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Do remotely piloted aerial vehicles make terrorism more costly for terrorists?: Empirical evidence from Pakistan

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Abstract

Purpose – The use of remotely piloted aerial vehicles (RPVs) as a counterterrorism strategy is intensely debated on grounds of legitimacy, political feasibility and human rights. This study aims to contribute to the understanding of the link between RPVs' strikes and terrorism through evidence-based analysis.

Design/methodology/approach – Using insights from economic analysis of counterterrorism, the study hypothesized possible channels through which RPVs may increase costs for terrorism. A novel data set is gathered to empirically test the theory-consistent prediction of a negative link between RPVs' strikes and terrorism in a multivariate econometric framework.

Findings – Focusing on RPVs' strikes in Pakistan over 2008 to 2013, the analysis yields important new insights. The principal finding suggests that RPVs reduce overall terrorism, while, without negating the negative spillover effects of RPVs use, there is no evidence of a positive feedback from civilian casualties to terrorism. These findings are not driven by extreme observations and satisfy a number of conventional diagnostic checks.

Practical implications – A well-constructed comparison and empirical evidence in this study implies that RPVs may yield net benefits in terms of greater security at regional and national levels.

Social implications – Moreover, as a proactive counterterrorism measure, RPVs can be an effective policing tool in crowded urban areas facing the greater threat of terrorism.

Originality/value – The study is the first to systematically analyze the link between RPV strikes and the magnitude of terrorism. The groundbreaking analysis thus extends the scope of economic inquiry to the role of RPVs as a counterterrorism strategy at national, regional and global levels. The findings of the study cast doubt on the validity of many popular notions about RPVs strikes, as they find little support in the empirical analysis.

Keywords Pakistan, Terrorism, Counterterrorism, USA, Remotely piloted aerial vehicles

Paper type Research paper

> It is a cruel and bitter truth that in the fog of war and our fight against terrorists specifically, sometimes mistakes can occur. One of the things that makes us exceptional is our willingness to confront squarely our imperfections and to learn from our mistakes. Barrack Obama.

JEL classification – D74, E0, H56, I19, O5

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1. Introduction

Terrorism has changed the nature of violent conflict. Unlike the interstate warfare of the twentieth century, the modern conflict involves non-state actors targeting and terrorizing states and citizens (World Bank, 2011). With this change emerge new policy challenges related to counterterrorism and the use of appropriate weapons and means to ascertain the security of citizens. A burning issue in this context is the use of remotely piloted aerial vehicles (henceforth, RPVs) as a weapon of choice against terrorism. The use of RPVs in targeting terrorists in their strongholds in Afghanistan, Iraq, Pakistan and Yemen, is considered controversial both in legal and human rights terms. Notwithstanding the controversies, the rising expenditures by world governments on RPVs technologies, from \$6.6bn in 2012 to an expected \$12bn in 2015, bespeak their increasing military use in future (PR Newswire, 2015). However, the extent to which RPVs are effective in countering terrorism is still unexplored. This study is an attempt to fill this gap.

Surprisingly, the debate on the use of RPVs does not provide any generalizable and robust empirical findings. (Fair, 2014 provides a critical assessment of the important studies related to the use of RPVs in the context of Pakistan). More to the point, the extant literature in economics of terrorism and conflict fails to consider RPVs among counterterrorism measures (Sandler, 2015; Schneider *et al.*, 2015; and Llussa and Tavares, 2011). Besides increasing the scope of existing studies, this paper contributes to the academic discourse on counterterrorism in two important ways. First, using theoretical insights, it identifies the channels through which RPVs may increase the opportunity cost of terrorism for the active terrorists and may discourage new entrants. Second, focusing on Pakistan, it tests interesting hypotheses surrounding the use of RPVs by gathering data and evidence on RPVs–terrorism link.

The objective of this study is to understand the nature and consequences of RPVs' strikes as a counterterrorism strategy. To this end, a monthly series on RPVs' strikes in Pakistan is constructed and analyzed covering January 2008 to December 2013 period. Besides formal evidence, a comparison is made between human loss caused by RPVs' strikes and terrorists' attacks to reveal the true nature of the RPVs' effectiveness as a counterterrorism measure. In addition, a weekly series of RPVs' strikes are also constructed to understand their nature and pattern in greater detail.

The findings of the study provide novel insights regarding counterterrorism efficacy of RPVs in Pakistan, and these findings are relevant for countries and regions facing counterterrorism challenges. For instance, the evidence suggests that RPVs' strikes have significant negative effect on the size of terrorism in Pakistan. In contrast, the popular notions that RPVs feed into terrorism through civilian casualties do not find support in our data, although we prefer not to deny the existence of such an effect. The inferences derived are statistically reliable and are robust against various specifications and sample innovations.

In terms of implications, the analysis and findings of the study are important for international and regional security experts and national policymakers. For instance, determining the efficacy of RPVs' strikes is necessary for ascertaining the nature and relative cost of alternative counterterrorism strategies; in understanding the public choice versus public interest perspective of counterterrorism policy; and for formulating the institutional framework required to use technologies like RPVs more effectively and legitimately (Hall and Coyne, 2014). Arguably, if RPVs' strikes are rooting out terrorists residing in Pakistan's borderlands then they are serving an important social purpose for the government and the people of Pakistan. Thus, the findings also contribute in understanding the political economy of various controversies surrounding RPVs' use as a counterterrorism weapon in an international context.

The rest of the paper is organized as follows. The next section discusses possible theoretical links between the RPVs and terrorism relying upon the existing literature on economics of counterterrorism. The details about the empirical methodology and data are given in Section 3. In Section 4, we present our findings, while Section 5 concludes the study.

2. Theoretical insights

The use of RPVs is contested on various theoretical grounds. The conflicting viewpoints are not only because of differing political economic perspectives, as argued by Hall and Coyne (2014), but are also related to the issues of risk and return faced by combatants. The latter perspective allows us to use choice–theoretic analysis to see how RPVs can affect the cost structure faced by terrorists.

Being remotely controlled, the use of RPVs creates an asymmetry in the distribution of risks with terrorists receiving the major share. For instance, as a fixed eye in the sky, RPVs are used to surveil the target area for days and weeks on end virtually without a blink. The continued surveillance of suspicious activities increases the cost of organizing and planning a terrorist act. It may also disrupt or disturb the supply of arms and ammunition for terrorists. Together, these two effects weaken their prowess in the face of a counterterrorism offensive and reduce their ability to produce effective attacks. From policymaker's perspective, the immaculate surveillance permitted by RPVs is less costly and risky compared to corresponding arrangements on ground using foot soldiers.

From the perspective of an individual terrorist, RPVs' target-killing of known terrorists, though controversial on legal grounds, increases the operating costs for active terrorists and opportunity cost of terrorism for potential entrants, *ceteris paribus*. The latter affect discourages the future supply of terrorists to militant organizations depriving them of the most important input to their production process. In other words, each RPV strike increases the cost of terrorism through the dual effect of punishment and deterrence (the opportunity cost effect of Freytag *et al.*, 2011). Using Beckerian analysis of crime, one can argue that both these "price" effects will change the tradeoff between terrorist and non-terrorist activities, making the latter more affordable at a given level of terrorist's satisfaction (Becker, 1968; Krueger and Maleckova, 2003).

Another related channel through which RPVs can have a greater influence on terrorism is by target-killing the top commanders in terrorists' organizations. The underlying "decapitation" hypothesis predicts that killing of terrorist leaders reduces their ability to carry out effective attacks (Johnston, 2012). The target killing of top commanders not only demoralizes the terrorist organization but also create a leadership vacuum that impairs their unity and ability to mobilize available resources most efficiently and harmoniously. In short, these different channels clearly suggest that RPVs' strikes are decreasing in terrorism, if we can keep other influences constant.

In contrast to anti-terrorism effects, RPVs may have pro-terrorism (second round or) indirect effects. As argued by many authors, RPVs are interpreted by the locals as a symbol of US hegemony, external intervention in their territory and a dishonor to the tribal traditions of self-government and autonomy (Abbas, 2010). As Akerlof and Kranton (2000) argue, a person's self-identity and social role affect her choices. Thus, either by whip of tradition or pull of ethical code, the argument goes, the local people may join hands with terrorists for the sake of vengeance (Ahmed, 2013). Importantly, perhaps, if the use of RPVs as a counterterrorism measure lacks public support, it may increase terrorism or at least strengthen terrorists' sympathizers (Keefer and Loayza, 2008). For Pakistan, the existing evidence as to which of these two competing influences prevail, is mixed and, in many cases, questionable. (See Fair, 2014 for an extensive assessment). This study is the first attempt to empirically test such competing claims using observational data.

Like theoretical ambivalence, the empirical evidence on the effects of RPVs is also inconclusive. The deaths of two aid workers occurred in an RPV attack in Pakistan on January 15, 2015, prompted a reaction from the US president, indicating the deep-seated political ramifications of the strategy. Such incidents multiply skepticism about RPVs' counterterrorism role and substantiate the claims about the lack of transparency and accountability associated with its usage and collateral damage it causes.

However, there exist sanguine views too. For example, according to a survey finding, local people in Pakistan's tribal areas view RPVs as an effective weapon against terrorists abusing their territory (The Economist, 2013). Are these findings plausible? The answer is yes because terrorism is causing people immense economic, social and psychological costs as per estimates provided by official sources, independent researchers and international agencies (Abbot, 2012; PES, 2014; Sultan, 2013; and GTI, 2014).

One can argue that if RPVs are squeezing terrorists' breathing space, making them less effective, and if the unintended consequences associated with their use are not different from other counterterrorism measures, then their use is justifiable. However, it would be speculative to conclude anything for or against RPVs without reliable empirical evidence. To this end, we turn toward empirical analysis.

3. Empirical model and data

The competing viewpoints about the pros and cons of RPVs can be tested using a simple empirical model. In general terms, the model can be specified as follows:

$$Terrorism_t = f((RPVs)_t, Controls; error_t), \quad (1)$$

where *Terrorism* stands for a measure of terrorism; the subscript t indicates frequency of time which is monthly in our case. To estimate equation (1), we need data on *Terrorism*, RPV strikes and various control variables.

3.1 Dependent variable

To develop a proxy for terrorism this paper uses data from Global Terrorism Database (GTD) which provides a detailed chronological record of terrorist incidents in countries across the globe. To classify as a terrorist incident, the GTD methodology requires that the act must be intentional, resulting from "conscious calculation on the part of a perpetrator", involves violence (either actual or its threat) and must be committed by sub-national actors (GTD Codebook, 2013). The data set contains detailed description of the events based on newspaper reports. The GTD data set covers each terrorist incident in various aspects related to its consequences like human toll, and classifies it according to its attributes like type of weapon being used, type of target, place of occurrence and perpetrators if known. (It is important to mention that the data related to terrorist incidents and the resulting injuries and casualties which are available at the GTD are compiled using news reports. It has to be kept in view that such secondary sources may not be entirely accurate. Nonetheless, the study assumes absence of any systematic bias in the information).

Using this information, we develop a monthly series of terrorist incidents taking root mean square of the number of terrorist incidents, the number of people injured and the number of fatalities caused by terrorist incidents in a given month. The resulting measure is different from a simple average in that it objectively assigns different weights to each of the components of a terrorist incident while capturing the damage caused by terrorism in all important aspects. For instance, in January 2009, there were 90 terrorist attacks and 1 suicide attack; the number of fatalities caused by these attacks was 86, while a total of 107 people were wounded in these attacks. This gives us 82.08 as the root mean squared value of the size of terrorism (*SizeTerr*).

However, as an alternative, we also use the number of successful terrorist attacks in a month as a measure of *Terrorism.* This measure is also taken from GTD data set, primarily to see the robustness of our empirical findings, as is explained below.

3.2 Magnitude of remotely piloted aerial vehicle strikes

The GTD does not include information on RPVs strikes. It is, therefore, gathered from International Security Program (ISP), a US-based private sector think-tank that provides detailed account of RPVs' strikes in Pakistan and Yemen (http://securitydata.newamerica.net/). Focusing on information related to RPVs' strikes in Pakistan, the same three dimensions of information (i.e. number of attacks, fatalities and injuries) are used to construct a monthly series of RPVs strikes. As for *SizeTerr*, root mean square of the three dimensions of RPV strikes is used to measure the counterterrorism magnitude of RPVs and is labeled *SizeRPV*.

3.3 Other controls

Among the control variables (*Controls*), it is important to include other measures of counterterrorism. For instance, security forces in Pakistan (Pakistan Army, Police Forces and Frontier Constabulary) are well equipped and serve as the first line of defense against any attack or insurgency. Therefore, without controlling for the influence of security forces' counterterrorism attempts, we cannot estimate the marginal effect of RPVs. Unfortunately, there does not exist any measure that allows us to capture the security forces' counterterrorism capacity. However, the GTD provides information on the number of terrorists kill (*NKillTerr*) in a terrorist incident. This measure is different from the total fatalities in a terrorist incident and is also different from the number of (local or foreign) security forces' personnel kill in a terrorist incident. Therefore, it is plausible to assume that *NKillTerr* is a useful proxy of local security forces' counterterrorism capacity.

Moreover, ISP also provides, based on authentic news resources, information about civilian casualties (*CivKillRPV*) associated with each RPV strike. As is explained below, this information is useful in testing hypotheses pertaining to RPVs second-round effects, for instance, the claims that civilian deaths by RPVs are the major factors behind increasing terrorism. Inclusion of this variable, therefore, is important not only to delineate the static benefit–cost effects but also to test the dynamic second-order (indirect) effects of RPVs (Schneider *et al.*, 2015).

3.3.1 Data and descriptive statistics. Our data set covers 72 months in total over a period from January 2008 to December 2013. Appendix at the end provides definition and sources of variables used in the empirical analysis. The first drone strike in Pakistan, according to ISP data, occurred in 2004 and successfully targeted the notorious militant Nek Muhammad. However, the period before 2008 was quiet in terms of the number of RPVs strikes. For instance, in 2005 to 2007, there were only 9 strikes (or 3 strikes per year, on average) while in 2008, the number doubled to 19, i.e. more than one strike per month on average. Thus, the period from 2008 onward is the one that witnessed noticeable deployment of RPVs in Pakistan.

On a related note, Pakistan Army entered into various peace accords with militants operating in the North Western Frontier areas of Pakistan during 2004 to 2007 (Abbas, 2010). The effect of these temporary peace accords may confound with the effect of RPVs on terrorism over the period. Therefore, to insulate our analysis from these issues, we focus on 2008 to 2013 period only.

Table I provides summary statistics of the key variables. It informs us about the size of terrorism and RPVs-based counterterrorism policy over the 72-month span of our information set. It is immediately clear that terrorists are much more ruthless: the monthly average of terrorism (*SizeTerr*) is around eight times that of *SizeRPV*. In other words, terrorist incidents cause, on average, much more terror and damage (i.e. fatalities and injuries) and occur more frequently than RPV strikes. Moreover, the maximum of *SizeTerr* is more than five times the maximum of *SizeRPV*, indicating greater indiscreetness of terrorists in targeting innocent civilians.

To capture the collateral damage associated with drone strategy, we develop a monthly series of civilians killed in RPVs' strikes (*CivKillRPV*) using information provided by ISP (Table I). The average civilian toll is less than three casualties with a standard deviation exceeding 7, reflecting "occasional accidents". In comparison, there are 9,710 civilians and security forces' personnel killed in terrorist incident over the time period of analysis, according to GTD data. In RPVs' strikes, the total civilian toll, according to ISP data, is 189, which is less than 2 per cent of the civilian deaths caused by terrorists.

Table I also reports the number of terrorists killed (*NKillTer*), the numeric value of the perpetrators' fatalities and is taken from the GTD. As can be seen, the average number of *NKillTer* in a month is not much different from the corresponding casualties

Variable	Months	Mean	SD	Minimum	Maximum
SizeTerr	72.00	179.92	87.61	32.60	465.07
SizeRPV	72.00	22.28	18.26	0.00	84.73
NKillTer	72.00	22.10	30.00	1.00	150.00
CivKillRPV	72.00	2.78	7.25	0.00	38.00
TSuccess	72.00	87.72	44.48	26.00	220.00

Note: Monthly series, January 2008 – December 2013
Source: Global Terrorism Database; International Security Program

Table I. Summary statistics

caused by the RPVs strikes. Nonetheless, the standard deviation of the former is much higher than the latter which may indicate either:

- greater accuracy of the RPVs in targeting terrorists than security forces; and/or
- the uncertain nature of fights that security forces have to indulge in when faced with a terrorist attack.

The latter effect is in line with the observation that RPVs caused asymmetric distribution of risk: this advantage is not available to security forces operating on ground.

The last variable in Table I is a measure of successful attacks by terrorists in a month (*TSuccess*). It is a categorical variable assuming a value of 1 if the attack is successful and 0 otherwise. It is taken from GTD which defines success in terms of "tangible effects of the attack" and not in terms of the goals pursued by terrorists' organizations (GTD Codebook, 2013). Using this measure of success, 88 per cent of the terrorist attacks over 2008 to 2013 period come out successful. This is significantly higher than the 50 per cent success rate observed at the global level (GTI, 2014). Focusing on the number of successful terrorist attacks in a month, one can see that minimum of *TSuccess* is 26, meaning that even the most "peaceful" month has witnessed, at most, only four terror-free days, i.e. days without any "tangible" terrorist consequences.

Table II reports the weekly frequency distribution of RPV strikes. From January 2008 to December 2013, it gives us 330 total strikes in 175 incidents over 288 weeks. Out of the total of 175 incidents, 82 are multiple strikes, i.e. more than one strike in a week. There are some interesting trends regarding the multiple RPV strikes in a week, and these are worth exploring for proper understanding of their efficacy.

The maximum recorded strikes in a week are eight that happened during December 27, 2010 to January 2, 2011. There are two cases of seven strikes per week recorded each in 2010 and 2011. In terms of percentage of total strikes, multiple strikes were 36 per cent in 2008 but increased to 44 per cent in 2009, and 63 per cent in 2010, before falling back to 53 per cent in 2012, and around 20 per cent in 2013 (Table II).

A comparison over the years reveals that 2010 has seen the largest number of RPVs strikes, as well as multiple strikes per week. Thus, it accounts for 30 per cent of the total strikes, while 28 per cent of total multiple strikes. One can only guess about the possible reasons behind the highest number of RPV strikes in the year 2010. It might reflect greater military liaison between USA and Pakistan forces in the war against terrorism or it might reflect change in the political regime at Washington with greater reliance on cost-effective RPVs than ground offensives. Going into these details is beyond the scope of this work.

Exploring trends through graphical analysis may also be helpful. Figure 1 depicts two major variables of interest, namely, *SizeTerr* and *SizeRPV*. An upward tendency in the size of terrorism is visible in Figure 1. It is only in the years 2010 and 2011 that *SizeTerr* subsides, where these are the very years when RPVs strikes witness increasing tendency. In more recent years, the upward tendency of *SizeTerr* is in contrast with the slightly downward and deceasing tendency in *SizeRPV*. However, in terms of frequency, terrorist attacks have become less frequent in recent years.

Following Enders (2007), one can define fatality ratio (i.e. number of fatalities per incident) separately for terrorist and RPV incidents to explore the trend in per incident fatalities over our study period. Thus, Figure 2 plots the ratio of the number of fatalities

Table II. Frequency distribution of RPV strikes

Year	Strikes per week (%)									
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	Total	No of strikes
2008	16.00 (64.00)	8.00 (32.00)	1.00 (4.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	25 (100.00)	33.00
2009	19.00 (55.88)	12.00 (35.29)	2.00 (5.88)	1.00 (2.94)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	34 (100.00)	50.00
2010	12.00 (34.29)	6.00 (17.14)	7.00 (20.00)	4.00 (11.43)	2.00 (5.71)	3.00 (8.57)	1.00 (2.86)	0.00 (0.00)	35 (100.00)	96.00
2011	13.00 (40.63)	8.00 (25.00)	4.00 (12.50)	3.00 (9.38)	2.00 (6.25)	0.00 (0.00)	1.00 (3.13)	1.00 (3.13)	32 (100.00)	78.00
2012	16.00 (57.14)	8.00 (28.57)	2.00 (7.14)	2.00 (7.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	28 (100.00)	46.00
2013	17.00 (80.95)	2.00 (9.52)	2.00 (9.52)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	21 (100.00)	27.00
Total	90.00 (52.33)	44.00 (25.58)	18.00 (10.47)	10.00 (5.81)	4.00 (2.33)	3.00 (1.74)	2.00 (1.16)	1.00 (0.58)	175 (100.00)	330.00

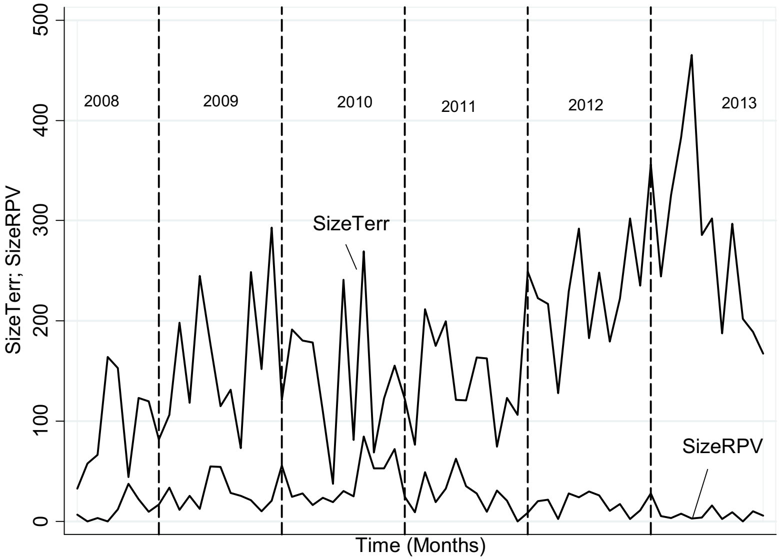

Figure 1.
Size of terrorism (SizeTerr) and size of RPV (SizeRPV) strikes over 2008-2013

Notes: Calculations use GTD and ISP data sets; SizeTerr is a composite measure of the number of incidents, the number of attacks, causalities and the number of injured in terrorist attacks over a given month. SizeRPV is a similar measure for RPV strikes. See text for details

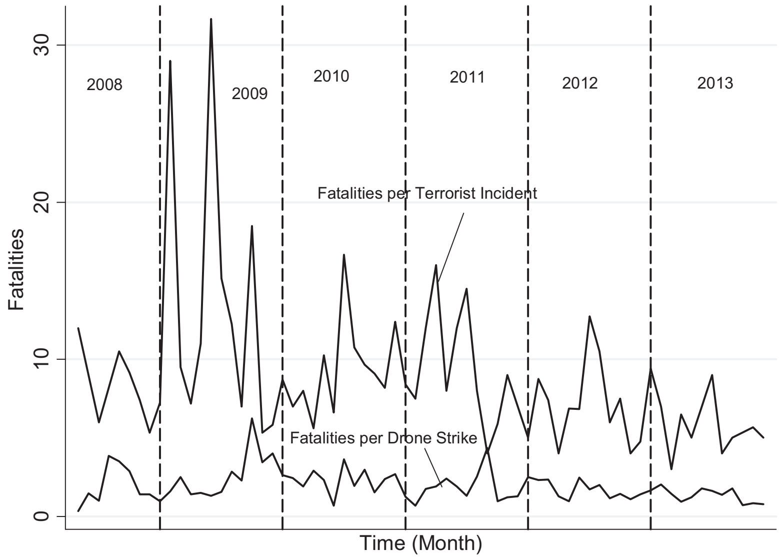

Figure 2.
Fatality ratio (terrorist attacks vs RPV strikes) over 2008-2013

Notes: Calculations use Global Terrorism Database (GTD) and International Security Program (ISP) data sets and the terrorist attacks per month. The message communicated by Figure 2 suggests that fatalities per attack have decreased in recent years. In other words, average terrorist attack has become less fatal over the years. The same holds for the fatalities per RPVs strikes.

Collectively, the picture communicated by Figures 1 and 2 reinforces one another: high frequency of terrorists' attacks may indicate weakening of the organizational structure of terrorists forcing them to opt for smaller-scale activities (thus an increase in frequency) (Findley and Young, 2012). Alternatively, the lower fatality ratio may reflect effective security measures on the part of security forces that constrain the scope of terrorist attacks (Enders and Sandler, 2004).

As we can notice, the graphical depiction is revealing short-term fluctuations more than the long-term trend. Therefore, Table III presents year-wise record of fatalities per terrorist attack (*Fatperatt*) in the case of terrorist incidents and fatalities per drone strike (*FatperRPV*) in the case of RPV strikes. Table III supports the earlier graphical conclusion that the average number of fatalities because of terrorist attacks have decreased over the years. This can be seen from the two indicators provided in Table III: one is the average annual number of fatalities per attack and second is the maximum number of fatalities per attack. The former has decreased from 2.06 to 1.35 per attack, and the latter from 11.75 to 4.57. The number of fatalities per RPVs strike also follows a decreasing trend albeit it is less sharp than *Fatperatt*. Thus, fatalities per RPV strike have decreased from 8.22 to 6.14.

However, unlike terrorists' attacks, the maximum number of fatalities associated with one RPV strike has increased. Thus, the average number of maximum fatalities has increased from 14 per RPV strike to 17. Together, the decreasing average number of fatalities per RPV strike and an increase in the number of maximum fatalities per RPV

Fatality Ratio	Obs	Mean	SD	Minimum	Maximum
		Year = 2008			
Fatperatt	31.00	2.06	2.37	0.13	11.75
FatperRPV	16.00	8.22	3.75	3.00	14.00
		Year = 2009			
Fatperatt	52.00	2.37	2.47	0.00	15.25
FatperRPV	34.00	12.35	14.48	0.00	80.00
		Year = 2010			
Fatperatt	52.00	2.23	2.32	0.08	11.92
FatperRPV	43.00	8.88	4.05	3.00	21.00
		Year = 2011			
Fatperatt	52.00	1.79	1.52	0.06	8.83
FatperRPV	33.00	9.89	6.84	3.00	27.00
		Year = 2012			
Fatperatt	53.00	1.73	0.94	0.50	4.14
FatperRPV	28.00	7.50	4.42	3.00	24.00
		Year = 2013			
Fatperatt	53.00	1.35	0.95	0.46	4.57
FatperRPV	21.00	6.14	3.41	2.00	17.00

Source: Author's calculation using Global Terrorism Database

Table III.
Fatalities per attack

strike signifies increasing precision and force of RPV strikes: greater caution to be precise has reduced the average number of RPV strikes, while greater force has increased the magnitude of the damage. Arguably, if there exist *precision effect* behind these dynamics, then it should cause significant increase in the cost of terrorist activity, and it may help curtail the size of terrorism. The next section uses formal analytical tools to uncover such regularities with greater precision and reliability.

Table III also presents the comparison of fatalities per attack both for terrorist incidents and RPV strikes. In terms of human toll, RPVs exceed terrorist attacks significantly. The average difference in fatalities is around 6.91 or 7 lives per attack. In other words, RPV causes seven more deaths compared to a terrorist attack. This difference attains its maximum in 2009 when it was almost 10 and was at a minimum in 2013 at 4.79 lives. This can be interpreted in various ways: positively, we can say that RPVs are precise and targeted and are used only after careful gathering of relevant information. That is why they have higher fatality rate per strike but have lower level of *SizeRPV* compared to *SizeTerr* as shown in Figure 1. At a superficial level, it can be argued that the RPV program is being used carelessly and so the difference is because of greater collateral damage reflecting carelessness (Shah and Holwinski, 2012). Admittedly, such arguments cannot be refuted without having access to detailed information. Nonetheless, it is important to uncover any systematic relationship using more powerful analytical tool of regression analysis.

4. Empirical findings

4.1 Results

Before estimating the proposed empirical Model (1), it is appropriate to test the statistical properties of the key variables.

The results of the unit root tests are shown in Table IV below using 1 and 2 lags for each of the variables of interest, where lag length is selected using usual lag length criteria (namely, Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC) and Schwarz's Bayesian Information Criterion (SIC) information criteria). As is clear from Table IV, all variables are stationary at the 1 per cent level. The hypothesis of stationary series holds even if one changes the lag length anywhere between 0 to 2, as is shown in the second column of Table IV. It implies that ordinary least squares (OLS) can be used to capture the relationship between our variables of interest.

To uncover various interesting dynamics in the proposed empirical structure of equation (1), we also test different specifications of our basic model using different lag structure of dependent and independent variables.

Variable	Test statistic (1 lag)	Test statistic (2 lags)
SizeDron	−4.938***	−2.703*
SizeTerr	−5.164***	−2.721*
NKillTer	−5.828***	−2.489
Fatperdron	−6.238***	−3.525**
Fatperter	−5.920***	−4,164***

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table IV.
Unit root test

In the first set of regressions, we explore the relationship between *SizeTerr* and *SizeRPV*, while controlling for the relevant factors. Whereas to mitigate issues related to endogeneity, we take lag of all the regressors. On the basis of theoretical insights identified in the previous section, one can expect that *SizeTerr*, *ceteris paribus*, is decreasing in *SizeRPV*. As discussed previously, this may be because of increased opportunity cost of terrorism and increased punishment. The punishment effect also encapsulates the target killing property of RPVs' strategy. As already mentioned, the underlying hypothesis here is that of decapitation (or killing of terrorist leaders) that reduces their ability to carry out effective terrorist attacks (Johnston, 2012). However, because of paucity of information about the profiles of terrorists killed in RPVs' strikes, we cannot differentiate between these two possible channels. Nonetheless, whatever is the underlying reality, the observational outcome associated with it should be a significant reduction in the size of terrorism.

Table V shows estimations using various specifications of controls and lags of dependent and independent variables. For each model, a battery of diagnostic tests is reported toward the bottom half of the table. With few exceptions, the models reported in Table V are satisfying the usual checks. For instance, all models are statistically highly significant (e.g. p value of F-test is significant beyond 1 per cent). At the 5 per cent level of significance, all models are free of omitted variable or specification error problems with the only exception of Model (5.2). Similar is the case with the autocorrelation test which ceases to be an issue once relevant lag structure is taken into account [e.g. Models (5.3) and (5.4)]. The residual term is also satisfying normality assumption. Thus, one can rely upon the inference derived from these models.

In terms of coefficients of explanatory variables, the estimates provide a negative and significant impact of *SizeRPV* on the *SizeTerr*. Considering base line specification [i.e. Model (1)], the numerical value of the estimates indicates that a unit increase in *SizeRPVs* reduces the size of terrorism by 1.5 units. This effect remains significant across all models even those with additional control variables and lags. One can notice

Dependent variable: *SizeTerr*	(5.1)	(5.2)	(5.3)	(5.4)
L. SizeRPV	−1.496*** (0.417)	−1.279*** (0.411)	−1.145*** (0.454)	−0.770* (0.413)
L. SizeTerr		0.388*** (0.128)	0.388*** (0.129)	0.163 (0.126)
L. NkillTer	0.518 (0.338)	0.043 (0.255)	−0.009 (0.254)	−0.105 (0.243)
L.CivKillRPV			−1.403 (1.055)	−1.620 (1.362)
L2.SizeTerr				0.409*** (0.102)
L2.SizeRPV				−0.706* (0.426)
L2.NkillTer				0.113 (0.200)
L2.CivKillRPV				1.069 (0.725)
Constant	204.48*** (19.314)	140.12*** (27.204)	142.16*** (27.355)	115.66*** (29.658)
Observations	71	71	71	70
R-squared	0.149	0.274	0.287	0.451
F test p-value	0.000	0.000	0.000	0.000
RESET[a] test p-value	0.205	0.033	0.070	0.063
Autocorrelation[b] p-value	0.035	0.000	0.602	0.769
Residual Normality[c] p-value	0.409	0.289	0.178	0.289

Notes: Robust standard errors in parentheses; $***p < 0.01$; $**p < 0.05$; $*p < 0.1$; "L" before a variable indicates "lag", "L2" means second lag; [a] H0: Model has no omitted variables; [b] Breusch–Godfrey LM test for autocorrelation. H0: No serial correlation; [c] Shapiro–Wilk W test for normal data. H0: Observations are normally distributed

Table V. Do RPV strikes reduce overall terrorism? (OLS estimates) that the magnitude of the coefficient reduces with greater generalization and reaches almost half in Model (5.4). However, the second lag of *SizeRPV* in Model (5.4) is also significant, and the combined effect of two lags is quite similar in size to its coefficient in the basic model.

In terms of elasticity, the coefficient of *SizeRPV* suggests a reduction in terrorism from 0.22 per cent (Model 5.1) to 0.12 per cent (Model 5.4) for each 1 per cent increase in the use of RPVs. These estimates seem plausible given the fact that drones are targeting terrorist bases only in a limited area (called Federally Administered Tribal Area) of Pakistan.

Among other variables, only the lag of *SizeTerr* has any significant and positive relation with current *SizeTerr*, indicating past dependence. In terms of elasticity, a 1 per cent increase in past months' terrorism translates into present terrorism to the tune of 0.39 per cent (Model 5.2) to 0.32 per cent (Model 5.4).

As mentioned in the previous section, the empirical results also shed light on popular claims that RPVs' strikes are turning local people into terrorists, as they interpret such strikes as attacks on their self-respect and identity (Ahmed, 2013). If this is the case, then the coefficient on *CivilKillRPV* strikes should increase the size of terrorism. However, as shown in Models (5.3) and (5.4), there is no significant feedback effect from *CivilKillRPV* to the size of terrorism. Thus, over the span of our study, we do not find any support for pro-terrorism effects of RPVs associated with unintended consequences. However, it would be premature to deny the existence of such an effect. It can be concluded, nonetheless, that using the specification and time period in question, the data do not lend any significant support to such popular notions or claims.

In sum, our analysis suggests that drone strikes have a significant negative, although modest, effect on terrorism. The most generalized model captures interesting dynamics among the various factors related to terrorism while satisfying the crucial assumptions related to underlying data-generating process necessary for a reliable inference.

4.2 Robustness

It is important to test to what extent our results are specific to particular definitions of the key variables, and to a given set of observations. Thus, Tables VI and VII present various models to check the robustness of the findings discussed in the previous section. In Table VI, the dependent variable is changed from *SizeTerr* to *TSuccess* as the measure of the size of terrorism. It is possible that despite a decrease in the overall

Dep var. TSuccess	(6.1)	(6.2)	(6.3)
L. SizeRPV	−0.747*** (0.252)	−0.717*** (0.254)	
L. NkillTer	0.481** (0.181)	0.469** (0.182)	0.595*** (0.168)
L. CivKillRPV		−0.320 (0.563)	−0.189 (0.496)
L. TotKilRPV			−0.415** (0.157)
Constant	94.904*** (10.071)	95.381*** (10.124)	90.916*** (9.070)
Observations	71	71	71
R-squared	0.230	0.233	0.305
F-test *p*-value	0.000	0.000	0.000

Notes: Robust standard errors in parentheses; $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table VI.
Robustness

incidents of terrorism, the proportion of successful terrorist attacks have increased. A successful counterterrorism strategy should reduce the ability of terrorists to carry out attacks both in terms of number and in terms of effectiveness of the attack. As shown in Models (6.1) and (6.2) (in Table VI), the results indicate a decrease in the number of successful terrorist attacks. This is in line with the results in the previous section. Specifically, the results indicate a decrease of seven successful attacks per month with an increment of ten RPV strikes per month, *ceteris paribus*.

Second, Model (6.3) estimates the basic regression using total number of terrorists kill in an RPV strike as the dependent variable in place of *SizeRPV*. In this case too, our results remain in line with our earlier findings.

Thirdly, it is important to check for the influence of outlier observations on the results. Thus, Models (7.1) and (7.2) in Table VII provide estimates after excluding four largest observations from two of our main variables, namely, the dependent variable *SizeTerr* and the main control variable *SizeRPV*. The new estimates are shown in Model (7.1) (for *SizeTerr*) and Model (7.2) (for *SizeRPV*). The results, as shown in Table VII, remain unaffected because of this change.

Finally, Models (7.3) and (7.4) in Table VII run robust regressions, a technique that assigns greater weight to well behave observations and lesser weight (or completely skip) the observations that are far from normal. As can be observed, our results withstand this change as well. In sum, the results presented in the previous section are robust against change in the dependent variable, different proxies of key independent variables and are not driven by extreme observations.

5. Conclusion

Since early 2000s, RPVs are being used to target terrorists in their hideouts in the conflict-ridden areas of Pakistan, Afghanistan and Yemen. The use of RPVs is controversial because of three different reasons:

(1) the asymmetric distribution of risk faced by combatants may induce abuse of RPVs and increase collateral damage;

(2) it may induce popular backlash as local people may interpret it as a symbol of foreign hegemony and external intervention in their affairs; and

(3) the target killing of terrorists without any legal procedures may increase the support of their cause and strengthen their sympathizers (Finkelstein, 2012 for various aspects of these issues).

Dependent variable: *SizeTerr*	(7.1) Excluding 4 largest values	(7.2)	(7.3) Robust regression tech.	(7.4)
L. SizeTerr	0.216* (0.111)	0.453*** (0.119)		0.345*** (0.127)
L. SizeRPV	−0.929** (0.463)	−1.289** (0.518)	−1.349** (0.565)	−1.226** (0.555)
L. NkillTer	0.143 (0.304)	−0.013 (0.340)	0.387 (0.342)	0.036 (0.368)
Constant	150.955*** (23.086)	129.720*** (25.735)	200.273*** (18.627)	144.689*** (27.757)
Observations	63	63	67	67
R-squared	0.159	0.322	0.109	0.214
F-test p-value	0.016	0.000	0.024	0.002

Table VII. Robustness against influential observations

Surprisingly, there is no evidence on the counterterrorism effectiveness of these aerial strikes. As the issue of terrorism continues to haunt governments and policymakers, it is necessary to understand and quantify the influence of RPVs on overall terrorist activities.

In this context, this study analyzes in detail the data related to RPVs' strikes in Pakistan and compare the magnitude of the damage they caused to terrorists – taking into account the civilian causalities inflicted by them – with the size of the damage caused by terrorists. Focusing on a period when RPV strategy was most effectively used, i.e. from 2008 to 2013, it is found that the average number of fatalities per terrorist attack has reduced, while the average number of fatalities per RPV strike is more or less the same, although the strikes are becoming less frequent more recently. Second, in terms of the average number of fatalities, an RPV strike exceeds an average terrorist attack. But in terms of overall damage, measured through a composite measure of casualties, injuries and number of attacks, the size of terrorism (*SizeTerr*) comes out much higher than the damage caused by the strikes of RPVs (*SizeDron*).

Going beyond simple exploratory data analysis, the study also tests the hypothesis of RPV-effectiveness using simple econometric models. An empirical model and its variants are estimated to capture interesting dynamics in the relationship between RPVs, civilian casualties due to RPVs' strikes, terrorist attacks and security forces' counterterrorism measures. The empirical evidence is reliable to the extent that it is satisfying the conventional battery of statistical tests. Our evidence suggests a significant and negative correlation between RPV strikes and the size of terrorism. Specifically, our estimates predict that a 1 per cent increase in *SizeRPV* reduces *SizeTerr* by 1.5 per cent, and the impact of RPVs on terrorism lasts till two months, indicating that RPVs indeed increase costs for terrorist organizations.

To check for the robustness of our findings, we run our main regressions using different proxies of terrorism and RPVs' counterterrorism strategy. In addition, we also make sure that extreme values are not driving our results using subsample estimates and robust regression techniques. It can be concluded that the results are robust against various specification issues and are not affected by outliers in the data. Importantly, there does not exist any evidence in favor of popular claims that RPVs are feeding into terrorism rather than curtailing it.

Without going into the debate regarding moral justification of RPVs, the evidence gathered in this paper suggests that RPVs provide an effective counterterrorism strategy. It implies that RPVs can be used cost effectively to police crowded urban areas facing terrorist threats.

Going forward, researchers may find it interesting to design quasi random experiments to check for the efficacy for RPVs while controlling for competing influences.

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Appendix

Definition and sources of variables

- *SizeTerr*: Defined as the root mean square of the three components – number of terrorist incident, number of injuries caused by each incident and number of deaths (either civilian or security personnel's) – associated with each incident. It also includes number of suicide attacks. Source: Global Terrorism Database.
- *SizeRPV*: Defined as the root mean square of three components – number of RPVs' strikes, number of terrorist it kills and number of injuries. It does not include number of civilian deaths. Source. International Security Program (http://securitydata.newamerica.net/).
- *NKillTer*: Defined as the number of terrorists kills in security forces operations. Source. Global Terrorism Database.
- *CivKillRPV*: Defined as the number of civilians kills in an RPV strike. Source: International Security Program.
- *TSuccess*: Defined as the number of successful terrorist attacks in a month. A successful terrorist attack is defined as one that fulfills its objective. Source: Global Terrorism Database.

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