (Cameron and Trivedi, 2009).

5 Data Sources

5.1 Dependent Variables: Suicide Bombings

The data for incidents and casualties in suicide bombings is taken from Chicago Project on Security and Threats (CPOST), University of Chicago, database. The CPOST database is one of the most prolific and widely used data repositories on suicide bombings.

5.2 Instrumented Variables: Incidence and Casualties of Drone Strikes

The data for drone strike incidents and casualties is taken from the New America Foundation (NAF) database which records 414 drone strikes in Pakistan between 2004 and 2018. The Bureau of Investigative Journalism (BIJ) and the Long War Journal (LWJ) are alternative sources, recording 430 and 404 drone strikes, respectively, during the same period. However, we use the NAF database because it provides detail not just on civilian casualties but also on identities of militant leaders, enabling an analysis of the impact of drone strikes that kill leadership figures leaders on suicide bombings.

5.3 Instrumental Variables: Cloud Cover, Precipitation and a Dummy for a Drone Base Closure

The data for cloud cover and precipitation comes from World Weather Online which is one of the largest online repositories of weather data covering approximately 3 million cities/towns worldwide.[17] Cloud cover is measured as the percentage of sky covered by clouds. Total precipitation is measured in millimeters. The dummy for drone base closure is 0 before November 26, 2011 and 1 afterwards. We purchased weather data for just North Waziristan which experienced 70 percent of all drone strikes in Pakistan between July 2008 and December 2016.[18] Accordingly, our empirical analysis includes only drone strikes in North Waziristan.

5.4 Other Control Variables

Controls include dummies for the holy months of Ramadan and Muharram, Parliamentary election periods and three military offensives by Pakistan's military. Islamic tradition discourages fighting during the month of Ramadan, possibly explaining some variation in suicide bombings (Jaeger and Siddique, 2018). Muharram is also an important religious month, particularly for Shiites, who march in processions in remembrance of death of Prophet Muhammad's grandson Hussain. Many Sunni militants in Pakistan consider Shiites to be heretic and target them particularly during this month, sometimes with suicide bombs. Pakistani militants oppose parliamentary forms of government and, hence, can be expected to launch suicide attacks for subversion during election periods.[19] The major Pakistani military operations known as *Zarb e Azab* (Sharp and Cutting Strike), *Rah-e- Haq* (Just Path) and *Rah-e-Rast* (Righteous Path) can be expected to influence suicide bombings.[20] Staniland, Mir and Lalwani (2018) provide the dates for these operations. Our final controls are dummies on the years 2011, 2012 and 2013 [21]

We report descriptive statistics for all the variables in the Appendix

[17] See https://www.worldweatheronline.com/aboutus.aspx for more information.
[18] We are restricted to this time period because world weather online data for North Waziristan starts from July 2008 and suicide bombing data terminates in 2016.
[19] For more on the Taliban's threat to elections see (Farhan & Mallet, 2013)
[20] The time periods for the three offensives in our models are 2014 to the end of our study period, September 2007 to February 2009 and May 2009 to July 2009 for *Zarb e Azab, Rah e Haq and Rah e Rast* respectively.
[21] We do not use dummies for years 2008, 2009, 2010, 2014, 2015 and 2016 due to the high correlation of these dates with military operations.

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5 Results

5.1 The Main Results

Table 2.2 shows second stage estimates, with time resolved down to the weekly level, using Limited Information Maximum Likelihood (LIML), Generalized Method of Moments (GMM) and Two-Stage Least Square (2SLS) estimators. Drone-strike coefficients are always positive with significance levels between 5% and 1%. The magnitudes of the estimates are large, ranging between 0.37 and 0.43, suggesting that every three drone strikes cause more than one suicide bombing within a week on average. Although one should not focus much attention on coefficient estimates for control variables it does seem worth noting that *Zarb-e-Azab* offensive does seem to be associated with a sharp drop in suicide bombings. The instruments appear to be quite strong with the first stage F statistics much larger than the conventional benchmark of 10 (Cragg and Donald, 1993). The final column in table 2.2 suggests that each drone strike causes roughly 9 suicide bombing deaths on average, a large effect indeed.

The estimate for drone strikes in the OLS small and insignificant (Table 2.2). However, results from several diagnostics tests suggest that drone strikes is an endogenous covariate in the model for suicide bombings, indicating that the estimate from OLS estimation is not reliable

Table 2.2 Instrumental Variable Regressions (Week-Level Contemporaneous Impact)

Dependent Variable: Number of Suicide Bombings (Fatalities in Suicide Bombings for the Final Column)

Variables	OLS	LIML	GMM	LIML	GMM	2SLS with Newe y-West S.E	2SLS with Newey -West S.E
Drone Strike	**-0.036 (0.44)**	**0.461*** (0.02)**	**0.435*** (0.00)**	**0.380*** (0.01)**	**0.371*** (0.01)**	**0.379** (0.04)**	**8.95*** (0.00)**
Other Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	No	No	Yes	Yes	Yes	Yes
1st Stage F statistic		20.98	20.86	49.38	49.38	49.38	49.38
F Statistic	8.03	8.80	8.79	7.13	7.18	7.20	4.01
Probability>Chi2	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The dependent variable is the number of suicide attacks in all columns except for the last one for which it is the number of fatalities in suicide attacks. All models include a constant and have 442 observations. p values are in parentheses. **** p< 0.01, ** p< 0.05 and * p<0.10.*

Table 2.3 gives results from further diagnostic tests. The endogeneity test of Baum. Schaffer and Stillman (2007) rejects in all models the null hypothesis that drone strikes are exogenous, thereby supporting our initial premise that research needs to address the endogeneity of drone strikes.[22] Next we consider the requirement that our instruments should be correlated with drone strikes but not with the error terms in the estimated equations. Indeed, our Hansen J tests (Baum, Schaffer and Stillman, 2007), reject the hypothesis of correlations between the instruments and the error terms in all models. Next, as further checks for possible weakness of our instruments, we perform Montiel Olea-Pflueger tests, which are robust to both heteroscedasticity and autocorrelation (Montieal-Olea and Pflueger,

[22] This test is implemented in Stata and is based on difference of two Sargan-Hansen statistics. These statistics are obtained by first estimating an equation which treat suspect regressors as endogenous and then another equation which treat them exogenous. The test is numerically equivalent of a Hausman test under conditional homoscedasticity.

2013). This test examines the possibility that the bias of an IV estimator exceeds a certain fraction, τ, of worst-case bias which arises if all the instruments are irrelevant. The effective F statistic is larger than the critical value for a 5 % worst case bias at a signifiance level of 1 %. In other words it is highly unlikely that our instruments suffer from bias which, in any case, would not exceed 5 % of worst case bias.

Finally, we employ the LM redundancy test to check whether we may be using too many instruments (Baum, Schaffer and Stillman, 2007) and always reject the hypothesis of redundant instruments.

To summarize, Tables 2.2 and 2.3 support the blowback idea encapsulated in hypothesis 1B and this finding is robust to a wide range of diagnostic tests.

Table 2.3 Results for Diagnostic Tests

Test for Endogeneity H_0= Drone strikes and Base Closure are exogenous	7.22 (0.007)
Hansen J Over-identification Test H_0= CloudCover *Precipitation and Drone Base Closure uncorrelated with error	0.26 (0.60)
Montiel-Pflueger Weak Instrument Test H_0= Bias in the IV estimator exceeds percentage τ of worst case bias Effective F Statistic	45.22
Critical value for 5 % worst case bias at 1 % level of signifiance	30.30
LM Test of Instrument Redundancy H_0= Instrument is redundant	Cloud cover * Precipitation= 6.35 (0.01) Base closure = 29.06 (0.00)

p values are in the parentheses

We now repeat our analysis but changing the time resolution to two-week periods (Table 2.4). The results are broadly consistent with what we found at 1-week time resolution with the coefficients on drone attacks falling within a range of 0.37 to 0.42 with less significance than before..

Table 2.4 Instrumental Variable Regressions (Two-Week Level Contemporaneous Impact)

`	Dependent Variable: Number of Suicide Bombings					D.V= Number of Fatalities in Suicide Bombing
Variables	**LIML**	**GMM**	**LIML**	**GMM**	**2SLS with Newey-West S.E**	**2SLS with Newey-West S.E**
Drone Strike	0.428** (0.02)	0.416** (0.02)	0.371** (0.04)	0.371** (0.03)	0.371 (0.11)	9.21** (0.01)
Other Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	No	No	Yes	Yes	Yes	Yes
1st Stage F statistic	16.30	16.30	25.67	25.67	25.67	25.67
F Statistic	9.60	9.60	7.30	7.31	9.39	4.01
Probability >Chi2	0.00	0.00	0.00	0.00	0.00	0.00

The dependent variable is the number of suicide attacks in all columns except for the last one for which it is the number of fatalities in suicide attacks. All models include a constant and have 222 observations. p values are in parentheses. **** p< 0.01, ** p< 0.05 and * p<0.10.*

Table 2.5 repeats our 2SLS analysis but with time divided, first, into three-week periods and, second, into four-week periods. The results, combined with the previous ones, suggest that much of the reaction to drone strikes is loaded into the last two weeks of the four-week aftermath. The coefficient on drone strikes exceed 1 already within the three-week window and rises to around 1.6 within the four-week window. These estimates are reminiscent of, but substantially larger than, the findings shown in figure 2.2 that did not account for endogeneity. These results further strengthen the evidence for the blowback thesis.

Table 2.5 Instrumental Variable Regression (Follow-up Impact)

	Dependent Variable Number of Suicide Bombings In period of t+ 3 weeks		Dependent Variable Number of Suicide Bombings in period of t+ 4 weeks	
Variables	**2SLS with Newey West S.E**	**2SLS with Newey West S.E**	**2SLS with Newey West S.E**	**2SLS with Newey West S.E**
Drone Strike	1.31** (0.02)	1.21** (0.02)	1.65** (0.03)	1.55** (0.02)
Other Control Variables	Yes	Yes	Yes	Yes
Time Dummies	No	Yes	No	Yes
F stat	11.14	8.64	12.17	9.65
prob>f	0.00	0.00	0.00	0.00

All models contain a constant. Models for t+3 weeks suicide bombings have 439 observations. Models for t+4 weeks suicide bombings have 438 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10.*

5.2 Decapitation Effects

We now focus attention just on drone strikes that eliminate militant leaders, i.e., so-called "decapitation" strikes. Jordan (2009) argues that the effectiveness of decapitation strikes depends upon a constellation of factors, such as group size, age and effectiveness in replacing leadership while Pape (2003) finds little evidence of their effectiveness in his study on suicide terrorism. On the other hand, Johnston (2012), accounting for endogeneity and measurement error, and Johnston and Sarbahi (2016) both found that decapitation reduces violence. Most recently, Rigterink (2021) found a causal blowback effect.

Our instrumental variables analysis, using 2SLS, suggests that decapitating drone strikes increase suicide bombings (Table 2.6), that is, we agree with Rigterink (2021) using an identification approach completely different from hers. The magnitude of our estimated drone-strike coefficient 2.78 is significantly larger than our estimated coefficients for all drone strikes, although statistical significance is only at the 10% level. Diagnostic tests support both the endogeneity of decapitation strikes and the strength of our instruments.

Table 2.6 Instrumental Variable Regressions (Decapitation Effect)

Variables	Dependent Variable: Number of Suicide Bombings 2SLS with Newey-West S.E.
Leader Killed in Drone Strike	2.78* (0.07)
Other Control Variables	Yes
Time Dummies	Yes
1st Stage F statistic	8.86
Montiel-Pflueger Weak Instrument Test H_0= Bias in the IV estimator exceeds percentage τ of worst case bias Effective F Statistic Critical value for 5 - 10 % worst case bias at 1 % level of signifiance	 9.87 11.18-9.41
Endogeneity Test *Null Hypothesis= Variables are Exogenous*	4.84 (0.01)
F Statistic	6.08
prob> F	0.00

All models contain a constant and have 442 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10.*

2.5.3 Spatial Distribution Effects

All of the above results concern suicide attacks at the national level. We now distinguish between four different areas at increasingly large distances from North Waziristan (Table 2.7). The estimates suggest that most of the first-week suicide-bombing reaction to drone strikes occurs between 100 and 300 kilometers from North Waziristan.[23]

[23] The results for regions beyond 400 kilometers are very small so we do not report them here.

Table 2.7 Spatial Allocation Effects

Variables	Dependent Variable: Number of Suicide Bombings Between 0-100 KM from NW	Between 100-200 KM from NW	Between 200-300 KM from NW	Between 300-400 KM from NW
Drone Strike	0.085* (0.09)	0.178** (0.04)	0.167** (0.01)	0.033 (0.33)
Other Control Variables	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
F stat	3.43	6.14	3.38	1.75
prob>F	0.00	0.00	0.00	0.06

All models contain a constant and have 442 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10.*

Table 2.8 repeats the analysis of Table 2.7 but with time counted in four-week intervals. The findings from predicted spatial allocation effects are reported in Table 2.9. Again, we find that most of the suicide-bombing response to drone strikes comes within a 100 to 300 kilometer range of North Waziristan.

Table 2.8 Follow-up Spatial Allocation Effect

Variables	Dependent Variable Number of Suicide Bombings in period t+ 4 weeks Between 0-100 KM from NW	Between 100-200 KM from NW	Between 200-300 KM from NW	Between 300-400 KM from NW
Drone Strike	0.288* (0.08)	0.769*** (0.01)	0.640*** (0.00)	0.037 (0.75)
Other Control Variables	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
F Statistic	5.22	9.24	4.08	3.41
prob>F	0.00	0.00	0.00	0.00

All models contain a constant and have 438 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10.*

Next we investigate whether suicide-bombing responses to drone strikes really do dissipate after 400 kilometers from North Waziristan as Tables 2.7 and 2.8 seem to suggest. Table 2.9 addresses this issue by repeating 2SLS estimates in Tables 2.2 and 2.5 but considering suicide bombings only within a 400 kilometer radius of North Waziristan. The estimated coefficients of 0.45 and 1.49 are close to the earlier estimated coefficients of 0.38 and 1.45, suggesting that, indeed, the reaction dissipates by the 400 kilometer mark.

Table 2.9 Subsample of 0-400 km from N.W

Variables	Week-Level Contemporaneous Impact Dependent Variable Number of Suicide Bombings	Follow-up Impact Dependent Variable Number of Suicide Bombing In period t+4 weeks
Drone Strike	0.463** (0.00)	1.73 (0.00)
Other Control Variables	Yes	Yes
Time Dummies	Yes	Yes
F Statistic	9.02	19.08
prob> F	0.00	0.00

All models contain a constant. Model for week level impact has 442 observations. Model for follow-up impact has 438 observations Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10.*

6 Further Robustness Checks

We ran bivariate probit regression for which the dependent variable is 1 if there is a suicide attack within the week after a drone strike and 0 otherwise. Again, we get a large and statistically significant effect of drone strikes on suicide attacks (Table 2.10).

Table 2.10 Bivariate Probit Regression

Variables	Dependent Variable Number of Suicide Attacks
Drone Strike (=1 if there is a strike)	0.736** (0.02)
Other Control Variables	Yes
Time Dummies	Yes
Wald Chi2	148.88
Prob>Chi2	0.00

The model contains a constant and have 442 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10*

The Appendix reports estimates from a Three Stage Least Squares (3SLS) estimator (Table AP-2), which is more efficient than 2SLS and is also preferred if errors across equations are correlated (Cameron and Trivedi, 2009). The results turn out to be quite similar to the 2SLS estimates. Finally, and γ_t is the error term. The second-stage equation AP-3 reports estimates using casualties in drone strike rather than drone-strike events to explain deaths in suicide bombings. Again, we find large and statistically significant effects that are supported by diagnostic tests.

7 Discussion

We find that drone strikes cause substantial increases in suicide bombing. These results are in conflict with theoretical propositions and empirical findings in Johnston & Sarbahi (2016), Mir and Moore (2018), Byman (2013) and Horowitz, Kreps and Fuhrmann (2016). However, none of these works grapple seriously with the endogeneity issue. Both Mahmood and Jetter (2019) and Rigterink (2021) do account for endogeneity, in very different ways, and find that drone strikes cause terrorism.

In contrast to all studies mentioned above, we specifically focus on suicide bombing. When we use an OLS estimator to measure the parameters instead, the coefficient of drone strikes turns out be negative with weak statistical significance [Table 2.2]. This would imply, as most of the previous studies have found as well, that drone strikes deter suicide bombing. However, various diagnostic tests reported earlier provide evidence in support of the endogeneity of drone strikes and the use of instruments. This is true even when we use alternative specifications and estimators such as Bivariate Probit and 3SLS. Hence, the results from OLS estimation are biased and not reliable. It does sometimes happen that OLS and IV coefficients have opposiste signes, e.g., the influential paper by Levitt (1997) on the effect of police on crime.

We have two major findings from our empirical analysis. First, an increase in drone strikes leads to an immediate increase of around 0.37-0.45 in suicide bombings. There is also evidence for at least 1 additional suicide bombing on average within one month following a drone strike. Possible blowback mechanisms are an increase in recruitment, perhaps including relatives of civilians killed in drone strikes, and retaliation. Shah (2018) uses an opinion poll of residents in tribal areas to argue against the notion that drone strikes stimulate recruitment of militants. However, this sample is biased towards strata of society targeted by the Taliban and there are documented stories about individuals resorting to suicide bombings to avenge deaths of relatives in drone strikes. For example, one Pakistani reported that "My neighbor was so furious when a drone killed his mother, two sisters and his 7-year-old brother last September that he filled his car with explosives and rammed it into a Pakistani army convoy. He had to avenge the death of his loved ones".[24] Tehrik Taliban Pakistan (TTP) have also claimed many attacks, such as the one in March 2009 in Lahore against the police academy, as retaliation for drone strikes.[25] Feffer (2016) suggests, correctly in our view, that blowback can happen without a substantial fraction of the population turning to violence in response to drone strikes and without a general consensus that drone strikes are bad. Strong reactions from a small minority of the population are sufficient, especially if these reactions involve suicide bombings which cause roughly 13 deaths and 43 injuries per attack. The strengthened reactions we find to such drone strikes that eliminate militants' leaders seem more likely to be driven by retaliation since such strikes to seem unlikely to particularly affect recruitment. However, Rigterink (2021) argues that the best explanation involves splintering and infighting within terrorist group that leads to indiscipline after leaders are killed.

The spatial allocation analysis suggests that the impact is exhausted within 0-400 km radius from North Waziristan. This radius covers almost all of Khyber Pakhtunkhwa (KPK) province, the capital city of Islamabad, major cities within Punjab province such as Rawalpindi, Faisalabad, Multan and the periphery of Lahore. Saeed, Syed and Martin (2014) studied militancy patterns in Pakistan and found that a large fraction of the violence during the 2000s took place in KPK and the erstwhile FATA regions, primarily because it was the latter region that was the launching pad for insurgency in Pakistan. The interior Sindh and major parts of Baluchistan seem to be almost immune from suicide bombings in retaliation for drone strikes.

[24] Cited in Williams (2010).

[25] See in BBC's report http://news.bbc.co.uk/1/hi/world/south_asia/7973540.stm.

8 Conclusion

Our findings suggest that drone strikes in Pakistan are counterproductive. Our analysis only includes strikes in North Waziristan, but these account for around 70 percent of all CIA drone strikes in Pakistan. Our main contribution is to use cloud cover, precipitation and a dummy for US drone base closure in Pakistan to instrument for drone strikes, thereby addressing an endogeneity problem that has plagued part of the literature in this area. Diagnostic tests support both the existence of the endogeneity problem and the quality of our instruments. The results indicate that drone strikes result, on average, in at least 1 suicide bombing in the subsequent month. These results suggest that roughtly 27-33 percent of the suicide bombings occurring between July 2008 and the end of 2016 can be attributed to drone strikes. The impacts are strongest between 100 and 300 kilometers from drone strike locations with no statistically significant impact beyond a 400 kilometer radius. The results also indicate particularly strong reactions to drone strikes that eliminate militants' leadership. These findings are robust to different estimators and specifications, including LIML, 2SLS, 3SLS, GMM and Bivariate estimations. There is now a growing body of evidence pointing to the counterproductive nature of drone strikes.

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Appendix

Table AP-1 Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
No. of Drone Strikes	0.672	1.18	0	7
No. Killed in Drone Strikes	4.595	8.41	0	50
No. of Leaders Killed in Drone Strikes	0.102	0.400	0	3
No. of Suicide Bombings	0.921	1.13	0	6
No. Killed in Suicide Bombings	11.98	22.10	0	108
Cloud Cover (% of total sky)	11.70	9.24	0	46.29
Precipitation mm	0.391	0.721	0	5.71
Cloud Cover * Precipitation	59.24	154.80	0	1444.27
Drone Base Closure	0.600	0.491	0	1
Ramadan	0.104	0.306	0	1
Muharram	0.090	0.287	0	1
Elections	0.023	0.149	0	1
Zarb e Azab	0.301	0.459	0	1
Rah e Haq	0.075	0.263	0	1
Rah e Rast	0.023	0.149	0	1

TableAP-2 Instrumental Variable Regression with 3SLS

Dependent Variable: No. of Suicide Bombings

Variables	Total Sample	0-100 KM	100-200 KM	200-300 KM	300-400 KM
Drone Strikes	0.378*** (0.01)	0.084 (0.14)	0.178** (0.05)	0.167*** (0.01)	0.033 (0.24)
Other Control Variables and Time Dummies	Yes	Yes	Yes	Yes	Yes

All models contain a constant and have 442 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10*

Table AP-3 Instrumental Variable Regression

Dependent Variable: No. of Suicide Bombings

Variables	2SLS with Newey-West S.E.
No. of Fatalities in Drone Strikes	1.34*** (0.00)
Other Control Variables	Yes
Time Dummies	Yes
1st Stage F statistic	44.36
Endogeneity Test *Null Hypothesis= Variables are Exogenous*	9.12 (0.00)
F Statistic	4.18
prob>F	0.00

The model contains a constant and have 442 observations. Parentheses contain p values. *** *p< 0.01, ** p< 0.05 and * p<0.10*