I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

POLICY PAPER SERIES

Conflict and the Composition of Economic Activity in Afghanistan

Virgilio Galdo
Gladys Lopez-Acevedo
Martin Rama

POLICY PAPER SERIES

Conflict and the Composition of Economic Activity in Afghanistan

Virgilio Galdo
World Bank

Gladys Lopez-Acevedo
World Bank and IZA

Martin Rama
World Bank and IZA

ABSTRACT

Conflict and the Composition of Economic Activity in Afghanistan*

Despite informality being the norm in conflict-affected countries, most estimates of the impact of conflict on economic activity rely on formal sector data. Using high-frequency data from Afghanistan, this paper assesses how surges in conflict intensity affect not only the formal sector, but also informal and illicit activities. Nighttime light provides a proxy for aggregate economic activity, mobile phone traffic by registered firms captures fluctuations in formal sector output, and the land surface devoted to poppy cultivation gives a measure of illicit production. The unit of observation is the district and the period of reference is 2012–16. The same dynamic specification and controls are used for the estimation in the three cases, making the results comparable across sectors. Controls include the presence of combat troops and the level of foreign aid at the local level, which both influence local living standards in Afghanistan. The results show that an increase in conflict-related casualties has a strong negative impact on formal economic activity in the following quarter and a positive effect on illicit activity after two quarters. The impact on aggregate economic activity is negative, but more muted.

Corresponding author:
Gladys Lopez-Acevedo
World Bank
1818 H Street, NW
Washington, DC 20433
USA

E-mail: gacevedo@worldbank.org

Introduction

Conflict can affect a country's development through various channels, including the loss of physical and human capital, the disruption of production processes, and the undermining of markets (Blattman and Miguel 2010). Not surprisingly, the empirical evidence available shows a negative correlation between economic activity and conflict intensity. But the available evidence is diverse in nature. Of the 42 studies reviewed for this paper, 20 assess impacts on aggregate economic activity and 12 focus exclusively on the formal sector of the economy. Only seven of the 42 studies deal with the impact of conflict on illicit activities, while just three focus on the informal sector.

Estimates of the impact of conflict on aggregate economic activity differ in their magnitude, but they are all negative and sizeable. De Groot et al. (2016) claim that global gross domestic product (GDP) would have been 15.7 percent higher in 2007, had there been no conflict since 1960. According to Collier (1999), civil wars result in a 2.2 percent decline in GDP per capita annually, primarily because of slow production but also due to the loss of capital. Similarly, Acemoglu et. al (2011) find that cities that suffered the Holocaust most intensely have grown less since then, and that administrative districts where the Holocaust had the largest impact have lower GDP per capita and lower average wages today. And Singh (2013) reports that Punjab districts experiencing a major terrorist incident saw their long-term fixed investment decline by around 17 percent.

A more recent literature has relied on detailed microeconomic data, rather than on aggregate GDP, average wages or fixed investment. And again, the estimated impact is unambiguously negative. For example, Besley and Mueller (2012) show that house prices in Northern Ireland declined with conflict-related killings. Berman et al. (2013) find that construction permits decreased in number in the Philippines when rebel groups triggered an escalation of conflict. And Blumenstock et al. (2018) report that mobile phone traffic by formal firms in Afghanistan fell when conflict-related casualties increased.

However, the data used in these analyses – both aggregate and disaggregate – are mostly from the formal sector of the economy. This is despite informality being prevalent in developing countries affected by conflict. Institutions are most often weak in these countries, and enforcement is ineffective. Households usually engage in subsistence agriculture or self-employment, whereas firms are small and have low capital intensity. Illicit activities, including drug production and commercialization, are common.

Several studies suggest that the response of informal activities to conflict is more muted than that of the formal sector. For example, Looney (2006) claims that the only part of the Iraqi economy to have survived both Saddam Hussein and the subsequent period of instability and insurgency was the country's informal

economy. In the Afghanistan context, Ciarli et al. (2015) show that the probability that a household engages in self-employment activities with low capital intensity, or in subsistence agriculture, increases with surges in conflict.

The impact of conflict could even be positive in the case of illicit activities. Stepanova (2012) argues that the war of the US-led coalition on the Taliban did not significantly reduce Afghanistan's opium economy. Lind et al. (2014) note that conflict increases the perception of lawlessness while destroying infrastructure that is crucial to the production of alternative crops. In interviews conducted by Keohler and Zuercher (2007), farmers confirm that opium poppy is one of the few available cash crops. And Goodhand (2008) even argues that in parts of Afghanistan drugs have contributed to some degree of political order.

The goal of this paper is to offer an integrated assessment of the change in formal, informal and illicit economic activity in response to surges in conflict. The analysis is for Afghanistan, a country that has been repeatedly at war. The focus is on the period starting in 2012, at a time when the intensity of conflict increased dramatically, after a decade of relative stability and rapid economic growth.

The analysis relies on high-frequency data from non-traditional sources of information to measure economic activity. Satellite imagery allows us to assess nighttime light intensity for "tiles" measuring just one square kilometer. Remote sensing by satellites is also informative on the land surface devoted to the cultivation of poppies in every season. And anonymized cell phone traffic data from several thousand registered firms have been made available by a major telephone operator.

These non-traditional sources of information make it possible to conduct rigorous empirical analyses despite the obvious shortcomings of official statistical systems in conflict-affected countries. It has been shown that nighttime light intensity is highly correlated with GDP in developing countries (Donaldson and Storeygard 2016, Henderson et al. 2012). In South Asia, this high correlation holds even at the subnational level (Beyer et al. 2018). It has also been documented that data from mobile phone records can be exploited to understand a large array of social phenomena from land use to wealth and asset distribution to traditional measures of firm activity (Pei et al. 2014, Blumenstock et al. 2015, Blumenstock et al. 2018), among others. And the land surface devoted to poppy cultivation has already been used as a direct measure of the size of illicit activities (Lind et al. 2014).

While there is no readily-available data source to assess economic fluctuations in the informal sector, these can be inferred from the other high-frequency series considered. Aggregate output is the sum of output by the formal, informal and illicit sectors, and there is a sense of the relative weight of these sectors in Afghanistan's economy in recent years. It is thus relatively straightforward to estimate the change in

informal sector activity as a weighted difference between the change in nighttime light intensity and the change in cell phone traffic among registered firms.

Non-traditional sources of information are also used to measure the intensity of conflict at the local level, and to control for potentially confounding circumstances. The US Pentagon has made available data on conflict-related casualties with a high level of spatial disaggregation, as well as information on the presence of international and Afghan troops at the district level. Based on information from international donor agencies, it is also possible to estimate the level of foreign aid at the district level.

The analysis is conducted with the district as the unit of observation, as this is the lowest level of spatial disaggregation for which all the relevant data are available. The estimates are for the period 2012-16. The initial year is the starting point of a rapid deterioration of the security situation in Afghanistan. The final year is the last one for which the Pentagon made spatially disaggregated data on conflict-related casualties available.

The high frequency of the data also allows estimating the response of each of the three sectors to conflicts with varying time lags. In this paper, the impacts from conflict are estimated over each of the four quarters following a surge in the number of casualties. The exercise reveals very different time patterns across sectors. The impact of local surges in conflict on overall economic activity is relatively modest, but their effect on the composition of output is dramatic.

The Afghan context

Following the fall of the Taliban regime in 2001, Afghanistan received massive international security and development assistance. More than 100,000 international troops were stationed in the country until 2012, supporting operations against the ongoing insurgency and assisting in building and training a national defense force. To ensure a path toward self-reliance, the government of Afghanistan and NATO partners agreed in 2010 on a gradual handover of security responsibilities. By 2018, there were only 16,229 international troops in Afghanistan.[1] There was also a substantial decline in military and civilian aid, from 90 percent of GDP in 2009 to 44 percent in 2018.

---

[1] See NATO (2018) Resolute Support Mission "placemat" as of November 2018. https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2018_11/20181112_2018-11-RSM-Placemat.pdf.

The withdrawal of international troops and security forces has been associated with a steady increase in conflict-related casualties. The number of civilians who died or were injured because of the conflict surged from 5,969 in 2009 to 10,993 in 2018 (figure 1a). Violence remains heavily concentrated in the western and southern parts of the country, but the northern region has also experienced a substantive increase in the number of civilian casualties (figure 1b).

Figure 1. Conflict-related casualties and injured in Afghanistan

Figure 1a. Casualties and injured over time
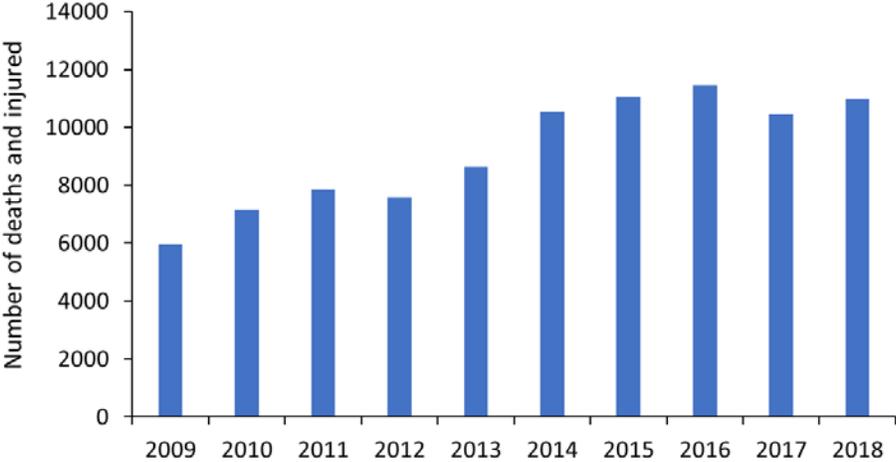
Figure 1b. Casualties and injured across space
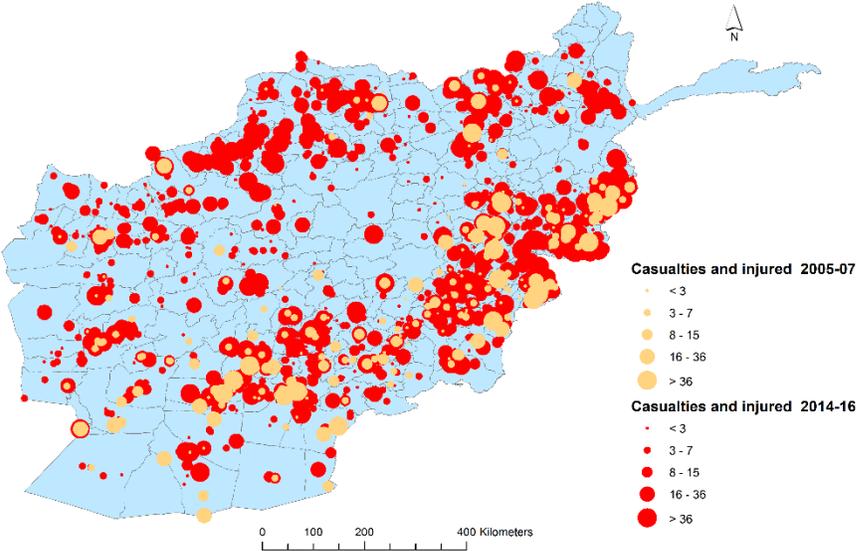
Source: Author's calculations based on UNAMA 2019 and GTD 2016.

The withdrawal of international troops and the decline in foreign aid adversely affected consumer and investor confidence and resulted in a sharp decline in domestic demand. New firm registrations fell by almost half between 2012 and 2016, across most sectors (figure 2a). The growth rate of GDP declined from an average of nearly 11 percent per year between 2007 and 2012 to barely 2.1 percent by 2016. (figure 2b).

Figure 2. Economic activity in Afghanistan

Figure 2a. Firm registration by sector
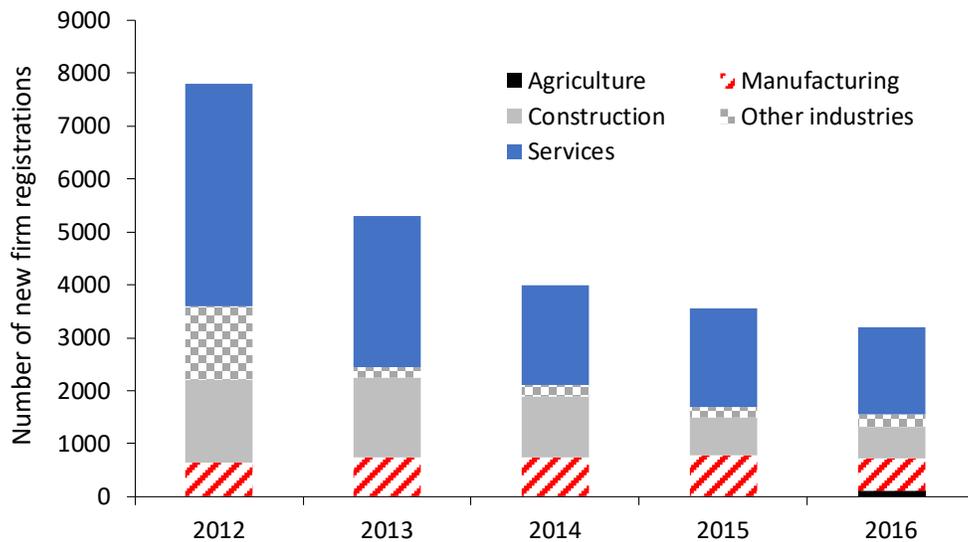
Figure 2b. GDP growth rates by sector
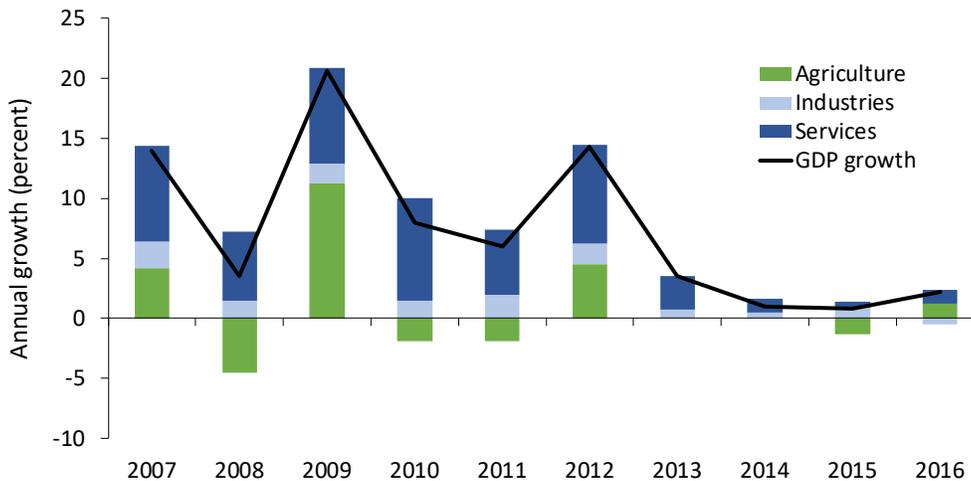
Source: World Bank (2018).

Previous research

Three studies in the literature on the impact of conflict on economic activity are especially relevant for the design of the methodology in this paper. These studies deal with the impact on aggregate output, on the formal sector and on illicit activities respectively. Differences in the approaches used in each case provide a useful backdrop to guide the empirical work for Afghanistan.

At the aggregate level, Abadie and Gardeazabal (2003) use a quasi-difference-in-differences approach to assess the impact of terrorism on the GDP per capita of the Basque Country from 1955 to 1977. To do so they construct a "synthetic control region", as a weighted combination of other Spanish regions. The economic evolution of this synthetic control region without terrorism is compared to the actual experience of the Basque Country using an autoregressive distributed lag model.

The gap ΔY in per capita GDP between treatment and control is the dependent variable in the analysis, and the number C of fatalities from terrorism (almost 800 over time) is the independent variable. The study estimates the impulse-response function to conflict assuming that the output gap ΔY in year t is determined by the number of deaths from terrorism C both in the same year and in the two previous years, as well as by the output gap in the two previous years:

$$\Delta Y_t = \beta + \sum_{k=0}^{2} \mu^k C_{t-k} + \sum_{k=1}^{2} \theta^k \Delta Y_{t-k} + u_t \tag{1}$$

The error term u_t in this equation is assumed to follow a first-order auto-regressive model. Therefore, the parameters in equation (1) are estimated using data on conflict and the output gap lagged for up to three years. No other control variables are considered in the proposed specification.

The results reveal a negative impact of deaths from terrorism in the previous year, but not in the same year or two years earlier (μ^1 is statistically significant but μ^0 and μ^2 are not). Based on the estimated coefficients, after the outbreak of terrorism, per capita GDP in the Basque Country declined about 10 percentage points relative to the synthetic control region.

Impacts on the formal sector are assessed by Blumenstock et al. (2018), who investigate how private sector firms in Afghanistan respond to changes in the local security situation. Whether the firms are active is assessed based on call detail records from one of the country's largest mobile network operators between April 2013 and December 2016. Call detail records are from cell phone towers spanning two-

thirds of the country's districts. In parallel, more than 100 major violent events are identified and geocoded based on the Global Terrorism Database (GTD).

The study builds its understanding of the formal sector response to conflict by analyzing the dynamic of mobile phone traffic and casualties during the 2015 Taliban attack on Kunduz, Afghanistan's fifth largest city. It then estimates a dynamic specification linking the number of firms Y^F active in district i and month t to the number of major violent events C in that district, over a 12-month period spanning a quarter before the event and three quarters afterward:

$$Ln\ Y_{it}^F = \beta + \sum_{k=-3}^{8} \mu^k\ C_{i,t-k} + \delta_i + \tau_t + \gamma_i t + \theta_d t^2 + \varepsilon_{it} \tag{2}$$

The specification includes fixed effects for districts (δ_i) and months (τ_t) as well as a quadratic time trend at the district level. It does not include other control variables.

The results show no impact in the three months preceding the violent event. The number of active firms falls by 4.9 percent in the month of the event, with the decline growing to 6 percent in the following month and persisting for up to five months. Six months after the event the impact becomes statistically insignificant. A more disaggregated analysis shows that larger firms are more responsive to violence.

As for illicit activities, Lind et al. (2014) explore how the intensity of conflict in Afghanistan changes the incentives faced by farmers and spurs opium production. Poppies are more drought-resistant than wheat, the main alternative crop. They also take little space relative to their value and can easily be transported off roads. The destruction or disabling of irrigation and transportation networks resulting from conflict therefore makes poppies relatively more profitable than wheat.

Data are from 329 Afghan districts from 2001 to 2007. The study notes that there are no available data on the amount of fighting during this period. One possible alternative was to rely on the number of combat activities by year, but information on such events was scarce and mostly based on media coverage. For this reason, the study bases its measure of conflict on the number of casualties from hostile encounters involving either NATO International Security Assistance Force (ISAF) forces or US forces participating in Operation Enduring Freedom (OEF). The conflict measure does not include Afghan casualties. The study argues that international forces tend not to be involved in poppy eradication or other anti-narcotic actions, implying that the chosen conflict indicator is plausibly exogenous to opium poppy production.

The main specification used in the empirical analysis links opium production Y^O in district i and year t to both the contemporary and lagged values of a dummy variable C indicating whether there were casualties in the locality:

$$Y_{it}^O = \beta + \sum_{k=0}^{2} \mu^k \, C_{i,t-k} + \delta_i + \tau_t + \varepsilon_{it} \qquad (3)$$

The specification includes fixed effects for districts (δ_i) and years (τ_t). The results show a mild impact of conflict on poppy cultivation in the same year, a strong impact in the following year, and an insignificant effect two years later. The results also hold after instrumenting the intensity of conflict using data on local rainfall. However, the effect is not significant for conflict taking place after the planting season, and it is weaker in districts with better law enforcement.

Methodology

The methodology in this paper builds on a combination of the approaches in the three studies reviewed above. Like all three of them, the estimation relies on a temporal structure to capture dynamic effects, and it measures the intensity of conflict through the number of casualties associated with it. As in the studies on Afghanistan by Blumenstock et al. (2018) and by Lind et al. (2004), the geographic unit of observation is the district. And data are organized by quarters, keeping in mind that the planting season for poppies is between the months of November and December, or the fourth quarter in the calendar year.

At the same time, the paper innovates relative to these three studies, in several ways. First, instead of a single dependent variable for the analysis there are now three of them, aimed at capturing aggregate economic activity Y^A, formal sector output Y^F, and illicit production Y^O respectively. Conceptually, these three variables verify:

$$Y^A = Y^F + Y^I + Y^O \qquad (4)$$

where I stands for informal sector activity.

The second innovation is to use a richer set of controls in the estimation, in addition to the lagged values of the conflict indicator, and district- and time-specific fixed effects. A recent study by Floreani et al. (2017)

shows that living standards in Afghanistan are affected by conflict not only directly, through increased violence, but also indirectly, through the presence of troops and the volume of foreign aid directed to the locality. While the direct effect is negative, the indirect effect is positive. Given that troops and aid are allocated in response to the insurgency, the paradoxical result is that living standards are higher in conflict-affected districts. Not including as controls the presence of troops and the level of foreign aid at the local level would therefore result in biased estimates.

With these two innovations, the specification used in the empirical analysis is:

$$Ln\, Y_{it}^j = \beta^j + \sum_{k=1}^{4} \mu^j C_{i,t-k} + \theta^j T_{i,t-1}^W + \delta^j T_{i,t-1}^A + \gamma^j D_{i,t-1} + \delta_i^j + \tau_t^j + \varepsilon_{it}^j \tag{5}$$

where $j \in \{A, F, O\}$ indicates the level at which the economic activity indicator is defined, i are districts, t are quarters, T^W are international troops, T^A are Afghan troops, and D is the volume of foreign aid received at the local level. International troops and Afghan troops are entered separately in the specification as their impact on local economic activity may be different, possibly due to the different extents to which they procure supplies locally (Floreani et al. 2016). The specification also includes fixed effects for districts (δ_i) and quarters (τ_t).

Equation (5) can be estimated by Ordinary Least Squares (OLS) provided that the right-hand side variables are exogenous. The identifying assumption is that the conflict variable is independent from economic activity after conditioning on location fixed effects, time fixed effects, the presence of combat troops and the level of international assistance. The irregular nature of Afghanistan's warfare gives support to this assumption (Ciarli et al. 2015). While a deterioration of the overall security situation could be anticipated as the international presence was scaled down, where exactly conflict would unfold is much more difficult to predict (Bazzi et al. 2019). This uncertainty over security risks makes local surges in conflict plausibly exogenous from the point of view of the empirical analysis. The OLS estimation is conducted with robust standard errors, because the indicators for troops and aid are measured at the province level, and not at the district level as the indicators for economic activity and conflict are.

Using the same dynamic specification to estimate the impact of conflict on each of the three dependent variables allows a more rigorous comparison of the time structure of effects across sectors. And building on equation (4) it is also possible to estimate, in a comparable manner, the dynamic impact of conflict on informal sector activity. as follows:

$$y^I = y^A - \alpha^F y^F - \alpha^O y^O \tag{6}$$

where lowercase variables indicate relative change, α^F is the estimated share of the formal sector in aggregate economic activity, and α^O is the corresponding share for the illicit economy.

In Afghanistan the informal sector has been estimated to account for 72 percent of total economic activity, with another 16 percent of it originating from illicit businesses (World Bank, 2005; SIGAR, 2018). These estimates are used in what follows for α^F and α^O respectively.

Data

The model is estimated using non-traditional data from a variety of sources, most of which are extraneous to the Afghan official statistical system. This approach is consistent with a broader trend to rely on big data to generate finely granular high-frequency estimates of otherwise conventional economic variables.

Aggregate economic activity

A stable relationship has been shown to exist between aggregate economic activity Y^A and the sum of nighttime light per area. Global level estimates suggest that a 1 percent increase in nighttime light is associated with 0.267 percent increase in economic activity (Henderson et al. 2012). For South Asian countries the increase in economic activity has been estimated at 0.248 percent, quite close to the global figure (World Bank 2017). Building on these results, it is assumed in what follows that the elasticity of aggregate economic activity to nighttime light is 0.25. This elasticity implies that the relative change in economic activity y^A, is only a quarter of the relative change in nighttime light.

The raw nighttime light data are derived from the VIIRS-DNB Cloud Free Monthly Composites, version 1, made publicly available by the Earth Observation Group at the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NOAA).

The released data are already adjusted to correct for saturation, blooming effects, and comparability, all issues that had been detected in a previous nighttime lights product known as DMSP-OLS. The data are further cleaned for this paper, taking advantage of the 2015 annual composite of stable VIIRS nighttime lights to define a background noise mask (Elvidge et al. 2017). Only cells lying outside this background noise mask are treated as stable lights, while those inside the mask are recoded with value zero, corresponding to no light. The VIIRS-DNB data are available from 2013 to 2016 on a monthly basis, with a

resolution of 15-arc seconds – approximately 500m x 500m tiles near the equator. For this paper, the raw data are aggregated to the district level, on a quarterly basis. Nighttime light is measured in Nanowatts/cm^2 /steradian.

Formal economic activity

Formal sector activity Y^F is proxied through the number of active formal firms. Admittedly formal firms have different sizes, and the ones for which data are available are likely to be among the largest ones. However, previous research suggests that larger formal firms are more likely to be impacted by conflict (Blumenstock et al. 2018). It follows that the observed change in the number of active formal firms overestimates the actual change in the overall economic activity. The net effect of these size and impact biases is unclear. In the absence of more information, it is assumed here that the relative change in formal economic activity y^F is proportional to the relative change in the number of formal firms for which data are available.

The number of active formal firms is computed from a list of organizations that signed up for plans with multiple phones belonging to the same account. Public and non-profit organizations are excluded from this list, whereas multiple accounts from the same organization are consolidated into one. This results in a sample of 2,300 private firms covering 125,000 subscribers. Whether a firm is active is inferred from call detail records from all the phones registered under the corresponding corporate subscriber account. Call records contain the identity of the parties involved in the communication, as well as the timing of the communication and the location of the antenna where the call was initiated. The raw data were provided by a major mobile phone operator in Afghanistan and processed by Blumenstock et al. (2018). For this paper, the data were made available at the district level, on a monthly basis, for the period from April 2013 to April 2016. Formal firms with active cell phone traffic are measured per 1,000 inhabitants.

Illicit economic activity

The land surface devoted to opium poppy cultivation is used to estimate Illicit economic activity Y^O. It is recognized that poppy yields per hectare may vary across different parts of the country and over time. Yields could also decline as the cultivated surface increases, and more marginal land is used. However, the relevant margin in this case is not between cultivated and uncultivated land, but between land devoted to poppies and land devoted to wheat, with both being similar in terms of their agricultural potential (Keohler and Zuercher 2007). Given the absence of detailed information on poppy yields across

land plots, the paper assumes that the relative change in illicit economic activity y^A is proportional to the relative change in the land surface devoted to opium cultivation.

The data on land use are generated by the Ministry of Counter Narcotics (MCN) of Afghanistan in collaboration with the United Nations Office on Drugs and Crime (UNODC). The extent of opium poppy cultivation is assessed on an annual basis through a methodology that combines field work with remote sensing techniques. The latter are needed because field work is dangerous, given the security conditions on the ground and the illegal nature of the crop. Image interpretation of geo-referenced ground and aerial photography allows to generate digital maps of poppy fields (UNODC 2007). The data on opium poppy cultivation used for this study are at the district level, for the period from 2007 to 2016 (UNODC 2016), measured in hectares per 1,000 inhabitants.

Conflict intensity

The intensity of conflict C is derived from the number of killings, a metric associated with terrorist attacks generated by the Global Terrorism Database (GDT). This is a comprehensive source produced by the National Consortium for the Study of Terrorism and Responses to Terrorism, at the United States Department of Homeland Security Center of Excellence. Data on casualties for Afghanistan are available from May 1973 to December 2016. The raw data are georeferenced and available on a monthly basis; for this paper, they are aggregated at the district level. The intensity of conflict is defined as the number of killings and normalized by their standard deviation across the sample.

Control variables

Information on the presence of international and Afghan combat troops – T^W and T^A respectively – comes from the NATO ISAF placemat for each Regional Military Command (NATO 2018). Placemats report province-level information on the number of ISAF troops by the contributing nations and on the localization of Provincial Reconstruction Teams (PRTs). Placemat issues also include information on the number of Afghan National Army (ANA) troops and on ISAF and ANA major units. Although information on PRTs is systematically reported, information on ISAF major units at the provincial level is only available from 2011 onwards. Combat troops are measured per 1,000 inhabitants in the province.

Foreign aid D is proxied by development assistance commitments. The data come from the Development Assistance Database (DAD), the main publicly available source of information on development assistance in Afghanistan. Data are available by donor and sector, at the provincial level. They can be disaggregated

into security-related aid and other forms of aid. Foreign aid is measured in constant US$ per quarter per 1,000 inhabitants, at 2010 prices.

Summary statistics for the variables used in the empirical analysis are reported in Table 1. During the period considered in this paper, Afghan districts have an average nighttime light intensity of 0.68 nanowatts, 1.2 active formal firms, 6.7 land hectares devoted to poppy cultivation per 1,000 inhabitants. On average, a district experiences 0.06 killings per 1,000 inhabitants per quarter. On average, a province hosts 2.6 international troops and 4.6 Afghan troops per 1,000 inhabitants. It also receives US$15,611 in foreign aid per 1,000 inhabitants per quarter, of which US$119 is for security and the rest for other forms of aid. However, these averages hide considerable variation.

Table 1. Summary statistics

Variable	N	Mean	Min	Max	Std. Dev.
Nighttime light (nanowatts)	5970	0.68	0.00	89.43	5.14
Active formal firms (per 1,000 inhabitants)	3159	1.12	0.01	18.71	1.68
Poppy cultivation (hectares per 1,000 inhabitants)	3582	6.73	0.00	416.5	27.20
Killings (per 1,000 inhabitants)	5970	0.06	0.00	6.81	0.22
ISAF troops (per 1,000 inhabitants)	646	2.66	0.00	38.73	5.46
ANA troops (per 1,000 inhabitants)	646	4.64	0.00	19.32	5.50
Security-related aid (USD per quarter per 1,000 inhabitants)	646	119	0.00	16555	878
Other aid (USD per quarter per 1,000 inhabitants)	646	15492	0.00	242573	27538

Results

The results of the estimation for overall, formal and illicit economic activity are presented in Tables 2, 3 and 4 respectively. Several variants of equation (5) are reported in each of the tables. The preferred specification appears in the fifth column. This specification separates international troops from Afghan troops and security-related aid from other aid.

Conflict has a negative effect on overall economic activity up to two quarters after a surge in the number of casualties. An increase in conflict by one a standard deviation is associated with reduction in nighttime light intensity by about 0.8 and 1.7 percent during the following two quarters respectively. The magnitude of this impact is stable across specifications. Given that the elasticity of aggregate economic activity to

14

nighttime light is estimated at 0.25, the relative change of the former when conflict increases by one standard deviation is approximately 0.4 percent (= 0.25x1.7).

The effect is much stronger in the case of formal economic activity. A one-standard deviation increase in the conflict indicator is associated with a 4.9 percent reduction in the number of formal firms active in the following quarter. The effect remains negative in the following quarters, but the estimates are not statistically significant.

Finally, conflict boosts the amount of land devoted to opium cultivation. The estimated coefficients are positive in all quarters. They are statistically significant for the second quarter after a surge in conflict, when opium poppy cultivation increases by an estimated 6.3 percent. These two estimated effects (4.9 and 6.3 percent) apply to formal and illicit economic activity respectively, given the assumption that activity is proportional to the chosen indicator in both cases.

The presence of combat troops is associated with greater overall economic activity. An additional international soldier per 1,000 inhabitants is associated with a 2.1 percent increase in nighttime light intensity a quarter after deployment. The effect is smaller, and not statistically significant, for Afghan troops. However, neither contingent has an impact on formal economic activity. The estimated coefficients are positive, but they are not statistically significant. Illicit economic activity, on the other hand, is negatively affected by the presence of Afghan troops. An additional Afghan soldier per 1,000 inhabitants is associated with a 4.4 percent reduction in opium poppy cultivation.

Foreign aid moderately contributes to overall economic activity. An additional dollar of security-related spending per capita is associated with a 1.1 percent increase in nighttime light intensity. On the other hand, other forms of aid do not have a noticeable effect. The impact of security-related aid is much greater for formal activity, with one additional dollar of spending leading to 2.1 percent more firms being active. But in this case other forms of aid have a negative impact, and it is statistically significant. Finally, both forms of aid discourage illicit activities, with the effect being particularly strong for security-related aid. In this case, one additional dollar of spending per capita reduces opium poppy cultivation by 0.23 log point, or roughly 20.5 percent.

The findings are similar if the indicators for combat troops and for foreign aid are normalized by corresponding standard deviation across the sample, similar to the way the conflict indicator is defined. The results of the estimation when using these alternative measures are available on request.

Table 2. Conflict and nighttime light

	log (sum of lights per area)				
	(1)	(2)	(3)	(4)	(5)
Conflict_{t-1}	-0.0110**	-0.00833*	-0.00825*	-0.00826*	-0.00821*
	(0.00488)	(0.00499)	(0.00499)	(0.00500)	(0.00496)
Conflict_{t-2}	-0.0203***	-0.0173***	-0.0173***	-0.0172***	-0.0172***
	(0.00659)	(0.00632)	(0.00632)	(0.00631)	(0.00631)
Conflict_{t-3}	-0.0103	-0.00742	-0.00751	-0.00744	-0.00749
	(0.00764)	(0.00676)	(0.00676)	(0.00675)	(0.00675)
Conflict_{t-4}	-0.00835	-0.00616	-0.00621	-0.00616	-0.00619
	(0.00792)	(0.00713)	(0.00712)	(0.00712)	(0.00710)
Troops_{t-1}		0.0211***		0.0212***	
		(0.00455)		(0.00453)	
ISAF_{t-1}			0.0217***		0.0215***
			(0.00476)		(0.00473)
ANA_{t-1}			-0.00943		0.00251
			(0.0758)		(0.0763)
AID_{t-1}		4.83e-07***	4.91e-07***		
		(1.85e-07)	(1.84e-07)		
Security_{t-1}				1.12e-05**	1.10e-05**
				(4.81e-06)	(4.81e-06)
Other aid_{t-1}				4.40e-07**	4.45e-07**
				(1.85e-07)	(1.83e-07)
District Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	5,970	5,970	5,970	5,970	5,970
Adj. R2	0.994	0.994	0.994	0.994	0.994

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3. Conflict and active formal firms

	log (active formal firms per 1,000 inhabitants)				
	(1)	(2)	(3)	(4)	(5)
$Conflict_{t-1}$	-0.0512*	-0.0488**	-0.0490**	-0.0489**	-0.0492**
	(0.0271)	(0.0247)	(0.0247)	(0.0246)	(0.0246)
$Conflict_{t-2}$	-0.0401	-0.0388	-0.0388	-0.0390	-0.0390
	(0.0303)	(0.0284)	(0.0283)	(0.0284)	(0.0283)
$Conflict_{t-3}$	-0.00931	-0.00819	-0.00792	-0.00852	-0.00819
	(0.0250)	(0.0243)	(0.0242)	(0.0243)	(0.0242)
$Conflict_{t-4}$	-0.0338	-0.0318	-0.0316	-0.0320	-0.0318
	(0.0251)	(0.0236)	(0.0235)	(0.0237)	(0.0235)
$Troops_{t-1}$		0.0264		0.0264	
		(0.0264)		(0.0264)	
$ISAF_{t-1}$			0.0239		0.0230
			(0.0257)		(0.0256)
ANA_{t-1}			0.172		0.224
			(0.196)		(0.209)
AID_{t-1}		-1.42e-06**	-1.42e-06**		
		(6.70e-07)	(6.72e-07)		
$Security_{t-1}$				1.83e-05***	2.09e-05***
				(6.39e-06)	(7.92e-06)
$Other\ aid_{t-1}$				-1.56e-06**	-1.58e-06**
				(6.89e-07)	(6.90e-07)
District Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	3,159	3,159	3,159	3,159	3,159
Adj. R2	0.835	0.836	0.836	0.836	0.836

Robust standard errors in parentheses

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

Table 4. Conflict and land devoted to poppy cultivation

	log (Poppy cultivation per 1,000 inhabitants)				
	(1)	(2)	(3)	(4)	(5)
Conflict$_{t-1}$	0.000540	0.000385	0.0107	-0.00158	0.00817
	(0.0395)	(0.0395)	(0.0397)	(0.0395)	(0.0398)
Conflict$_{t-2}$	0.0640*	0.0613*	0.0640*	0.0603*	0.0630*
	(0.0365)	(0.0365)	(0.0369)	(0.0365)	(0.0369)
Conflict$_{t-3}$	0.0450	0.0429	0.0530	0.0450	0.0539
	(0.0530)	(0.0528)	(0.0525)	(0.0526)	(0.0524)
Conflict$_{t-4}$	0.0674	0.0667	0.0626	0.0676	0.0637
	(0.0614)	(0.0610)	(0.0593)	(0.0610)	(0.0595)
Troops$_{t-1}$		-0.00704		-0.00729	
		(0.00910)		(0.00903)	
ISAF$_{t-1}$			0.0105		0.00877
			(0.0124)		(0.0122)
ANA$_{t-1}$			-0.0478**		-0.0444**
			(0.0186)		(0.0187)
AID$_{t-1}$		-5.10e-06**	-4.79e-06**		
		(2.41e-06)	(2.42e-06)		
Security$_{t-1}$				-0.000274***	-0.000233**
				(9.41e-05)	(9.14e-05)
Other aid$_{t-1}$				-5.05e-06**	-4.77e-06**
				(2.41e-06)	(2.42e-06)
District Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	3,582	3,582	3,582	3,582	3,582
Adj. R2	0.805	0.805	0.805	0.805	0.805

Robust standard errors in parentheses

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

These findings suggest that conflict has important consequences for the structure of economic activity. The impact of a surge in conflict-related casualties is much stronger on formal and illicit activities than on overall economic activity. This is shown by Figure 3, which traces the evolution of aggregate, formal and illicit economic activity based on the estimated coefficients in our preferred specifications and the assumed 0.25 elasticity of aggregate economic activity to nighttime light intensity. Both panels in this figure are computed for an increase in conflict-related casualties by one standard deviation. In panel 3a the shock lasts for one quarter only, whereas in panel 3b it continues over time. This figure also shows the predicted impact on informal economic activity based on equation (6) and the estimated sectoral weights in total economic activity.

Conclusion

Most available estimates of the impact of conflict on economic activity focus on indicators giving a disproportionate weight to the formal sector. And this is despite informal and illicit activities being common, if not predominant, in conflict settings. Aggregate indicators such as GDP tend to underestimate informal sector activities, and to exclude illicit activities. Wages matter only for relatively better-off segments of the population, as the majority of those at work tend to be farmers or self-employed. Disaggregated indicators from non-traditional sources, from housing prices to construction permits to mobile phone traffic from registered firms, also refer to formal markets and organizations.

While some studies have analyzed the effects of conflict on informal and illicit activities, this paper is the first one to consider impacts across formal, informal and illicit activities simultaneously. The proposed methodology is firmly anchored in the literature, although it pays special attention to the dynamic structure of conflict impacts, and it controls for other variables that have been shown to affect economic activity in conflict settings. The main innovation of the paper comes from the reliance on non-traditional sources of data with a high degree of spatial granularity. Thus, nighttime light intensity is used to measure economic activity at the aggregate level, mobile phone traffic from registered firms for the formal sector, and the land surface devoted to poppy cultivation for illicit activities.

The results suggest that the main impact of conflict is not as much on aggregate economic activity as it is on its composition. Conflict escalation is associated with a major drop in formal sector activity, an increase in its informal sector counterpart, and a surge in illicit activities. Therefore, assessments that focus on indicators giving a disproportionate weight to the formal sector tend to overestimate the impact of conflict on economic activity.

Figure 3. The impact of a surge in conflict on economic activity

3a. Temporary surge in conflict
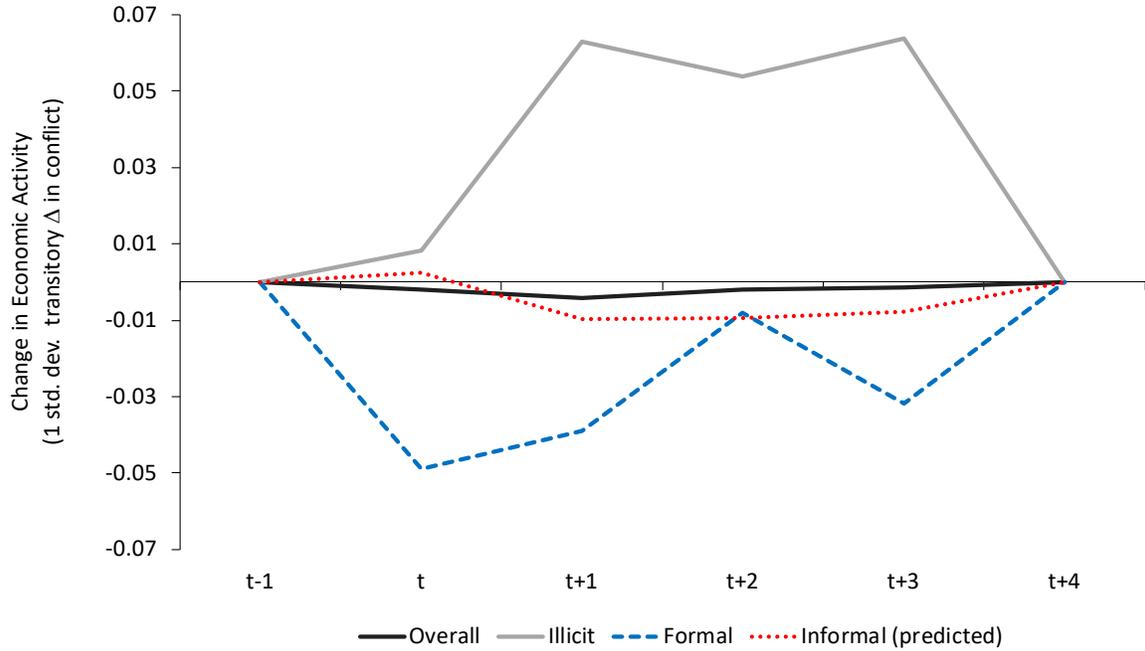
3b. Permanent surge in conflict
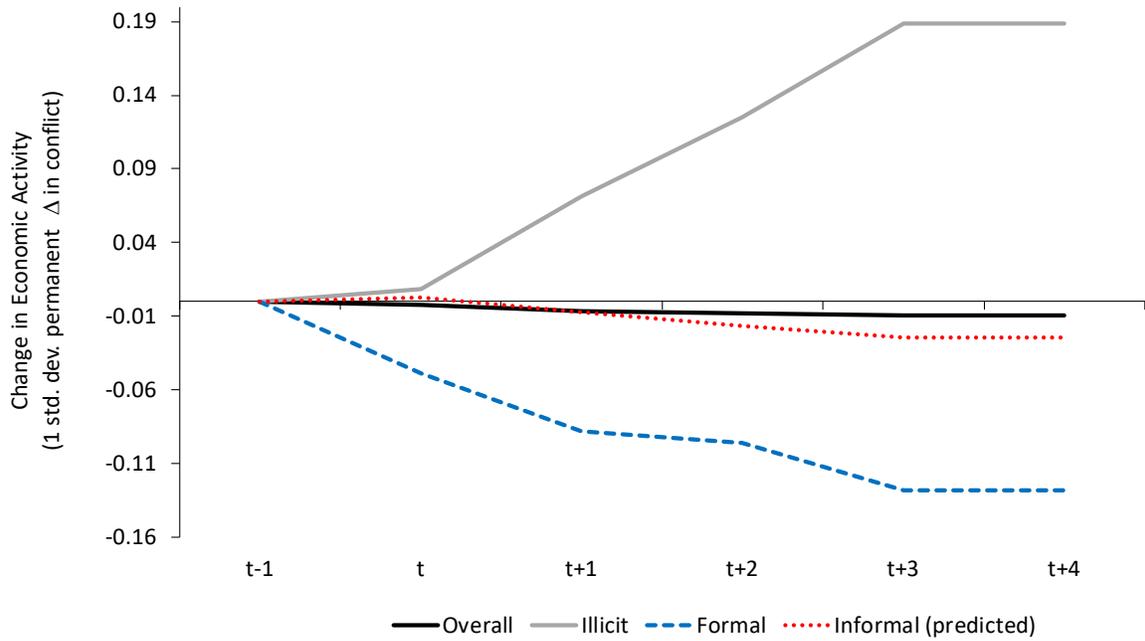
This finding should not be interpreted as downplaying the adverse consequences of conflict. A change in the composition of economic activity, from formal to informal and illicit, could have important indirect effects. The formal sector provides jobs that tend to be better than those in the rest of the economy and is the source of the tax revenue needed to pay for social services. Illicit activities are likely to have negative externalities, from greater insecurity to higher corruption. Through the change in the structure of the economy, a small decline in aggregate economic activity could still be associated with a major decline in the well-being of the population.

The impact of conflict on the structure of the economy also has potential policy implications. If conflict undermines formal sector activity, efforts to improve the business environment for formal sector firms become less effective. The results in this paper rather call for efforts to make the informal sector more productive, and more attractive relative to illicit activities.

References

Abadie, A., and Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. *American Economic Review* 93(1): 113-132.

Acemoglu, D., Hassan, T.A., Robinson, J. (2011). Social Structure and Development: A Legacy of the Holocaust in Russia. *Quarterly Journal of Economics* 126 (2): 895–946.

Bazzi, S., Blair R.A., Blattman, C., Duber, O., Gudgeon, M., Peck R.M. (2019). The promise and pitfalls of conflict prediction: evidence from Colombia and Indonesia. *NBER Working Paper* 25980. Cambridge, MA: National Bureau of Economic Research.

Berman, E., Felter, J., Kapstein, E., & Troland, E. (2013). Predation, taxation, investment and violence: evidence from the Philippine*s. NBER Working Paper* 19266. Cambridge, MA: National Bureau of Economic Research.

Besley, T. and Mueller, H. (2012). Estimating the peace dividend: the impact of violence on house prices in Northern Ireland. *American Economic Review*, 102(2): 810–33.

Beyer, R.C.M, Chhabra, E., Galdo, V. and Rama, M.G. (2018). Measuring districts' monthly economic activity from outer space. *Policy Research Working Paper* 8523. Washington, DC: The World Bank.

Blattman, C., and Miguel, E. (2010). Civil war. *Journal of Economic literature* 48(1): 3-57.

Blumenstock, J., Cadamuro, G., and On, R. (2015). Predicting poverty and wealth from mobile phone metadata. *Science* 350(6264): 1073-1076.

Blumenstock, J., Ghani, T., Herskowitz, S., Kapstein, E. B., Scherer, T., and Toomet, O. (2018). Insecurity and industrial organization: Evidence from Afghanistan. *Policy Research Working Paper* 8301. Washington, DC.: The World Bank.

Ciarli, T., Kofol, C., and Menon, C. (2015). *Business as unusual. An explanation of the increase of private economic activity in high-conflict areas in Afghanistan.* SERC Discussion Papers 0182. London: Spatial Economics Research Centre.

Colier, P. (1999).   On the economic consequences of civil war. *Oxford Economic Papers* 51(1): 168-183.

Colier, P. (1999).   On the economic consequences of civil war. *Oxford Economic Papers* 51(1): 168-183.de Groot, O. J., Bozzoli, C., and Brück, T. (2015). The global economic burden of violent conflict. *Household in Conflict Network (HiCN) Working Paper* 199. Brighton: Institute of Development Studies at Sussex.

Donaldson, D and Storeygard, A. (2016). The View from Above: Applications of Satellite Data in Economics. *Journal of Economic Perspectives* 30 (4): 171–98.

Elvidge, C.D., Baugh, K., Zhizhin, M., Hsu, F.C., and Ghosh, T. (2017). VIIRS night-time lights. *International Journal of Remote Sensing* 38(21): 5860-5879*.*

Floreani, V. A., Lopez-Acevedo, G, Rama, M. (2016). Conflict and Poverty in Afghanistan's Transition*. Policy Research Working Paper* 7864. World Bank, Washington, DC: The World Bank.

Goodhand, J. (2008). Corrupting or consolidating the peace? The drugs economy and post-conflict peacebuilding in Afghanistan. *International Peacekeeping* 15(3): 405-423.

Henderson, J. V., Storeygard, A. and Weil, D.N. (2012). Measuring economic growth from outer space. *American Economic Review* 102(2): 994-1028*.*

Koehler, J., and Zürcher, C. (2007). Statebuilding, conflict and narcotics in Afghanistan: The view from below. *International Peacekeeping* 14(1): 62-74.

Lind, J. T., Moene, K. O., and Willumsen, F. (2014). Opium for the masses? Conflict-induced narcotics production in Afghanistan. *Review of Economics and Statistics* 96(5): 949-966.

Looney, R. (2006). Economic consequences of conflict: The rise of Iraq's informal economy. *Journal of Economic Issues* 40(4): 991-1007.

NATO (North Atlantic Treaty Organization). (2018). Resolute Support Mission Placements Archive 2007-2018. https://www.nato.int/cps/en/natolive/107995.htm.

Pei, T., Sobolevsky, S., Ratti, C., Shaw, S. L., Li, T., and Zhou, C. (2014). A new insight into land use classification based on aggregated mobile phone data. *International Journal of Geographical Information Science* 28(9): 1988-2007.

Singh, P. (2013). Impact of Terrorism on Investment Decisions of Farmers: Evidence from the Punjab Insurgency. *Journal of Conflict Resolution,* 57(1): 143–168.

SIGAR (Special Inspector General for Afghanistan Reconstruction). (2018). Private sector development and economic growth: lessons from the U.S experience in Afghanistan.

Stepanova, E. (2012). Illicit drugs and insurgency in Afghanistan. *Perspectives on Terrorism* 6(2).

Sutton, P. C., Elvidge, C. D., and Ghosh, T. (2007). Estimation of gross domestic product at sub-national scales using nighttime satellite imagery. *International Journal of Ecological Economics and Statistics* 8(S07): 5-21.

UNODC (2007, 2016, 2017). *Afghanistan Opium Survey.* New York: United Nations Office on Drugs and Crime.

UNAMA (2019). Afghanistan Protection of Civilians in Armed Conflicts Annual Report 2018. Kabul: United Nations Assistance Mission in Afghanistan.

World Bank. (2005). Afghanistan--State Building, Sustaining Growth, and Reducing Poverty. Washington DC: The World Bank.

World Bank (2017). *Growth out of the Blue.* South Asia Economic Focus. Washington DC: The World Bank.

World Bank (2018). *Afghanistan to 2030: Economic Development under Fragility*. Washington DC: The World Bank.