Insecurity and Industrial Organization: Evidence from Afghanistan*

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Abstract

One-fifth of the world's population lives in countries affected by fragility, violence and conflict, impeding long-term economic growth. However, little is known about how firms respond to local changes in security, in part because of the difficulty of measuring firm activity in these settings. This paper makes two contributions. First, we develop a method for observing private sector activity using data from mobile phone networks, and validate this measure with existing administrative data as well as an original survey of 2,300 firms in Afghanistan. Second, we use this new measure of firm activity to examine how major violent events affect firm activity. To provide intuition for this response, our main analysis begins with a detailed empirical case study of the 2015 Taliban attack on Kunduz, Afghanistan's fifth largest city. We then generalize this approach by studying how nationwide location decisions of these private Afghan firms respond to 80 large terrorist attacks occurring from 2013-2016. We find a negative impact on firm presence in areas that experience major conflict, which is driven both by an increase in firm exit and a reduction of entry. These impacts attenuate after a month, and vary substantially depending on firm size.

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1 Introduction

Standard models of growth and development assume that economic transactions occur in an environment with secure property rights and no threats to personal safety. But for the 1.5 billion people living in countries affected by violence, conflict and fragility, this assumption fails (World Bank, 2011).[1] A recent literature demonstrates the many channels through which insecurity may affect economic outcomes, including the destruction of physical capital, deterrence of investment, disruption of livelihoods, and the weakening of institutions (Abadie and Gardeazabal, 2003; Fielding, 2004; Blattman and Miguel, 2010; Miguel and Roland, 2011; Besley and Mueller, 2012). Researchers, however, have a less clear understanding of how conflict affects the private sector — owing in part to the fundamental challenge of obtaining firm-level data in insecure regions (Besley et al., 2011). As a result, past research has focused on publicly traded firms and a few select settings where high-quality administrative data is available (Guidolin and La Ferrara, 2007; Bruck et al., 2012).

This paper makes methodological and substantive contributions to the study of firm behavior in fragile states. Methodologically, we develop and validate a new approach for measuring the dynamic geographic footprint of private companies. This approach uses administrative records of mobile phone activity to extract the presence, entry, exit, and relocation decisions of firms at very high frequency and spatial granularity. We apply these techniques to data obtained from Afghanistan's largest mobile phone operator, which contains billions of phone calls occurring between 2013-2016, a period of rising insecurity. To our knowledge, this is the first concerted effort to measure the activity of private firms in developing countries using passively-collected digital data.[2] We therefore compare our measurements to

[1] Terms like "civil war" and "rebellion" generally do not appear in the leading textbooks on economic growth (cf. Jones, 2002). For instance, one of the best-selling texts on development economics devotes a single paragraph to political instability — including inter-state and civil wars, coups d'etat, and rebellions (Perkins et al., 2013).

[2] This methodology extends work by Blumenstock et al. (2015), who use mobile phone data to analyze the distribution of wealth and poverty in Rwanda, as well as recent work using satellite imagery to measure productivity and wealth (Henderson et al., 2012; Jean et al., 2016). Prior work does not typically differentiate private firms from other types of economic activity.

three independently-collected administrative datasets from the Afghan government (including corporate registration and tax records), as well as an original survey of over 400 Afghan companies that we conducted in 2016. These data make it possible to calibrate and carefully validate our inferred measures of firm size and location. More generally, these tests suggest that phone-based measures of firm activity can complement and extend traditional sources of data collection, particularly in developing and conflict-affected countries.

Our main results then use this new measure of firm activity to study how the private sector in Afghanistan responds to violence. To provide intuition, we first present a detailed case study of the firm response to the "Fall of Kunduz," a major Taliban attack on Kunduz, the country's fifth largest city. Using our phone-based measures of firm activity, we observe an immediate and pronounced drop in firm presence in the area. This reduction is driven by the relocation of corporate subscribers from inside to outside the city limits. The drop persists for the full three-week period of the attack, and induces a long-term trend break in corporate subscriber activity in Kunduz of roughly 1 standard deviation.

We next develop an empirical strategy to generalize from this dramatic case study to the pervasive conflict in Afghanistan. This analysis combines mobile phone records of several thousand Afghan firms with four years of geocoded data on confirmed fatalities from the Global Terrorism Database, which contains hand-coded records of terrorist attacks that were reported in local and national media sources. We use panel fixed-effects regressions (with quadratic district-specific time trends) to estimate the effect of violence on firm activity, and to explore heterogeneity in the response by firm type. We highlight three main results.

First, we find that in response to major attacks — defined as violent events in the top percentile of confirmed killings — firms immediately curtail operations in the affected regions. The effect is most pronounced in the month immediately following the attack, and implies a reduction of activity by roughly 4-6%. The negative effect persists, but gradually abates, for approximately six months. These impact of violence is robust to a series of increasingly restrictive econometric specifications, including our preferred panel fixed effects regressions

with both linear and quadratic trends.

Second, the overall effect is driven both by an increase in firm exit and a decrease in firm entry. Specifically, companies are 8-16% less likely to begin operating in districts that have experienced a major attack and 6-23% more likely to cease operations. Consistent with earlier results and the Kunduz case study, this effect is most pronounced in the month following the attack, though there is suggestive evidence of longer term persistence.

Finally, we observe considerable heterogeneity in how firms respond to violence, providing some insight into the mechanisms through which insecurity may affect firm decision-making. Most notably, the effect in our sample is concentrated among larger firms - where firm size is measured by the total number of subscribers (phone numbers) assigned to a corporate account. Our results suggest an under-studied channel through which insecurity may impede the growth of firms in poor economies: anticipating the costs of managing insecurity, firms may decide to remain small to avoid differential exposure to this risk. These latter results are also supported by original survey data we collected from a subsample of more than 400 firms from our corporate calling data sample. In the survey data, we observe that larger firms are significantly more likely to report business disruptions from anti-government group activity and to adapt their business practices in response to such experiences - even when controlling for firm headquarters' location and industry. Relatedly, we find that our administrative data results are concentrated among firms with more mobile forms of physical capital (e.g., construction and transport), suggesting that the ability to relocate valuable assets may be essential to understanding firm responses to violence.

Our work engages two existing literatures that currently have limited intersection: the first on the economic consequences of conflict, and the second on the industrial organization of firms in developing countries. The economics of conflict literature extends the focus of North (1990) on national institutions and strong property rights regimes (Svensson, 1998) to highlight the effects of a breakdown in institutionally-enforced order. Classic examples have highlighted the macro-economic consequences of violent conflict on GDP in Spain (Abadie

and Gardeazabal, 2003), on investment in Israel (Fielding, 2004), and on housing prices in Ireland (Besley and Mueller, 2012). In the spirit of Guidolin and La Ferrara (2007), who study the effect of Angola's conflict on diamond companies, we focus on the micro-level of firm behavior in conflict settings, and introduce a novel measurement approach that enables a focus beyond publicly-traded firms.[3] We also build on recent work by Besley and Mueller (2017) who use World Bank enterprise survey data on the costs of protection that firms incur in insecure environments. Consistent with their suggestion that large firms in such contexts will be more susceptible to predation, we find that the negative effects of violence are concentrated among larger firms.

Regarding industrial organization, Klapper and Richmond (2011) note that research on "the survival of formal firms has important implications for development strategies. In order for the private sector to act as an 'engine of growth' and advance the development process it is necessary for firms to survive and grow." While generally not written in the context of conflict settings, the literature on industrial organization, including in developing countries, can help generate hypotheses regarding the structure of firms in such environments.[4] As Cefis and Marsili (2005) observe, "the growth and survival of firms will depend on their ability to successfully adapt their strategies to changing environments." The behavior of smaller firms is of potential importance to the competitiveness and growth of a nation's economy as well. As Beck et al. (2005) point out, bilateral and multilateral aid agencies have sought to promote the Small and Medium-Sized Enterprise (SME) sector through various programs and subsidies in developing countries in order to increase competition and productivity, and generate employment. To date, much of the literature and related policy analysis has emphasized the role of weak institutions, credit constraints and access to information on firm growth in the developing world (Laeven and Woodruff, 2007; De Mel et al., 2008; Jensen and Miller, 2017); insecurity may provide another channel.

[3] As a complement to Ciarli et al. (2015), who find higher rates of self-employment in conflict affected areas of Afghanistan using household survey data, our results suggest that formal employment opportunities may fall with insecurity.

[4] See Li and Rama (2015) for a recent review.

We proceed in four sections. In the next section, we briefly review Afghanistan's economic and security background during the period of our data collection. Section 3 summarizes our data and measurement validation exercises. Section 4 provides our results on insecurity, including both the Kunduz case study and the nationwide analysis, and highlight potential mechanisms and adaptation strategies for future exploration. We conclude with recommendations for further research and discuss implications for policymakers.

2 Economy and Security in Afghanistan

2.1 Afghanistan's Economy

The World Bank defines Afghanistan as a "deeply fragile and conflict-affected state." From an economic perspective, "GDP per capita is among the lowest in the world, poverty is deep and widespread, and social indicators are still at very low levels" (World Bank, 2016). Although it was the world's single largest recipient of official development assistance in 2014, Afghanistan's GDP per capita was just $660 that year (IMF, 2014). Growth in Afghanistan has been "rapid and volatile" over the past decade, owing to changes in inflows of development assistance, changes in agricultural prices, and changes in military spending (World Bank, 2016).[5]

For a decade following the 2002 removal of the Taliban from power, growth averaged 9.4 percent per annum. These high growth rates would seemingly suggest that Afghanistan is a promising site for private sector investors. However, as Floreani et al. (2016) point out, this growth did not translate into a durable reduction in poverty. Poverty levels did fall in certain regions, like Kandahar and Helmand, which saw the most intense fighting, but these were largely the result of economic spillovers from large infusions of military spending on local economies. With the drawdown of military forces beginning in 2012, and corresponding

[5]For a recent overview of the private sector in Afghanistan drawn from the existing official data and interview sources, see Ghiasy et al. (2015).

decreases in development aid and increases in the intensity of conflict, the country has gone into a recession and poverty levels are again climbing.

This period of growth has also failed to benefit exporters. Trade, as a share of GDP, has been falling since 2003, due to an overvalued exchange rate and the lack of international competitiveness of Afghan firms. Further, Afghan companies that have the capability of servicing the foreign aid and military sectors have done so. At the present time, only three economic sectors besides opium are actively exporting: mining, carpets, and dry fruits. From a sectoral perspective, the UN Food and Agriculture Organization estimates that agriculture constitutes 25 percent of GDP and 58 percent of employment with the remainder divided between industry and services. As Klapper and Richmond (2011) argue, formal sector industrial firms are key drivers of long-run economic growth, innovation, and employment creation. Informal firms are generally less productive, and make fewer investments in human capital and new production techniques. Thus, understanding the behavior of formal firms might reveal broader trends in the economy that limit long-run development and growth.

Regarding the private sector, "there is little data on investment activity in Afghanistan," a gap this study seeks in part to redress (World Bank, 2015). The Integrated Business Environment Survey (IBES) in 2009 estimated approximately 400,000 firms operating in Afghanistan, in a variety of sectors. The vast majority of these firms (94 percent according to IBES) are small, containing less than 9 employees. However, firms with over 500 employees, which constitute just .17 percent of all firms, support nearly one-third of all industrial employment. The firm size category which contributes the least total employment is SMEs (here between 10-499 employees).

In sum, the Afghan economy is fragile, both at the start of our study and today. Despite a long period of near double-digit growth, and massive inflows of foreign aid and military expenditure, the country has not yet found a sustainable growth path and has faced a sharp contraction since 2012. A range of serious challenges linked to limited infrastructure, weak institutions, and related issues—all exacerbated by four decades of conflict—continue to

impede progress in reducing national poverty levels.

2.2 Insecurity in Afghanistan

Since the late 1970s, Afghanistan has experienced violence and political instability, laying complex foundations for the current insecurity. A coup d'etat by the communist People's Democratic Party of Afghanistan (PDPA) in April 1978 sparked internal conflict, and resulted in the invasion of Soviet troops in December 1979. The resulting geopolitical alignment consolidated the Afghan state's dependence on the USSR as Western and Islamic states directed assistance to mujahidin resistance groups. This anti-communist resistance culminated with the withdrawal of Soviet troops in February 1989, though the client regime of President Sayid Muhammad Najibullah maintained control until the USSR's collapse in 1991. After mujahidin commanders took Kabul in 1992, new divisions emerged along ethnic lines with the governments of Iran, Pakistan and Uzbekistan backing different conflict factions.

In the early 1990s, the Taliban movement arose in the southern city of Kandahar and promoted itself as an Islamist law and order response to predation by mujahidin commanders. With support from Pakistan, the Taliban quickly gained ground and took Kabul in September 1996, with ongoing resistance limited to a few concentrated mujahidin-controlled areas in the northeast, northwest and west of the country. After the September 11, 2001 attacks in the United States were traced to the al-Qaeda terrorist network, the Taliban leadership refused to turn over the al-Qaeda leader Osama bin Laden who they were hosting in Kandahar. Starting in October 2001, small joint CIA-Special Forces teams delivered resources to former mujahidin commanders while collecting targets for a massive US air campaign. Kabul fell to former mujahidin fighters in November 2001, and Kandahar fell to a combination of US troops and mujahidin fighters in December.[6]

With the support of US and international military forces, prospects for security ap-

[6]That month, the UN and US brokered the establishment of a power-sharing government led by Hamid Karzai. Karzai was elected president in national elections held in 2004 and reelected in 2009, ultimately holding power until he was replaced in September 2014 by a national unity government formed by Ashraf Ghani and Abdullah Abdullah after a contested election.

peared to improve during the early years of the Karzai administration as attention focused on integrating mujahidin commanders into the national government. In 2006, the Taliban insurgency reemerged with increased financial and technical support and mounted a series of increasingly violent offensives from bases inside Pakistan. NATO International Security Assistance Forces (ISAF) and Afghan National Security Forces (ANSF) responded, with violence escalating through 2009, leading to a surge of U.S. forces by the newly elected Obama Administration. However, the surge was linked to a transition plan to drawdown US forces starting in 2012 and handover primary responsibility for security operations to the ANSF by 2014. In December 2014, NATO forces formally ended combat operations in Afghanistan, though American and other NATO troops continue to serve as advisors today.

Despite the agreement of Afghan and US policymakers on the need for a transition to Afghan leadership in the ongoing counter-insurgency conflict, the process has not been without consequence or controversy. As Figure 1 shows, the five years from 2012-2016 in our security data has marked a steady increase in the number of confirmed fatalities due to local terrorist attacks and a corresponding increase in the number of Afghan districts perceived as insecure. This recent trend of increasing violence motivates our interest in how the Afghan private sector responds to rising insecurity and further emphasizes the need for novel measurement strategies given the challenging setting for data collection.

3 Data

In this study, we combine three complementary data sources to achieve a fine-grained perspective on the economic behavior of private firms in Afghanistan: administrative mobile phone records, administrative government records, and original firm survey data. Since 2002, mobile phone penetration in Afghanistan has grown rapidly, with four private operators and one public operator serving a total market of over 19.7 million subscribers out of an estimated population of 21.5 million adults (World Bank 2015).

3.1 Summary Statistics

As a measure of firm activity, we use anonymized call detail records (CDR) covering four years from the one of the country's largest mobile network operators. As in prior studies using CDR data (c.f. Blumenstock et al. (2015)), we observe a record of each call that was initiated, including anonymized identifiers for the calling and called parties, the date and time of the call, and the coordinates of the cell phone tower of the calling party. We do not observe the actual identity of the calling or called parties, nor do we observe the content of their communication. Unlike prior work, we focus our attention on CDR data of corporate line customers, a subset of subscribers who have signed up for a corporate pricing plan that allows for the linking of multiple phones to a single account. We observe the company names of corporate line customers as well as the operator's classification of customer business type (e.g., "construction", "government", "transport", etc). We screen these company types to remove public or non-profit organizations, including health, education or media groups, leaving us with a sample of more than 2,300 private organizations covering over 125,000 subscribers active during our 45 months of data from April 2013 to December 2016. These data include 1,350 active cell phone towers distributed across 267 of Afghanistan's 398 districts, which collectively cover over 80% of the population.[7]

As shown in Table 1, the average (median) firm is active for 34 (45) months and is observed in 34 (22) districts during the period of our data. While the average firm has 52 subscribers, the median firm has 4, implying a skewed distribution of firm size with a small number of very large firms. The mobile network operator provides coarse sectoral information about firms in the form of an internally recorded business type. We see that 19% of firms are in construction, 13% of firms are in manufacturing, 12% are in transportation, 11% are in trade, less than 2% each are in finance, IT or security, and 41% are labeled as other.

Firms with corporate phone accounts present in our data may be different from "typical"

[7] Afghanistan's challenging terrain, limited infrastructure and persistent insecurity limit the expansion of mobile network coverage to more remote and underpopulated districts.

Afghan firms. While we would like to be able to characterize this selection of firms relative to all others, there is no existing census of firms covering the period of our data.[8] One reasonable benchmark is the World Bank's Enterprise Survey conducted in May-July 2013, which includes a random stratified sample of 416 firms reweighted based on firm size, sector and location strata. In Table A1, we show that on average the firms in our CDR data appear to have twice as many subscribers as the number of employees from firms in the Enterprise Survey sample, that the CDR firms are less likely to appear in trade or manufacturing categories, and that CDR firms are more likely to have their headquarters based in Kabul. We expect that firms that register for corporate lines are more likely to be large, formal firms based in urban areas, and are unlikely to include smaller, informal firms operating only in rural areas. However, larger urban firms compose a major portion of formal employment and are an important driver of growth, and thus are of particular interest.

For most of our analysis, we aggregate the CDR data to the firm-district-month level.[9] We address potential measurement concerns about mobile network coverage being mechnically correlated with violent events by dropping any district that records at least one month without 28 days of coverage (excluding 94 districts, $\sim$1/3 of our sample). This conservative approach may lead us to underestimate the magnitudes of our effects by excluding more unstable districts where the response to violence may be more severe; we also confirm that our results are robust to dropping only district-month observations which have less than 28 days of coverage. The data aggregation process results in a balanced panel of 7,785 district-months, with an average (median) district-month including 101 (57) active firms and 507 (149) active subscribers. We merge this district-month panel with geocoded data from the Global Terrorism Database (GTD) on over 10,000 confirmed fatalities from terrorism in

[8]The Central Statistics Office completed an Integrated Business Enterprise Survey (IBES) in 2009, which included a screening survey that attempted a census of every firm with 10 or more employees in the country and used random area sampling for firms with fewer than 10 employees. Some administrative datasets do exist for this period, but each have their own limitations/ For example, official business registration databases simultaneously under-count firms that do not register to evade tax obligations and over-count the registration of "ghost" firms created to pursue contracts.

[9]A brief description of the data processing required to complete this task is included in Appendix A1.

Afghanistan.[10] In Table 1, we show the mean (median) district-month records 1.3 (0) GTD killings, with a maximum value of 244 killings.[11] We also report that 8% of district-months are categorized as insecure in internal security tracking data from a national survey firm.[12]

3.2 Measurement Validation

A key methodological question in this study is how strong is the correlation between activity in the CDR and more traditional measures of firm activity. In Figure 2, we conduct a principal component analysis of the three main sources of variation in our district-month panel (log of active firms, active subscribers and calls) and plot the first principal component for April 2013 on a map of Afghanistan's districts. As expected, major urban centers such as Kabul (center-north), Kandahar (south), Hirat (west), Mazar (north-west), Kunduz (north-west) and Jalalabad (east) are clearly visible. We include red dots at locations of GTD killings from May 2012-April 2013, demonstrating the nationwide geographic distribution of violence that we exploit in the analysis below. We complete three additional validation exercises using a combination of official government data sources and original survey data.

First, we validate the physical location of firms against CDR measures in Table A2. For each firm appearing in the CDR, we compute the top one, five and ten "modal districts" by first calculating the most commonly used district in all outgoing calls for each subscriber in each month, and then recording the frequency with which each district appears as the mode for all of the firm's subscribers.[13] In Panel A, we compare these modal districts to

[10]Maintained by National Consortium for the Study of Terrorism and Responses to Terrorism (START) at the University of Maryland, the GTD database is constructed from keyword filtering of high-quality media sources and hand coded by teams of researchers, including providing geo-coordinates for the city or district an event takes place. Killings include confirmed fatalities of either victims or attackers. Thus, in order to be included in our dataset, a killing must be recorded by a credible media source and meet the GTD coding teams definition of terrorism: "the threatened or actual use of illegal force and violence by a nonstate actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation." While this introduces the likelihood of under-measuring violent incidents, it increases our confidence that we are focused on meaningful events.

[11]This observation corresponds to the attack on Kunduz in September 2015 that we discuss in detail below.

[12]A coding of insecure indicates the survey firm was unwilling to send enumerators to that district in that month for survey data collection activities.

[13]Note that the number of modal districts for a firm is bounded by the number of subscribers. The average

the headquarter district locations from two official business registration sources collected in 2016: the Central Business Registry (CBR), where formal firms must register to receive a tax identification number, and the Afghanistan Investment Support Agency (AISA), for firms seeking foreign investment. We successfully name match 934 firms to the CBR dataset and 110 firms to the AISA dataset, and find that 74% (79%) of firm headquarters matched the top modal district and 87% (93%) matched one of the top five modal districts in CBR (AISA). Using original survey data collected from over 400 firms in spring 2017, we complete a second validation exercise in Panel B where we include self-reported districts of headquarters and other offices in either 2014 or 2017. We find that 67% of 2017 office districts match the top 5 modal districts and that 70% match the top ten modal districts, with similar percentages in 2014. These findings increase our confidence in the potential of CDR data to proxy for employees' physical locations, especially with spatially and temporally aggregated measures.

Next, we validate the size of firms against CDR measures in Table A3. For each firm, we calculate the number of unique subscribers (phone numbers) active from January-March 2014, where we winsorize the top 1% of values to address large outliers. We then compare these subscriber totals to the total firm employment numbers gathered during April and May 2014 as part of the screening survey for the Central Statistics Office's Integrated Business Enterprise Survey (IBES).[14] We successfully name matched 190 firms to this dataset, and find a robust, positive relationship between these two independent measures of firm size; the cross-sectional correlation is .79 in levels in column (1) of Panel A ($p < .05$) and .22 in logs in column (1) of Panel B ($p < .01$). We again extend this exercise comparing our original survey data from spring 2017 with the number of unique subscribers in October-December 2016 and three years earlier in October-December 2013, and find a strong cross-sectional correlation between self-reported employees in 2017 of .57 in levels ($p < .05$) and .23 in logs ($p < .01$). These results suggest that active subscribers can provide useful information about

(median) firm has 5.8 (2) modal districts.

[14]The IBES survey sample combined a listing of 4,000 establishments with 10 or more employees (including public and non-profit organizations) and a random area sample of establishments with less than 10 employees.

firm size, even after transforming the data to a logarithmic scale. In general, substantial caution is warranted when using subscribers as a proxy for firm size, given that firms may either maintain more phone lines than employees or alternatively may not provide corporate lines for all of their employees.[15]

Third, we validate aggregate economic activity against CDR measures in Table A4 and Table A5. For each province-month in Table A4, we calculate the number of total corporate calls and compare this to province-level tax revenue records from the Ministry of Finance's Afghanistan Financial Management Information System (AFMIS). Using currently available data, we have 17 overlapping months for a panel of 34 provinces during 2013 and 2014. We find a positive relationship between the total corporate calls and tax revenues: a one standard deviation increase in calls in a province is associated with a .85 standard deviation increase in provincial tax revenues ($p < .01$). These results are robust to controlling for unobserved time-variant and time-invariant factors: the coefficient and significance is unchanged when adding month fixed effects and remains similar (.70 standard deviations at the 10% level) when also adding province fixed-effects. And for each district-month in Table A5, we calculate the number of total corporate calls and compare this to district-level nightlights data available from NOAA's VIIRS Day/Night Band Nighttime Lights. In columns (1)-(3) the outcome variable is the standardized average level of nightlights in that district-month, and in columns (4)-(6) it is the standardized total level of nightlights, which allows for larger districts to contribute more. Again, we find a positive relationship between calling time and these measures of aggregate economic activity: a one standard deviation increase in calls in a district is associated with a .28 standard deviation increase ($p < .01$) in average nightlights and a .35 standard deviation increase ($p < .01$) in total nightlights, even when including district and month fixed effects.

Overall, these validation exercises increase our confidence in the economic content of

[15]In Appendix Figure A1, we demonstrate this particular concern holds for single-subscriber firms, which share a similar size distribution of self-reported employees as firms with more than one subscriber. In columns (5)-(8) of Table A3, we show the correlations between number of employees and number of subscribers are consistently larger after dropping single-subscriber firms.

the CDR data. Firm location, firm size and aggregate tax revenues are all correlated with CDR based measures, with the validation of firm location measures proving particularly compelling. Limitations notwithstanding, this suggests the potential of this methodological approach, particularly in settings like Afghanistan where reliable data on the temporal or spatial distribution of firm activity is scarce.

4 Insecurity and Industrial Organization

How does insecurity affect the spatial and temporal organization of firms in Afghanistan? To provide some intuition for how Afghan firms respond to violence, we begin with an empirical case study of a major episode of violent conflict: the Taliban takeover of Kunduz, Afghanistan's fifth largest city. We then develop an estimation strategy that allows us to more precisely quantify the effects of countrywide violence on firm behavior.

4.1 Kunduz Case Study

The "Fall of Kunduz" is one of the most significant events in the past decade of the Afghan conflict. On 28 September 2015, Taliban fighters overran Kunduz city, following a battle that had ebbed and flowed since the previous April in neighboring districts. This marked the first time since 2001 that the Taliban had captured a major city and signaled the continuing strength of the insurgency. Kunduz was retaken by the Afghan National Army (ANA) on 13 October, with support from U.S. ground and air forces. Since then, sporadic violence has continued in and around the city, and the Taliban made another concerted attempt to overtake Kunduz in October 2016.[16]

We exploit the CDR data to demonstrate how subscribers from private firms, along with general mobile phone users, responded to the unexpected Taliban seizure of Kunduz in late-September and October 2015. In Panel A of Figure 3, we plot normalized call volumes for

[16] Additional background on the Kunduz case is provided in Appendix A2.

all towers in a 70 km radius of the Kunduz city center over a 24-week period centered on the takeover of the city on September 28 (marked by the black dashed line). We divide calling towers into two categories based on if the tower is located within a 10 km radius of the city center and thus covers urban areas (marked in green), or if the tower is located in a 10-70 km radius and thus covers rural areas and neighboring small cities (marked in orange).[17] The 10km radius approximates the boundaries of Kunduz district, which is the unit of geographical analysis below. We also divide callers based on if they are corporate lines subscribers (dashed line for "private"), or if they are part of the entire population of subscribers (solid line for "all"). These two categorizations result in four combinations, and we normalize each over the 24-weeks by subtracting the mean and dividing by the standard deviation for comparability.

Figure 3a shows a relatively smooth pre-trend in all four groups leading up to the seizure of Kunduz on September 28th, followed immediately by a sharp fall in the volume of calls originating from towers inside the city (green lines) and a corresponding spike in calls originating from towers outside the city (orange lines).[18] This effect lasts until the city is cleared in mid-October, and suggest some signs of persistence in that the level of activity inside the city returns to a level that is roughly 1 standard deviation lower in November and December 2015 than the previous levels in August and September.[19]

Returning to Figure 3a and comparing the dashed green line to the solid green line, we see evidence that corporate line subscribers responded to the September 2015 attack by leaving the city more quickly than regular users but also returned earlier. The same pattern reappears in Figure 3b with the October 2016 attack, suggesting that the behavior

[17] Appendix Figure A2 shows a map with the locations of towers in each radius.

[18] Appendix Figure A3 plots the daily locations of 150 corporate subscribers observed calling on the most days, demostrating their relocation from inside to outside the Kunduz city limits.

[19] In Appendix Figures A4 and A5, we show placebo plots for calling activity over the same time period in four other provincial capitals: Kandahar and Lashkar Gah, both located in the more violent southern region of the country, and Hirat and Mazar, located in the west and northwest of the country closer to Kunduz. We do not find evidence of a similar response in any other city when Kunduz is seized. We do note a secular decline in the normalized activity of subscribers in Hirat and Mazar but note that is pattern precedes the attack on Kunduz and shows no evidence of sharp break in September 2015. By contrast, Appendix Figure A6 shows the long-term trend in activity in Kunduz was positive before September 2015 and flat afterward.

of corporate line subscribers may be a leading indicator of trends by all subscribers. The underlying mechanism for this effect is unclear, and might include more resources for travel, better information on the security situation, or higher risks of being targeted individually. Overall, this micro-level evidence of how one large shock to security affects firm behavior measureable in CDR data motivates our shift to a large panel data analysis.

4.2 District-Firm-Month Panel Results

Next, we exploit our panel dataset of CDR measures and GTD killings to explore the generalized relationship between local changes in district-level insecurity on firm and employee presence. As our main dependent variables, we use the CDR data to determine whether a given firm was present in a given district during a given month based on cell tower locations used for calls placed by subscribers of that firm. In the analysis, we use two measures for firm presence: first, whether any call was made by any subscriber of that firm originating from that district in that month, which captures the extensive margin of presence by subscribers. And second, an alternate measure of whether the modal calling location of a subscriber affiliated with that firm was in that district in that month, reflecting an intensive margin where each subscriber is assigned to only one district in each month. For our independent variable, we first calculate the total number of killings in a district-month and select the top 1% of this distribution (21 or more killings). We create an indicator variable, Major Violent Event, that equals 1 if 21 or more killings took place in that month in that district.[20]

We estimate the relationship between firm presence in a district and recent killings using the following estimating equation:

$$Y_{idt} = \beta \mathbb{1}(MajorViolentEvent)_{dt-1} + \theta_{id} + \delta_t + \sigma_{dm} + \gamma_d * t + \mu_d * t^2 + \epsilon_{idt} \qquad (1)$$

where Y_{idt} is an indicator variable that equals 1 if firm, i, is present in district, d, in month

[20] After dropping districts without complete CDR coverage, we count 80 such events distributed across 38 districts across the country and appearing in 37 of our 45 months of data.

t. $\mathbb{1}(MajorViolentEvent)_{dt-1}$ is the indicator variable for 21 or more killings in district d in month $t-1$, $\theta_{i,d}$ is a set of firm-district fixed effects controling for a firm's average presence in a given district. δ_t are month fixed effects while σ_{dm} are a set of district-calendar month fixed effects that capture seasonal variation in violence and firm activity. $\gamma_d * t$ and $\mu_d * t^2$ are district-specific linear and quadratic time trends. Throughout, we cluster our errors, ϵ_{idt}, at the district-level. Our coefficient of interest is β, which we interpret as the average treatment effect of a major violent event on firm presence. To support a interpretation, the required identifying assumption would be that killings are independent of economic factors after conditioning on θ_{id}, δ_t, σ_{dm}, $\gamma_d * t$ and $\mu_d * t^2$. While violence is not randomly allocated, and the major events we study may be correlated with underlying changes in the local economic and security environment, this specification isolates the discrete change in firm behavior following a major violent event.

Table 2 presents the main results, where Panel A uses the first outcome measure of any subscriber activity and Panel B uses the second measure of modal subscriber activity. In column (1) we show the raw correlation without fixed effects, which is positive but statistically insignificant. This may be because terrorist killings often take place near urban centers with more economic activity. In column (2) we include district-by-firm fixed effects to control for differences that are constant within the pairings of firm and geographic units, and observe a negative correlation. In column (3) we add month fixed effects to control for unobserved time trends like the secular increase in violence across the country and in column (4) we add district-by-calendar month fixed effects to address district-specific seasonality such as fighting or migration patterns. The magnitude of our estimated coefficient in column (4) of Panel A on violence implies that a major violent event is associated with a 20 percent reduction ($p < .05$) in the average likelihood of firm presence in the following month (reported in the "Beta/Mean" row). In columns (5) and (6), we add district linear and quadratic trends to address the concern that violent attacks may be preceded by changing trends in local economic conditions; as expected, the estimated effect attenuates – falling to 4 percent in

column (6) of Panel A – but remains significant at the 1% level. In Panel B of Table 2, the dependent variable is modal firm activity - assigning each subscriber to only one district for each month based on their most frequent calling location - and we find qualitatively similar patterns to those in Panel A, though the relative magnitude of the effect sizes is larger given lower mean outcomes.[21,22]

In Table 3, we show that this relationship can be decomposed into both an increase in exit by firms that were present in that district during the month of the event, and a decrease in entry of firms that were not present. Column (1) of Table 3 repeats the coefficient from column (6) of Table 2. Column (2) introduces a new outcome variable, Firm Entry (=1), which is an indicator variable that equals one if a firm is not present in the previous month and then is present in the current month, where presence is measured at the district-level using our first outcome measure of any subscriber activity. We observe a nearly 8% decrease ($p < .01$) from the average level of firm entry in the month after a Major Violent Event. Column (3) introduces the corresponding outcome variable, Firm Exit (=1), which is an indicator variable that equals one if a firm is present for at least one prior month and then absent for the current month; firm exit increases over 5% ($p < .10$) in the month after a Major Violent Event. Columns (4)-(6) show similar patterns using the modal measure of firm presence, though with larger relative magnitude of effect sizes given the lower base levels: specifically, a 17% decrease in entry ($p < .10$), and a 23% increase in exit ($p < .10$).[23]

Next, we turn our attention to the persistence of these effects. In Figure 4, we plot the coefficients from the following event study specification which includes three leads, one current term, and eight lags of major violent event on firm activity, including the full set of

[21]Both measures of firm presence have strengths: any subscriber activity picks up on short-term visits that may be business related, while the modal subscriber activity focuses on the most frequent location.

[22]In Appendix Table B1, we show these results are robust to restricting the panel to only calls made during the Afghan work week (e.g., 9am-5pm local time, Sunday-Thursday), though the standard errors increase in the modal results in Panel B. In general, we prefer to use the full period of daily calling activity and focus attention on comparing the any activity measures to the modal activity measures for comparison purposes.

[23]Appendix Table B2 shows relative magnitudes can be 2-5 times larger when dropping district-specific linear and quadratic trends.

controls from Equation 1 above.

$$Y_{idt} = \sum_{k=-3}^{8} \beta_k \mathbb{1}(MajorViolentEvent)_{dt-k} + \theta_{id} + \delta_t + \sigma_{dm} + \gamma_d * t + \mu_d * t^2 + \epsilon_{idt} \qquad (2)$$

In column (1) of Appendix Table B3, we report the corresponding coefficients for the event study where the outcome variable is Firm Active (=1). We find inconsistent support for anticipation prior to a major violent event, the first and second leads do not have significant coefficients, though the third period lead term has a negative coefficient that is 3 percent of the mean value ($p < .10$). In the month of the event itself, we estimate a small and statistically insignificant coefficient. And in the first month after a major event, we find a 5 percent decrease from the mean level of firm presence ($p < .01$), which attenuates to 3 percent ($p < .10$) in the second month. The gradual converging trend in lagged coefficients in Figure 4a may suggest persistence in the negative effects of firm activity beyond the second month. Although the point estimates lose their statistical significance after the second lag, their magnitude remains at least one-third as large as the initial response for up to 5 months, which rules out a temporal adjustment in which economic activity returns shortly after an event. The remaining columns in Appendix Table B3 apply the event study specification to Firm Entry and Firm Exit as well as the modal variables from Table 3. Most interestingly, we see evidence of anticipation in Firm Exit in the first and third leads of column (3), as shown in Figure 4c. This implies that firms may perceive proximate changes in the security environment and seek to exit prior to major events. Separately, the results using the modal activity measures in columns (4) - (6) are consistent with the any activity measures, though we have less statistical power due to the lower base rate of firm presence.

Tables 4 and 5 explores heterogeneity in our main effects based on firm size and industry to provide insights into which types of firms are most affected by violence. For size heterogeneity, we divide firms based on their total number of unique subscribers: firms with 1 subscriber ("Single"), firms with 2-9 subscribers ("Small"), and firms with 10 or more

subscribers ("Large"). While 4 is the median number of subscribers per firm in our data, each of the preceding groups composes roughly one-third of the dataset. Table 4 is divided into three panels, corresponding to the three outcome variables of Firm Active, Firm Entry and Firm Exit. In all three panels, we observe that dropping single subscriber firms in column (2) leaves the main results virtually unchanged. As discussed above and demonstrated in Appendix Figure A1, we are concerned that single-subscriber firms do not reflect single-employee firms and thus are not a useful proxy for firm size. Therefore, we restrict attention here to the comparison between small and large firms in columns (4) and (5). In all three panels, we observe that large firms have a larger absolute and relative (to the mean) magnitude and stronger levels of statistical significance than smaller firms. The same pattern holds using modal firm presence in Appendix Tables B4.

For industry heterogeneity, we rely on the operator's classification of firm business type into five categories: construction, trade, manufacturing, transport and other – where the final category reflects insufficient data for classification. The results of Table 5 suggest significant heterogeneity: while construction and transport firms have negative and statistically significant coefficients on Firm Active in Panel A, the decrease in Firm Entry in Panel B is concentrated in transport, and the increase in Firm Exit is weakly observed in construction and manufacturing. Speculatively, construction and tranportation activities may be associated with more mobile forms of physical capital (e.g., trucks and equipment) than other activities like trade or manufacturing. Plausibly, the differential ability to relocate valuable physical assets may affect firm responses to violence. As a caveat, we note that the version of these results using modal subscriber presence in Appendix Table B5 instead emphasizes the role of manufacturing firms.

To explore the mechanisms behind our results, Table 6 summarizes survey data from over 400 firms in our CDR sample demonstrating that larger firms are significantly more likely than smaller firms to report increased levels of exposure and responses to insecurity. For this analysis, we divide our sample into "small" and "large" firms by splitting the sample

at the median number employees in the data (12). In Panel A, we create two composite indexes of the questions listed in Panel B (Insecurity Exposure) and Panel C (Insecurity Response) using a covariance-weighted sum of z-scores of the underlying variables following the technique described in Anderson (2008). We then report for each variable the mean for small firms and the difference in means between large and small firms, where we successively add controls for industry and headquarters province to control for time-invariant unobserved sources of heterogeneity.

In the most demanding specification shown in the final column of Table 6, we observe a large firm is .13 standard deviations ($p < .10$) more likely than a small firm to report experiencing business disruptions from anti-government groups, and in particular 9% more likely ($p < .05$) to report having its assets threatened or destroyed and 14% more likely ($p < .05$) to report having essential public infrastructure destroyed. Similarly, we observe a large firm is .31 standard deviations ($p < .01$) more likely than a small firm to report adapting business practices in response to insecurity, and in particular 19% ($p < .01$) more likely to invest in private security, 18% ($p < .01$) more likely to make protection payments to local powerholders, 11% more likely to change its buyers or suppliers to avoid insecure areas ($p < .05$), 10% ($p < .05$) more likely to relocate its employees from insecure areas, and 5% ($p < .10$) more likely to stop operations permanently. While not causal evidence of the role of firm size, this correspondence between self-reported behavior in the survey data and the patterns in the administrative data from Table 4 suggests large firms are more likely to be exposed and responsive to insecurity than small firms.

4.3 Discussion

We use a novel data source, corporate cell phone account records, to test the hypothesis that firms and employees operating in conflict-affected settings respond to increased local insecurity by decreasing their local presence. Specifically, we find a significant, 4-6% reduction in firm presence in the month immediately following a major violent event in a district.

The effect is composed of both an increase in exit by firms that were present in that district during the month of the event, and a decrease in entry of firms that were not present. The negative impact on firm presence lasts for only one month at conventional significance levels, though there is suggestive evidence of longer term persistence. Finally, we observe considerable heterogeneity in how firms respond to violence, providing some insight into the mechanisms through which insecurity may affect firm decision-making. Most notably, the effect in our sample is concentrated among larger firms, and potentially in firms with more mobile forms of physical capital.

Our findings on size heterogeneity are consistent with existing work suggesting that larger firms are more vulnerable to predation, which also notes the significant distortionary impact this may have on firm productivity and growth (Besley and Mueller, 2017). Theoretically, the direction of size heterogeneity is ambiguous and potentially non-linear, with large firms more able to privatize their own security provision (and thus become resilient to insecurity) and better equipped to adjust their areas of operation, but also more exposed to risks associated with their level of investment and public profile. Nonetheless, this finding does raise significant concerns about the implications of insecurity for competition and private sector development. Unlike public security, private security is excludable and potentially rival, as when a local powerholder offers to provide protection to a limited number of firms based on relational contracts. In such examples, insecurity may raise entry costs in already underdeveloped economies and further impede the replacement of low-productivity firms by potential high-productivity competitors.

5 Conclusion

To our knowledge, ours is the first study to use call detail records of mobile phone subscribers to understand firm behavior in a conflict-affected country, or indeed in any country. From a methodological standpoint, the validation exercises in this study suggest the promise of this

approach - not as a substitute to the crucial work of collecting survey and administrative data on firms, but as a complement, particularly in fragile states where collecting firm-level data may prove challenging. By using CDR, researchers, businesses and policymakers can extend the temporal and spatial fidelity of traditional data sources at low cost. The application of CDR data to examine micro-level responses to the takeover of Kunduz by Taliban insurgents in September-October 2015 also increases our confidence that these data contain information that can expand our understanding of the relationship between conflict and economic activity, as we demonstrate in our district-month panel results.

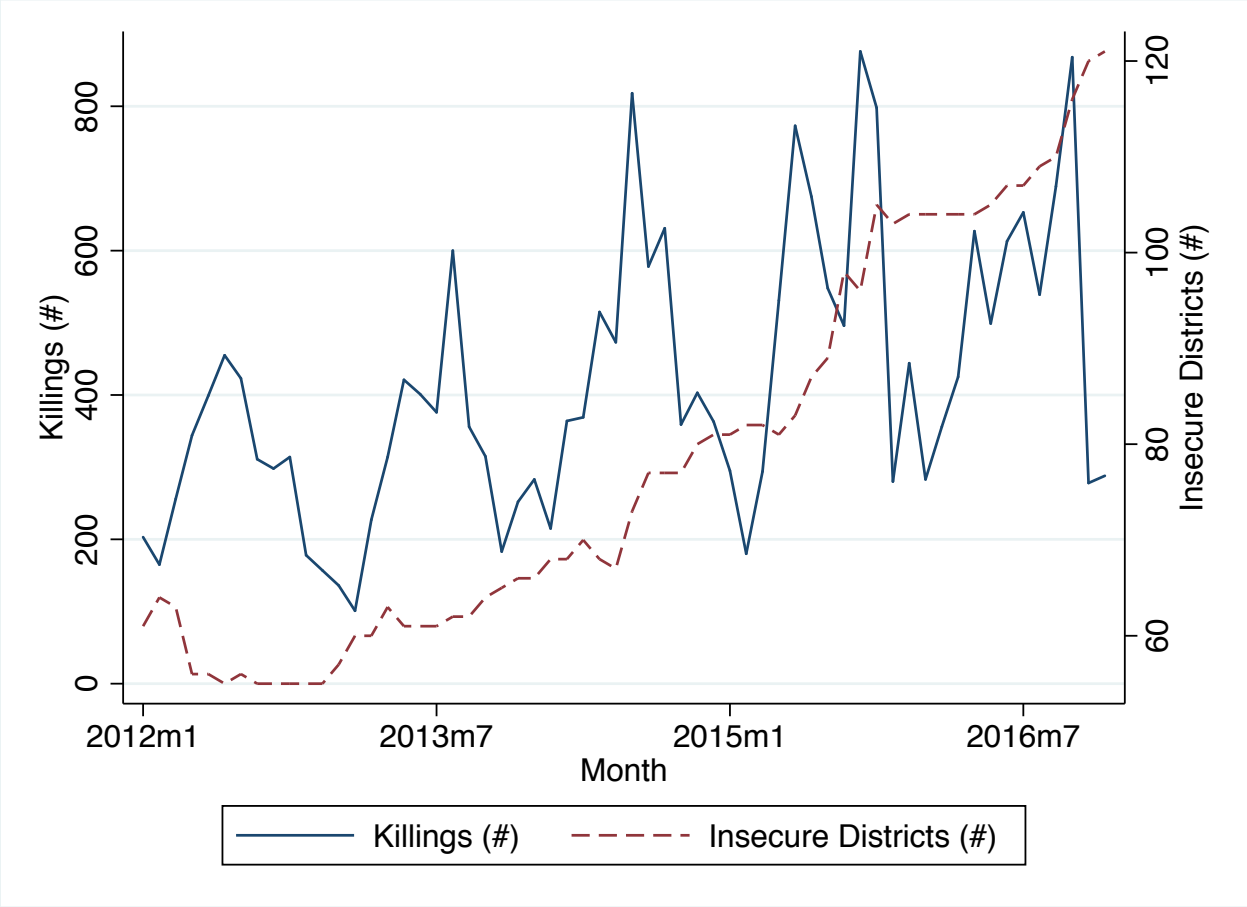
We contrast our findings with those of Besley and Mueller (2012), who estimate the peace dividend using increases in housing prices in Northern Ireland at the end of The Troubles. The internal logic of their setting is a virtuous cycle of decreased killings, leading to increased asset values, which in turn motivates increasing public investment in security. Tragically, like many other conflicts in developing economies, Afghanistan suffers from a vicious cycle in which increases in killings lead to decreases in economic activity, which in turn undermine state capacity to deliver security and public perceptions that the situation will improve. In the case of Kunduz, public perceptions about the long-term ability of the government to protect the city may have been at least as important in explaining firm behavior as realities on the ground. In future work, we plan to more deeply explore the gap between security perceptions and realities, and the corresponding implications for business and public policy in insecure settings like Afghanistan.

Based on our research to date, we note three potential implications for policymakers to consider from this work, all of which deserve further consideration. First, given scarce resources for the provision of security, a potential tradeoff exists between providing security in urban areas where economic activity is concentrated and in rural areas where the insurgency maintains its strongholds. While both objectives are clearly important, most economic activity occurs in cities, so failing to secure the urban cores may have grave consequences for long-term development. Second, the costs of security provision raise costs for firms, with

potential consequences for industrial organization and the size distribution of enterprises. If, for example, the cost of security raises barriers to entry, then this could have competitive effects that influence the long-run trajectory of private sector development and, eventually, economic growth. Third, given the nexus between economic activity and security that we (among others) have established, it is worth examining how donor support to private sector development can be most effective in conflict settings. For example, policy efforts aimed at improving institutions, relieving credit constraints and promoting access to information have featured in many bilateral and multilateral attempts to bolster the local private sector. Our research suggests that these policies must be nested within a context of security provision if they are to have their greatest impact. More generally, academics and policy-makers need to improve their understanding of how and where economic life evolves in the absence of generalized security, and the conditions under which targeted efforts to support the private sector might break a vicious cycle and reinforce the public provision of security.

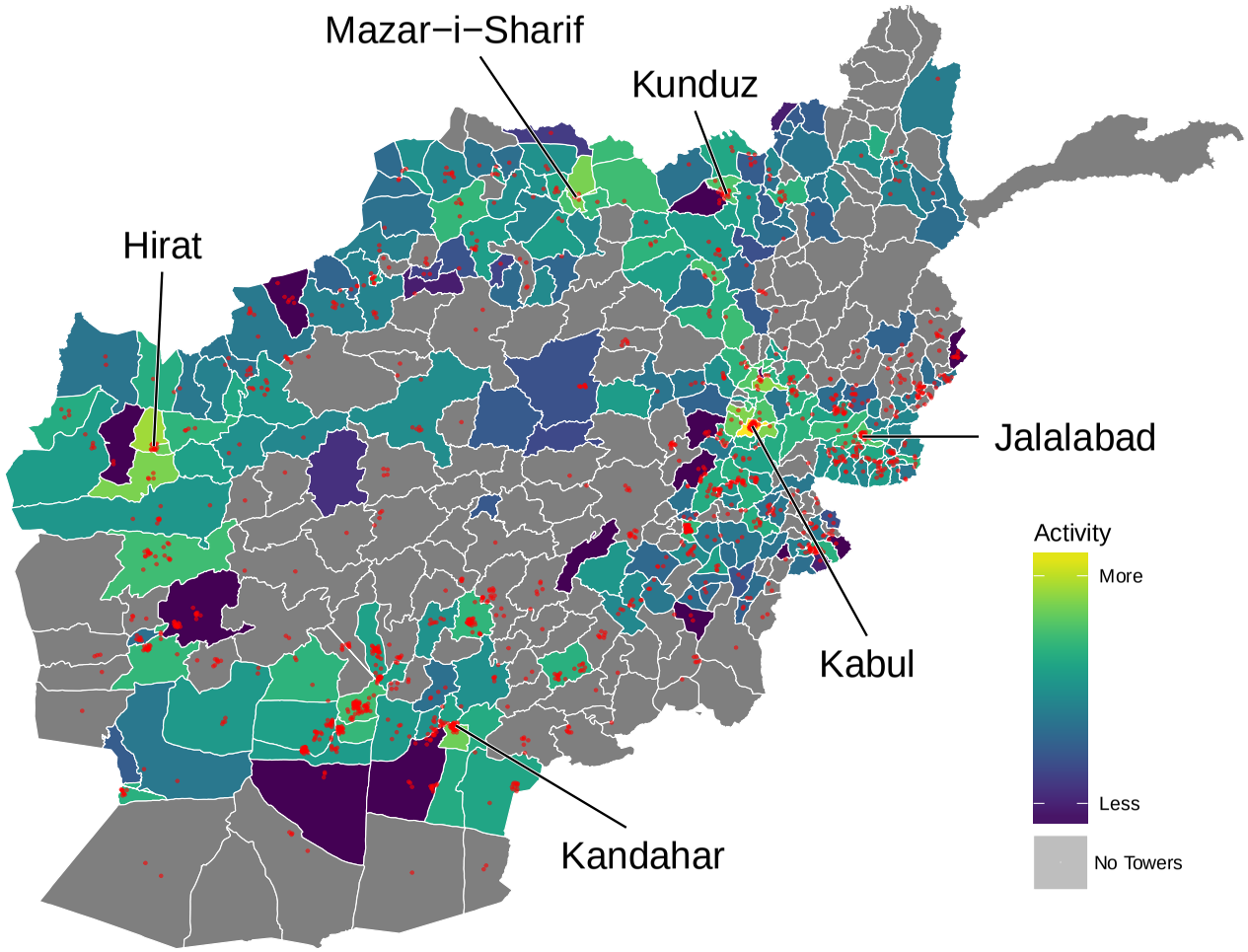
Tables and Figures

Figure 1: Total Killings and Insecure Districts in Afghanistan (2012-2016)



Notes: Killings reflect total confirmed fatalities in Global Terrorism Database (GTD) and Insecure Districts reflect internal security tracking data from a national survey firm. See text for details.

Figure 2: Corporate Line Activity and Killings



Notes: First principal component of the log number of active firms, subscribers and calls per district in corporate line mobile phone records for April 2013. Districts without mobile coverage are shown in grey. Red dots mark locations of conflirmed fatalities recorded in Global Terrorism Database (GTD) for May 2012-April 2013. See text for details.

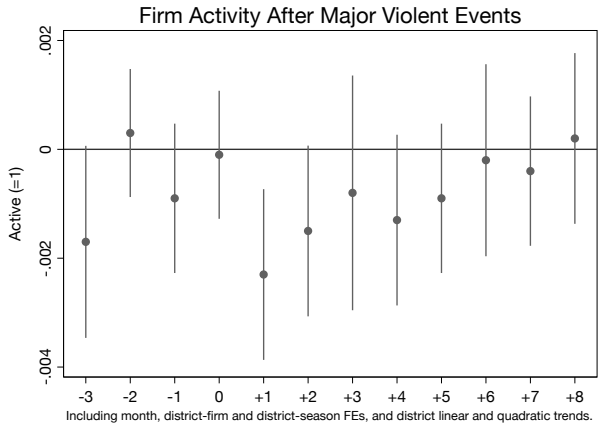
Figure 3: Mobile Phone Activity and the Fall of Kunduz (2015 & 2016)

(a) 2015

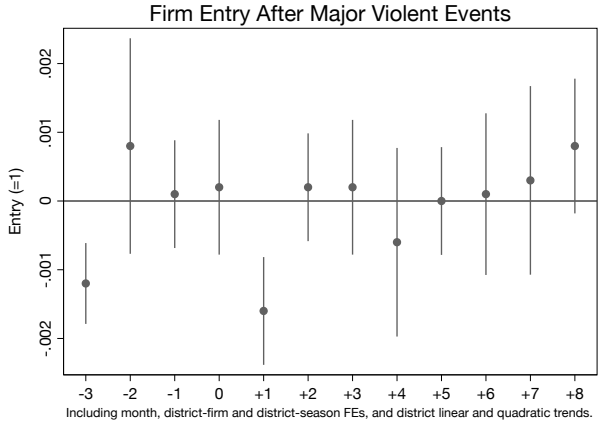
(b) 2016

Notes: Panels show mobile phone calls by firms (dashed lines) and all subscribers (solid lines) in the Kunduz region in 2015 (top panel) and 2016 (bottom panel). Green lines indicate calls from numbers within 10km of the city center; Orange lines indicate calls initiated from between 10km and 70km of the city center. Vertical dashed lines mark the dates of two Taliban attacks on Kunduz city (September 28, 2015 and October 3, 2016).

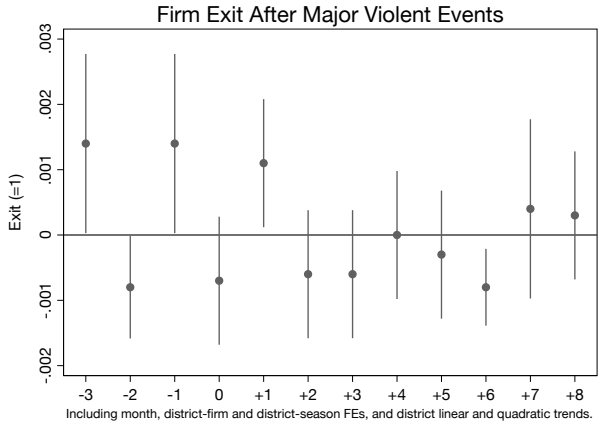
Figure 4: Major Violent Events and Firm Activity: Event Study



(a) Firm Activity



(b) Firm Entry



(c) Firm Exit

Notes: Event study coefficients from regressions of Firm Active (=1) in Panel A, Firm Entry (=1) in Panel B, and Firm Exit (=1) in Panel C on 3 leads, current term, and 8 lags of Major Violent Event (=1) with time fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. 95% confidence intervals shown.

Table 1: Summary Statistics

	N	Mean	SD	Min	Med	Max
Panel A: Firm Level						
Months Active in CDR	2306	33.82	14.80	1	45	45
Districts Active in CDR	2306	33.57	33.24	1	22	172
Total Subscribers	2306	52.26	287.71	1	4	10686
Total Calls	2306	94140	811245	1	12087	36102988
Type: Construction	2306	0.1904	0.39	0	0	1
Type: Manufacturing	2306	0.1331	0.34	0	0	1
Type: Transportation	2306	0.1180	0.32	0	0	1
Type: Trade	2306	0.1123	0.32	0	0	1
Type: Security	2306	0.0152	0.12	0	0	1
Type: Finance	2306	0.0121	0.11	0	0	1
Type: IT	2306	0.0056	0.07	0	0	1
Type: Other	2306	0.4098	0.49	0	0	1
Panel B: District-Month Level						
Total Killed	7785	1.290	5.81	0	0	244
Major Violent Event (=1)	7785	0.010	0.10	0	0	1
District Insecure (=1)	7785	0.077	0.27	0	0	1
Total Firms	7785	101.46	143.10	1	57	1383
Total Subscribers	7785	506.99	1671.57	1	149	21278
Total Calls	7785	27885	179770	1	2906	2636652
Panel C: Firm-District-Month Level						
Firm Active In District (=1)	15818428	0.05	0.22	0	0	1
Subscribers	15818428	0.25	8.03	0	0	5025
Calls	15818428	14	825	0	0	595103

Table 2: Firm Activity After Major Violent Events

Panel A: Any calls made from district	(1)	(2)	(3)	(4)	(5)	(6)
	Firm has employee who is active in district (=1)					
Major Violent Event (1 lag)	0.1306	-0.0100**	-0.0077*	-0.0100**	-0.0024***	-0.0019***
	(0.1059)	(0.0048)	(0.0045)	(0.0050)	(0.0007)	(0.0006)
Mean Outcome	0.0499	0.0499	0.0499	0.0499	0.0499	0.0499
Beta/Mean	2.6151	-0.1994	-0.1547	-0.2009	-0.0479	-0.0376
Observations	15818428	15816179	15816179	15816179	15816179	15816179
Adj R2	0.0031	0.5802	0.5813	0.5817	0.5834	0.5835
Panel B: Employee based in district	Firm has employee whose primary tower is in district (=1)					
Major Violent Event (1 lag)	0.1323	-0.0072	-0.0066	-0.0080	-0.0015**	-0.0011**
	(0.0981)	(0.0045)	(0.0043)	(0.0051)	(0.0006)	(0.0005)
Mean Outcome	0.0171	0.0171	0.0171	0.0171	0.0171	0.0171
Beta/Mean	7.7303	-0.4201	-0.3838	-0.4678	-0.0860	-0.0625
Observations	15818428	15816179	15816179	15816179	15816179	15816179
Adj R2	0.0091	0.6860	0.6861	0.6862	0.6878	0.6878
District-Firm FEs	No	Yes	Yes	Yes	Yes	Yes
Time FEs	No	No	Yes	Yes	Yes	Yes
District-Season FEs	No	No	No	Yes	Yes	Yes
District Lin Trends	No	No	No	No	Yes	Yes
District Quad Trends	No	No	No	No	No	Yes

Notes: Observation is a firm-district-month. Dependent variable in Panel A equals 1 if any call was made by that firm in that district-month, and 0 otherwise. Dependent variable in Panel B equals 1 if the modal calling tower for at least one of the firm's phones was in that district during that month, and 0 otherwise. Major Violent Event equals 1 if previous month in top 1% of killings distribution, and 0 otherwise. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Firm Entry and Exit After Major Violent Events

	(1) Firm Active (=1)	(2) Firm Entry (=1)	(3) Firm Exit (=1)	(4) Modal Active (=1)	(5) Modal Entry (=1)	(6) Modal Exit (=1)
Major Violent Event (1 lag)	-0.0019***	-0.0011***	0.0008*	-0.0011**	-0.0004*	0.0006*
	(0.0006)	(0.0003)	(0.0004)	(0.0005)	(0.0002)	(0.0003)
Mean Outcome	0.0499	0.0143	0.0147	0.0171	0.0025	0.0026
Beta/Mean	-0.0376	-0.0771	0.0538	-0.0625	-0.1666	0.2325
District-Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
District-Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
District Lin Trends	Yes	Yes	Yes	Yes	Yes	Yes
District Quad Trends	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15816179	15417587	15417587	15816179	15417587	15417587
Adj R2	0.5835	0.0914	0.0924	0.6878	0.0685	0.0686

Notes: Observation is a firm-district-month. Firm Entry (Exit) equals 1 if firm is absent (present) for at least 1 prior month and then present (absent) for at least 1 month, where presence is measured by at least one call made by one of the firm's phones from that district in that month. Modal Entry (Exit) is defined analogously, but where presence is measured by the modal calling tower for at least one of the firm's phones being in that district during that month. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Firm Activity, Entry and Exit - Heterogeneity by Firm Size

	(1)	(2)	(3)	(4)	(5)
Panel A	Firm Active in District (=1)				
Major Violent Event (1 lag)	-0.0019***	-0.0019**	-0.0019*	-0.0003	-0.0035**
	(0.0006)	(0.0009)	(0.0011)	(0.0005)	(0.0017)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0499	0.0655	0.0107	0.0226	0.1104
Beta/Mean	-0.0376	-0.0286	-0.1817	-0.0142	-0.0319
Observations	15816179	11324580	4491599	5791694	5532886
Adj R2	0.5835	0.5827	0.5173	0.5183	0.5819
Panel B	Firm Entry into District (=1)				
Major Violent Event (1 lag)	-0.0011***	-0.0012***	-0.0009***	-0.0002	-0.0023***
	(0.0003)	(0.0004)	(0.0003)	(0.0004)	(0.0008)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0143	0.0184	0.0038	0.0081	0.0292
Beta/Mean	-0.0771	-0.0649	-0.2269	-0.0235	-0.0771
Observations	15417587	11034978	4382609	5648623	5386355
Adj R2	0.0914	0.0890	0.0837	0.0856	0.0826
Panel C	Firm Exit from District (=1)				
Major Violent Event (1 lag)	0.0008*	0.0007	0.0011*	-0.0003	0.0017*
	(0.0004)	(0.0005)	(0.0007)	(0.0004)	(0.0009)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0147	0.0190	0.0041	0.0085	0.0299
Beta/Mean	0.0538	0.0347	0.2719	-0.0353	0.0552
Observations	15417587	11034978	4382609	5648623	5386355
Adj R2	0.0924	0.0901	0.0834	0.0862	0.0837

Notes: Observation is a firm-district-month. Firm sample is all firms in column 1, firms with 2 or more subscribers in column 2, single subscriber firms in column 3, firms with 2-9 total subscribers in column 4, and firms with 10 or more total subscribers in column 5. All regressions include month fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Firm Activity, Entry and Exit - Heterogeneity by Firm Industry

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A	Firm Active in District (=1)					
Major Violent Event (1 lag)	-0.0019***	-0.0041***	0.0000	-0.0001	-0.0031*	-0.0016***
	(0.0006)	(0.0014)	(0.0013)	(0.0014)	(0.0017)	(0.0006)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0499	0.0503	0.0441	0.0517	0.0557	0.0492
Beta/Mean	-0.0376	-0.0829	0.0008	-0.0023	-0.0624	-0.0313
Observations	15816179	3088396	1874801	2017872	1915456	6919654
Adj R2	0.5835	0.5553	0.5539	0.5903	0.6042	0.5955
Panel B	Firm Entry into District (=1)					
Major Violent Event (1 lag)	-0.0011***	-0.0012	-0.0001	-0.0010	-0.0029***	-0.0009*
	(0.0003)	(0.0011)	(0.0010)	(0.0007)	(0.0011)	(0.0004)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0143	0.0155	0.0139	0.0148	0.0152	0.0134
Beta/Mean	-0.0771	-0.0828	-0.0062	-0.0682	-0.2042	-0.0613
Observations	15417587	3013660	1829994	1964588	1868573	6740772
Adj R2	0.0914	0.0890	0.0928	0.0922	0.0925	0.0916
Panel C	Firm Exit from District (=1)					
Major Violent Event (1 lag)	0.0008*	0.0013*	0.0004	0.0015*	0.0016	0.0002
	(0.0004)	(0.0008)	(0.0011)	(0.0008)	(0.0011)	(0.0005)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0147	0.0162	0.0147	0.0151	0.0157	0.0137
Beta/Mean	0.0538	0.0904	0.0257	0.0994	0.1116	0.0165
Observations	15417587	3013660	1829994	1964588	1868573	6740772
Adj R2	0.0924	0.0901	0.0945	0.0932	0.0929	0.0925

Notes: Observation is a firm-district-month. All regressions include month fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Exposure and Responses to Insecurity (Survey) - Heterogeneity by Firm Size

Outcome:	Mean for Small Firms	Difference in Means Large - Small Firms		
Panel A: Composite Indices				
Insecurity Exposure Index	0.00	0.22***	0.21***	0.13**
	[0.56]	(0.06)	(0.06)	(0.06)
Insecurity Response Index	0.00	0.36***	0.36***	0.31***
	[0.64]	(0.07)	(0.08)	(0.08)
Panel B: Insecurity Exposure Index Variables:				
Affected by Insecurity (=1)	0.75	0.07*	0.07	0.00
	[0.43]	(0.04)	(0.04)	(0.04)
Employees Threatened/Killed (=1)	0.20	0.09**	0.08*	0.06
	[0.40]	(0.04)	(0.05)	(0.05)
Assets Threatened/Destroyed (=1)	0.19	0.12***	0.12**	0.09**
	[0.39]	(0.04)	(0.05)	(0.05)
Infrastructure Destroyed (=1)	0.46	0.22***	0.19***	0.14**
	[0.50]	(0.05)	(0.05)	(0.05)
Experienced Fall in Demand (=1)	0.34	0.01	0.04	0.03
	[0.47]	(0.05)	(0.05)	(0.05)
Panel C: Insecurity Response Index Variables:				
Invest in Private Security (=1)	0.33	0.24***	0.23***	0.19***
	[0.47]	(0.05)	(0.05)	(0.05)
Make Protection Payments (=1)	0.21	0.23***	0.22***	0.18***
	[0.41]	(0.04)	(0.05)	(0.05)
Change Buyers or Suppliers (=1)	0.19	0.11**	0.12**	0.11**
	[0.40]	(0.04)	(0.04)	(0.04)
Relocate Employees (=1)	0.24	0.12**	0.12**	0.10**
	[0.43]	(0.04)	(0.05)	(0.05)
Stop Operations Permanently (=1)	0.06	0.05*	0.05*	0.05*
	[0.23]	(0.03)	(0.03)	(0.03)
Industry FE		NO	YES	YES
HQ Province FE		NO	NO	YES

Notes: Each cell is a separate regression. Small firms have below median number of employees (1-11) and large firms have above median number of employees (12+). Indices are created as the covariance-weighted sum of z-scores of the underlying variables, following the technique described in Anderson (2008). Standard deviations in brackets and robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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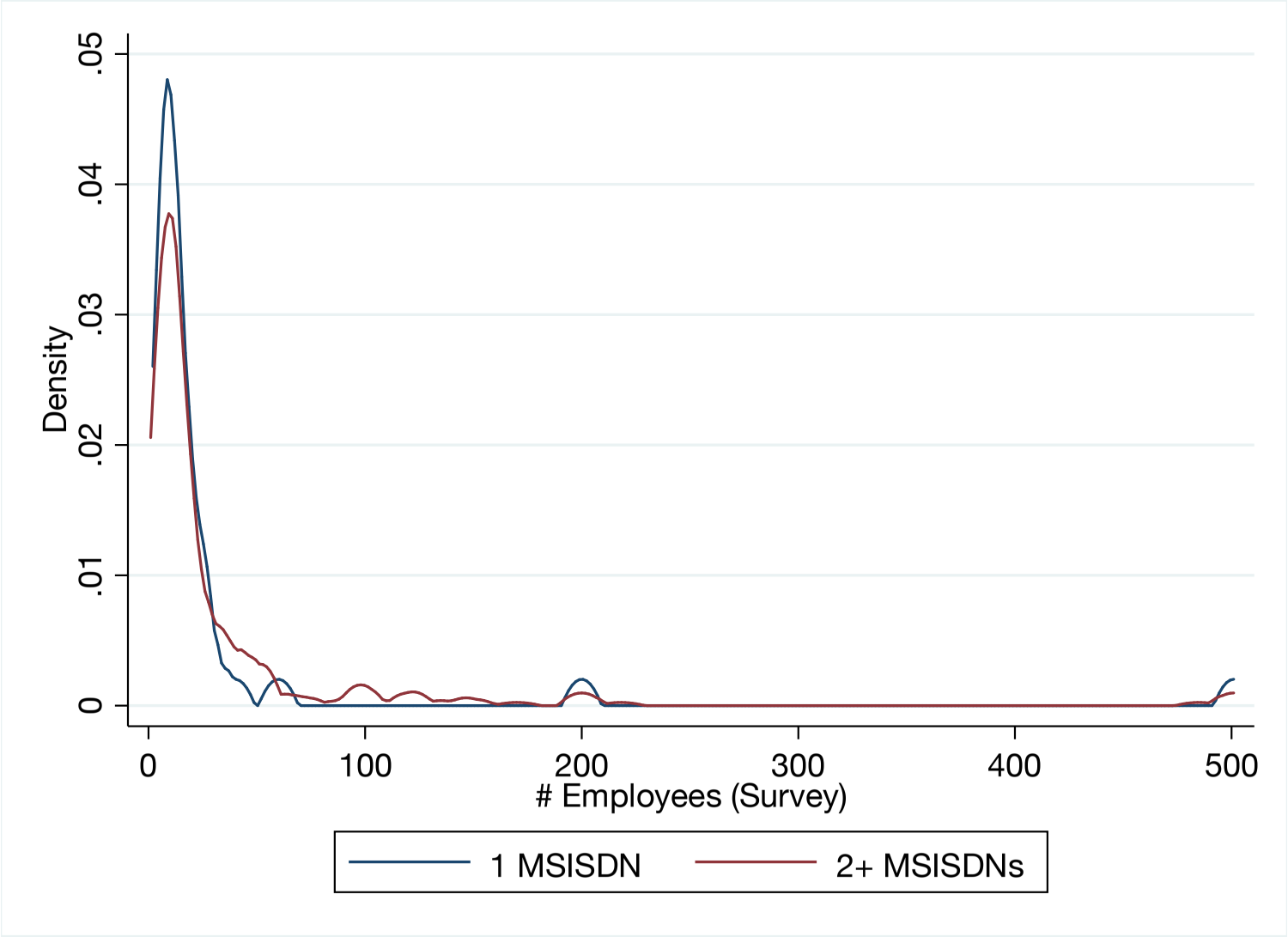
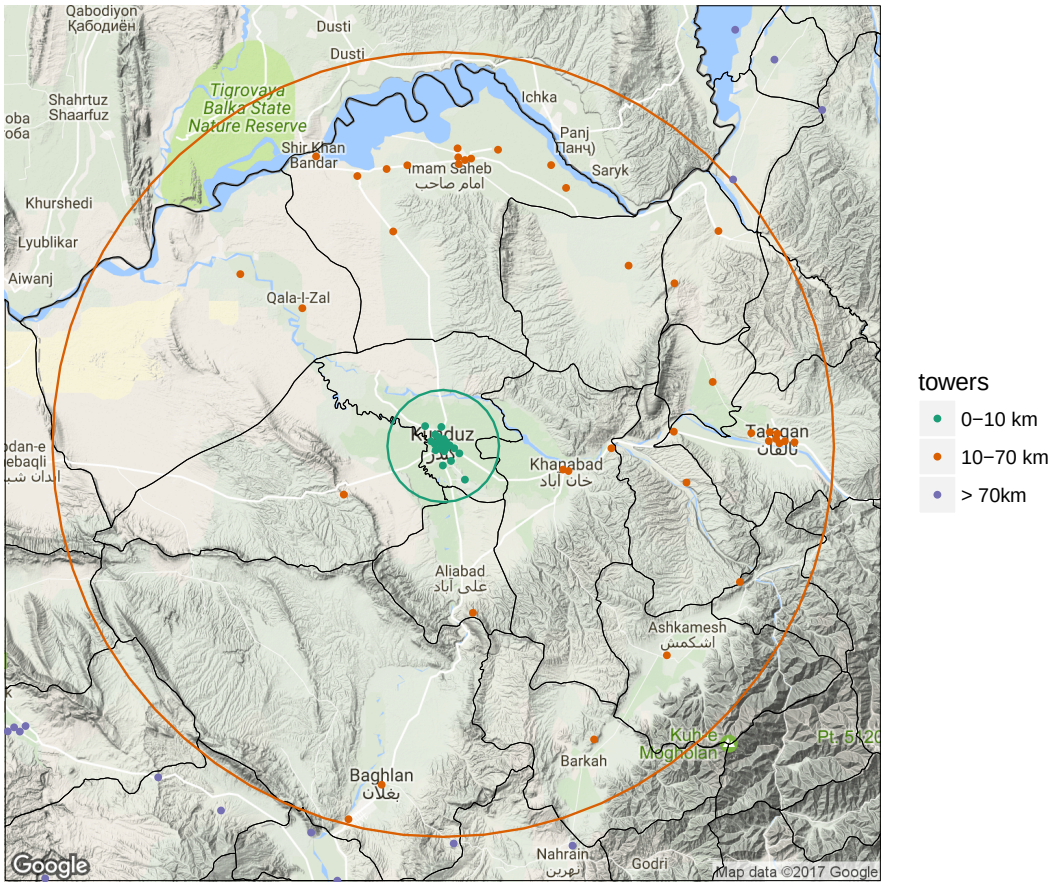
Figure A1: Employee Size Distributions by Total Number of MSISDNs



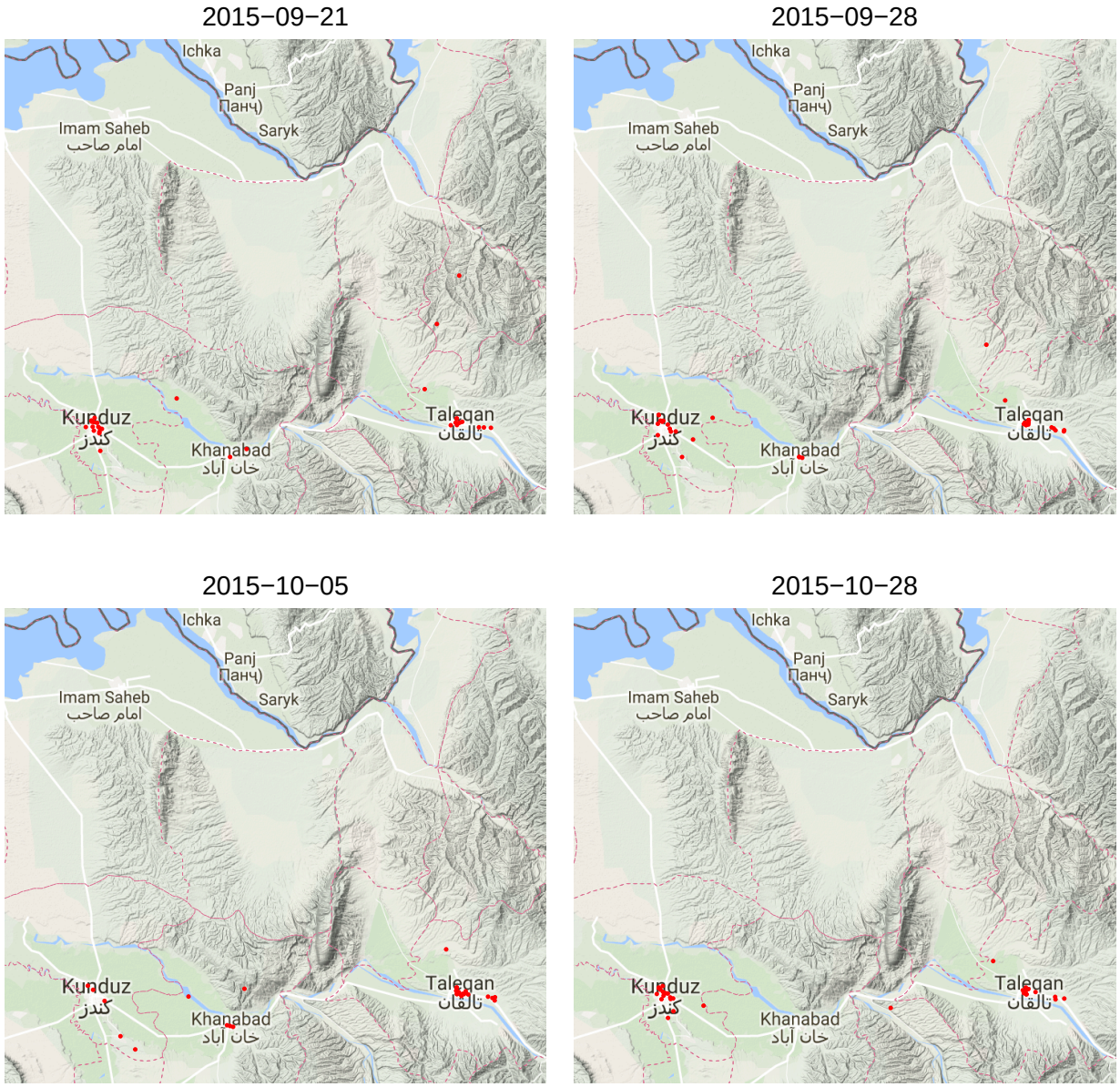
Notes: Employee data from original survey sample (n=327). Windsorizing number of employees at 1%.

Figure A2: Mobile Tower Locations near Kunduz



Notes: Inner circle marks 10 km radius from Kunduz city center, and outer circle marks 70km radius from Kunduz city center. See text for details.

Figure A3: Daily Locations of Corporate Lines Subscribers - Kunduz 2015



Notes: Red dots represent daily locations of corporate line subscribers near Kunduz in 2015 calculated using CDR calling towers. Top left figure shows September 21, 2015, one week prior to the attack on the city. Top right figure shows September 28, 2015, the day of the attack. Bottom left figure shows October 5, 2015, one week after the attack and before it was cleared of insurgents. Bottom right figure shows October 28, 2015, one month after the attack on the city and after it had been cleared of insurgents. See text for details.

Figure A4: Placebo Tests: Calling Activity near Kandahar and Lashkar Gah (2015)

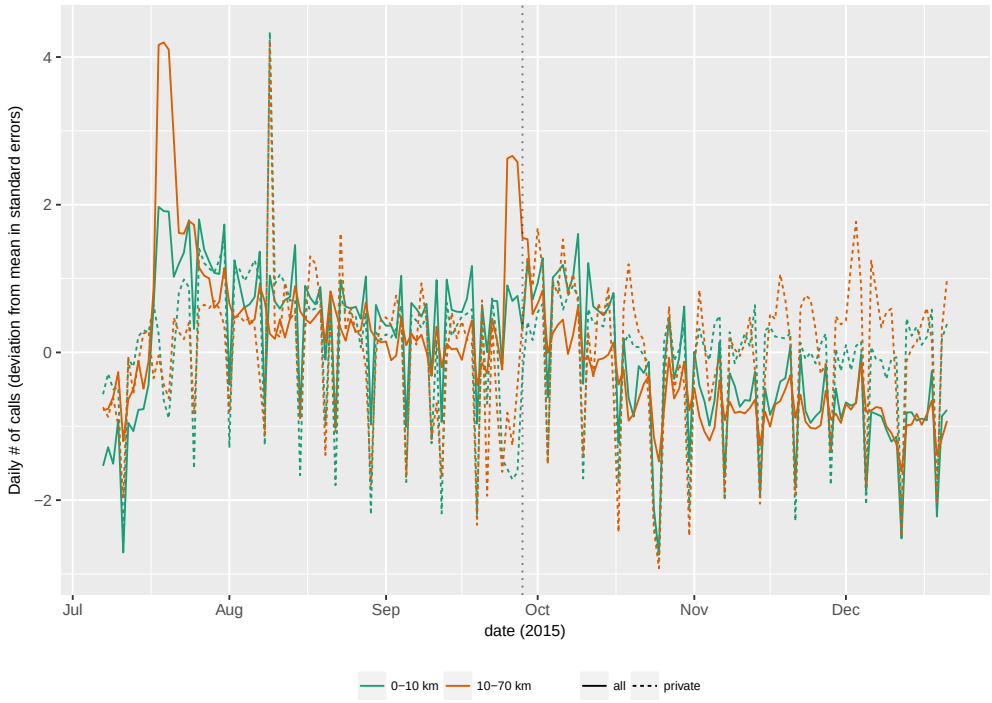
(a) Kandahar - 2015

(b) Lashkar Gah - 2015

Notes: Dashed black line in both panels marks date of September 28, 2015 attack in Kunduz city.

Figure A5: Placebo Tests: Calling Activity near Hirat and Mazar (2015)

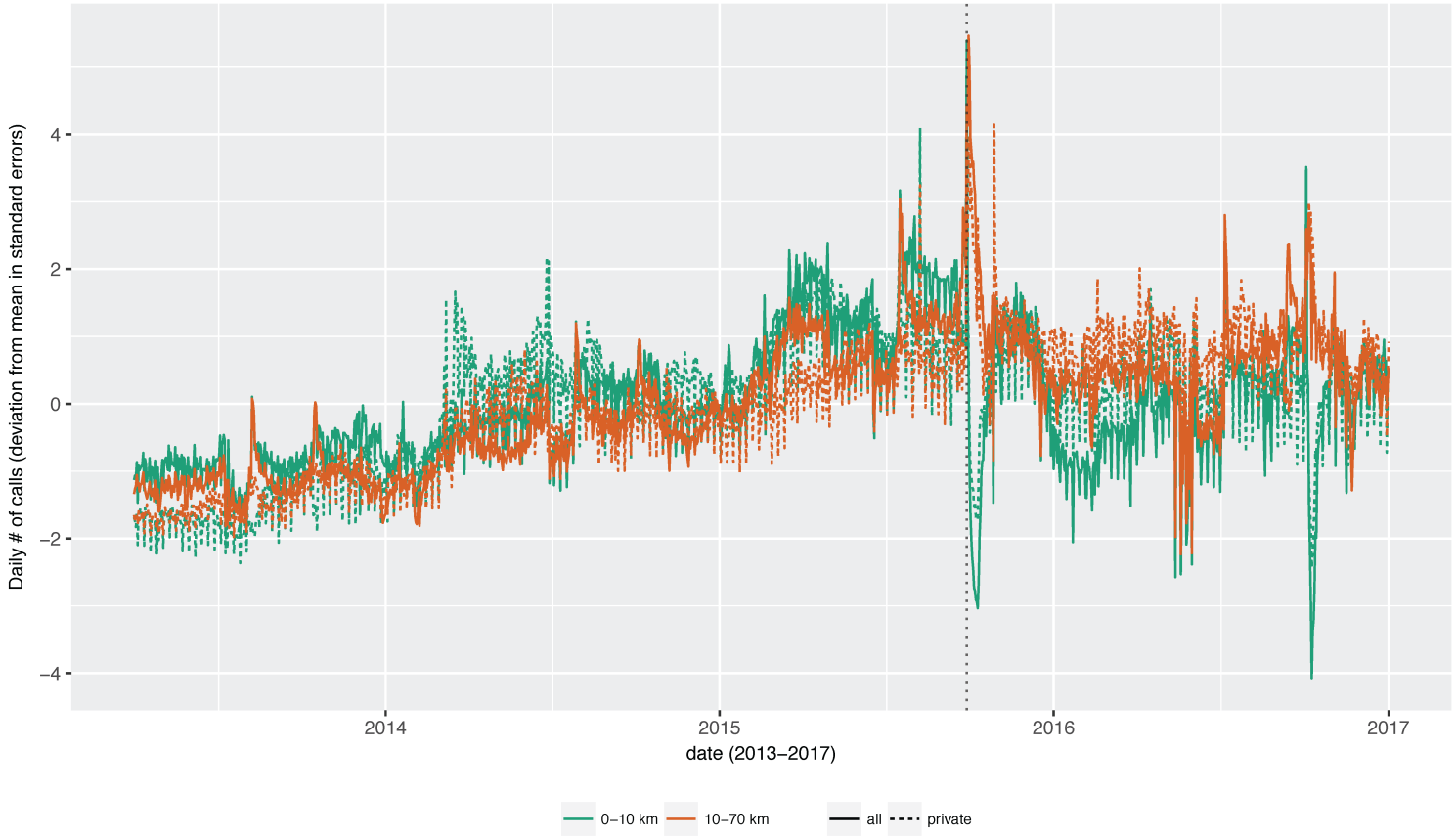
(a) Hirat - 2015



(b) Mazar - 2015

Notes: Dashed black line in both panels marks date of September 28, 2015 attack in Kunduz city.

Figure A6: Calling Activity Inside and Outside of Kunduz (2013-2016)



Notes: Dashed black line in both panels marks date of September 28, 2015 attack in Kunduz city.

Table A1: Survey Instrument Representativeness Table

	Enterprise Survey (Survey Vars)	CDR Sample (CDR Vars)	CDR Surveyed Sample (CDR Vars)	Survey Sample (Survey Vars)
Num Employees At Present	21.375	52.261	54.788	33.970
Sector Trade (=1)	0.397	0.112	0.103	0.073
Sector Manufacturing (=1)	0.355	0.133	0.379	0.271
Sector Construction (=1)	0.104	0.190	0.185	0.268
Sector Transport (=1)	0.144	0.118	0.106	0.148
Sector Security (=1)	0.000	0.015	0.012	0.010
Sector Finance (=1)	N/A	0.012	0.017	0.033
Sector Information Technology (=1)	N/A	0.006	0.010	N/A
Sector Other (=1)	0.000	0.410	0.187	0.178
HQ in Kabul (=1)	0.404	0.614	0.599	0.700
HQ in Hirat (=1)	0.192	0.167	0.202	0.200
HQ in Balkh (=1)	0.137	0.082	0.108	0.079
HQ in Nangahar (=1)	0.146	0.034	0.027	0.020
HQ in Kandahar (=1)	0.122	0.023	0.010	0.000
HQ in Kunduz (=1)	N/A	0.020	0.015	0.002
N	416	2306	406	406

Notes: Mean values reported for each variable. Enterprise survey means reweighted to reflect nationally representative population. Columns 2 and 3 utilize CDR variables. CDR "Num Employees At Present" calculated based on total MSISDNS for each firm in 2016. CDR sector code was calculated based on a category provided by the phone company, matched to the corresponding two-digit ISIC code (Rev. 4). CDR headquarters are calculated using the firm's first modal district as a proxy. CDR Surveyed refers to the firms in CDR who were surveyed. Columns 1 and 4 utilize survey variables. 'Sectors' and 'Number of Employees at Present' are self-reported, as provided by each survey. World Bank (Enterprise) sector code was calculated based on the four-digit ISIC code (Rev. 3) reported for the primary good or service produced by each firm. Survey headquarters are self-reported, as provided by each survey.

Table A2: Location Validation

Panel A: Headquarters				
	Observations	% HQ Match Top 1 Modal	% HQ Match Top 5 Modal	% HQ Match Top 10 Modal
AISA	110	82.73	92.73	92.73
CBR	934	73.34	83.30	83.94
Survey	406	79.80	88.18	88.67
All Combined	1119	74.71	84.81	85.43
Panel B: All Offices				
	Observations	Num of Offices	% Offices Match Top 5 Modal	% Offices Match Top 10 Modal
Survey 2017 Response	406	2.71	62.41	64.18
Survey 2014 Response	395	2.39	64.87	66.35
Survey All	801	2.55	61.88	63.65

Notes: Observation is a firm in Panel A and a firm-year in Panel B.

Table A3: Employee Size Validation

	Number of Employees				Number of Employees			
Panel A: Levels								
Subscribers	0.789**	0.569**	0.315**	0.104	0.793**	0.631***	0.346**	0.056
	(0.346)	(0.231)	(0.159)	(0.182)	(0.350)	(0.224)	(0.156)	(0.160)
Trim	No Trim				Drop Single Subscriber Firms			
Sample	2014 IBES	2016 Survey	All Survey	All Survey	2014 IBES	2016 Survey	All Survey	All Survey
Mean Y	41.79	40.10	33.72	33.72	45.31	34.02	30.56	30.56
# Obs	190	312	580	580	157	273	500	500
Year FE	-	-	NO	YES	-	-	NO	YES
Orgid FE	-	-	NO	YES	-	-	NO	YES
R2	0.2650	0.0351	0.0212	0.7253	0.2711	0.1983	0.0924	0.8209
	Log Employees				Log Employees			
Panel B: Logs								
Log Subscribers	0.220***	0.231***	0.169***	0.071	0.239***	0.274***	0.188***	0.069
	(0.068)	(0.047)	(0.040)	(0.100)	(0.077)	(0.049)	(0.044)	(0.100)
Trim	No Trim				Drop Single Subscriber Firms			
Sample	2014 IBES	2016 Survey	All Survey	All Survey	2014 IBES	2016 Survey	All Survey	All Survey
Mean Y	2.63	2.68	2.57	2.57	2.68	2.69	2.60	2.60
# Obs	190	312	580	580	157	273	500	500
Year FE	-	-	NO	YES	-	-	NO	YES
Orgid FE	-	-	NO	YES	-	-	NO	YES
R2	0.0713	0.0975	0.0538	0.8675	0.0766	0.1295	0.0611	0.8594

Notes: "Number Employees" is self-reported survey data from the Integrated Business Enterprise Survey (IBES) in early 2014 and in our original survey data from early 2017, where in the latter source measured both current employees and employees from three years prior. "2017 Survey" sample only includes response to current employees question, while "All Survey" sample includes responses to both current employees and employees from three years prior. Total Subscribers is the count of unique MSISDNs per firm in the CDR data and is calculated from January - March 2014 for the IBES regressions in column (1) and (5), from October-December 2016 for the 2017 Survey regressions in column (2) and (6), and from October-December 2013 and October-December 2016 in columns (3), (4), (7), (8). The top 1% of Total Subscribers values are winsorized in all columns, and all single subscriber firms are dropped in columns (5)-(8). *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Aggregate Economic Activity Validation - Taxes

	Tax Revenues (z-score)		
	(1)	(2)	(3)
Total Calls (z-score)	0.85***	0.85***	0.70*
	(0.10)	(0.10)	(0.39)
Constant	-0.00	-0.15*	-0.15***
	(0.07)	(0.08)	(0.05)
# Provinces	34	34	34
# Observations	578	578	578
R-Squared	0.730	0.747	0.894
Year-Month FE	NO	YES	YES
Province FE	NO	NO	YES

Notes: Standard errors clustered at province level. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Aggregate Economic Activity Validation - Nightlights

	Average Nightlights (z-score)			Total Nightlights (z-score)		
	(1)	(2)	(3)	(4)	(5)	(6)
Total Calls (z-score)	0.57***	0.57***	0.28***	0.61***	0.61***	0.35***
	(0.02)	(0.02)	(0.11)	(0.08)	(0.08)	(0.09)
Constant	-0.00	0.09	0.08***	0.00	0.09	0.08**
	(0.05)	(0.07)	(0.03)	(0.05)	(0.08)	(0.04)
# Districts	173	173	173	173	173	173
# Observations	7785	7785	7785	7785	7785	7785
R-Squared	0.322	0.391	0.817	0.374	0.385	0.888
Year-Month FE	NO	YES	YES	NO	YES	YES
District FE	NO	NO	YES	NO	NO	YES

Notes: See paper text for details. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table B1: Firm Activity After Major Violent Events (Work Week Panel)

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Any calls made from district	Firm has employee who is active in district (=1)					
Major Violent Event (1 lag)	0.1326	-0.0093*	-0.0074	-0.0098*	-0.0023***	-0.0019***
	(0.1040)	(0.0049)	(0.0046)	(0.0053)	(0.0007)	(0.0006)
Mean Outcome	0.0388	0.0388	0.0388	0.0388	0.0388	0.0388
Beta/Mean	3.4169	-0.2389	-0.1914	-0.2513	-0.0582	-0.0480
Observations	15722932	15721029	15721029	15721029	15721029	15721029
Adj R2	0.0041	0.5722	0.5729	0.5731	0.5747	0.5747
Panel B: Employee based in district	Firm has employee whose primary tower is in district (=1)					
Major Violent Event (1 lag)	0.1313	-0.0070	-0.0063	-0.0079	-0.0013	-0.0008
	(0.0970)	(0.0047)	(0.0045)	(0.0053)	(0.0008)	(0.0007)
Mean Outcome	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165
Beta/Mean	7.9754	-0.4229	-0.3854	-0.4777	-0.0773	-0.0486
Observations	15722932	15721029	15721029	15721029	15721029	15721029
Adj R2	0.0093	0.6746	0.6748	0.6749	0.6766	0.6766
District-Firm FEs	No	Yes	Yes	Yes	Yes	Yes
Time FEs	No	No	Yes	Yes	Yes	Yes
District-Season FEs	No	No	No	Yes	Yes	Yes
District Lin Trends	No	No	No	No	Yes	Yes
District Quad Trends	No	No	No	No	No	Yes

Notes: Observation is a firm-district-month, and panel is constructed using only calls made from 9am-5pm local time on Sunday-Thursday (the Afghan work week). Dependent variable in Panel A equals 1 if any call was made by that firm in that district-month, and 0 otherwise. Dependent variable in Panel B equals 1 if the modal calling tower for at least one of the firm's phones was in that district during that month, and 0 otherwise. Major Violent Event equals 1 if previous month in top 1% of killings distribution, and 0 otherwise. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table B2: Firm Entry and Exit After Major Violent Events (Without District Trends)

	(1) Firm Active (=1)	(2) Firm Entry (=1)	(3) Firm Exit (=1)	(4) Modal Active (=1)	(5) Modal Entry (=1)	(6) Modal Exit (=1)
Major Violent Event (1 lag)	-0.0100**	-0.0016***	0.0001	-0.0080	-0.0007**	0.0003
	(0.0050)	(0.0005)	(0.0005)	(0.0051)	(0.0003)	(0.0002)
Mean Outcome	0.0499	0.0143	0.0147	0.0171	0.0025	0.0026
Beta/Mean	-0.2009	-0.1150	0.0046	-0.4678	-0.2662	0.1149
District-Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
District Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
District Lin Trends	No	No	No	No	No	No
Dist Quad Trends	No	No	No	No	No	No
Observations	15816179	15417587	15417587	15816179	15417587	15417587
Adj R2	0.5817	0.0910	0.0920	0.6862	0.0685	0.0685

Notes: Observation is a firm-district-month. Firm Entry (Exit) equals 1 if firm is absent (present) for at least 1 prior month and then present (absent) for at least 1 month, where presence is measured by at least one call made by one of the firm's phones from that district in that month. Modal Entry (Exit) is defined analogously, but where presence is measured by the modal calling tower for at least one of the firm's phones being in that district during that month. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table B3: Firm Activity, Entry and Exit After Major Violent Events - Leads and Lags

	(1) Firm Active (=1)	(2) Firm Entry (=1)	(3) Firm Exit (=1)	(4) Modal Active (=1)	(5) Modal Entry (=1)	(6) Modal Exit (=1)
Lead 3	-0.0017*	-0.0012***	0.0014**	-0.0017	-0.0006**	0.0009*
	(0.0009)	(0.0003)	(0.0007)	(0.0011)	(0.0003)	(0.0005)
Lead 2	0.0003	0.0008	-0.0008**	-0.0009	0.0003	-0.0004*
	(0.0006)	(0.0008)	(0.0004)	(0.0006)	(0.0004)	(0.0002)
Lead 1	-0.0009	0.0001	0.0014**	-0.0009	0.0000	0.0003
	(0.0007)	(0.0004)	(0.0007)	(0.0007)	(0.0001)	(0.0003)
Current	-0.0001	0.0002	-0.0007	-0.0004	0.0003	-0.0005
	(0.0006)	(0.0005)	(0.0005)	(0.0003)	(0.0004)	(0.0003)
Lag 1	-0.0023***	-0.0016***	0.0011**	-0.0014*	-0.0004	0.0006*
	(0.0008)	(0.0004)	(0.0005)	(0.0008)	(0.0003)	(0.0003)
Lag 2	-0.0015*	0.0002	-0.0006	-0.0015	-0.0001	-0.0002
	(0.0008)	(0.0004)	(0.0005)	(0.0012)	(0.0003)	(0.0004)
Lag 3	-0.0008	0.0002	-0.0006	-0.0013	0.0002	-0.0001
	(0.0011)	(0.0005)	(0.0005)	(0.0010)	(0.0007)	(0.0004)
Lag 4	-0.0013	-0.0006	-0.0000	-0.0012*	0.0000	0.0001
	(0.0008)	(0.0007)	(0.0005)	(0.0007)	(0.0005)	(0.0002)
Lag 5	-0.0009	0.0000	-0.0003	-0.0010**	-0.0001	-0.0006
	(0.0007)	(0.0004)	(0.0005)	(0.0004)	(0.0003)	(0.0005)
Lag 6	-0.0002	0.0001	-0.0008**	-0.0001	0.0001	-0.0009***
	(0.0009)	(0.0006)	(0.0003)	(0.0005)	(0.0004)	(0.0002)
Lag 7	-0.0004	0.0003	0.0004	-0.0009	-0.0006**	0.0002
	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0003)	(0.0007)
Lag 8	0.0002	0.0008	0.0003	-0.0004	0.0002	-0.0002
	(0.0008)	(0.0005)	(0.0005)	(0.0004)	(0.0003)	(0.0003)
Mean Outcome	0.0508	0.0146	0.0150	0.0174	0.0025	0.0026
Observations	14627150	14232364	14232364	14627150	14232364	14232364
Adj R2	0.5865	0.0924	0.0927	0.6927	0.0694	0.0697

Notes: Observation is a firm-district-month. All regressions include time fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table B4: Firm Activity, Entry and Exit - Heterogeneity by Firm Size (Modal Version)

	(1)	(2)	(3)	(4)	(5)
Panel A	Modal Active in District (=1)				
Major Violent Event (1 lag)	-0.0011**	-0.0012**	-0.0007	-0.0005	-0.0020**
	(0.0005)	(0.0006)	(0.0006)	(0.0006)	(0.0010)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0171	0.0225	0.0036	0.0068	0.0389
Beta/Mean	-0.0625	-0.0539	-0.2061	-0.0709	-0.0511
Observations	15816179	11324580	4491599	5791694	5532886
Adj R2	0.6878	0.6827	0.7475	0.7645	0.6631
Panel B	Modal Entry into District (=1)				
Major Violent Event (1 lag)	-0.0004*	-0.0004	-0.0004	0.0002	-0.0011*
	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0006)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0025	0.0033	0.0004	0.0008	0.0060
Beta/Mean	-0.1666	-0.1250	-1.0489	0.3194	-0.1850
Observations	15417587	11034978	4382609	5648623	5386355
Adj R2	0.0685	0.0670	0.0815	0.0743	0.0634
Panel C	Modal Exit from District (=1)				
Major Violent Event (1 lag)	0.0006*	0.0006	0.0007**	0.0005	0.0006
	(0.0003)	(0.0004)	(0.0003)	(0.0003)	(0.0006)
Firm Size Sample	All	No Single	Single	Small	Large
Mean Outcome	0.0026	0.0034	0.0005	0.0008	0.0061
Beta/Mean	0.2325	0.1634	1.4257	0.5748	0.1028
Observations	15417587	11034978	4382609	5648623	5386355
Adj R2	0.0686	0.0671	0.0807	0.0726	0.0636

Notes: Observation is a firm-district-month. Firm sample is all firms in column 1, firms with 2 or more subscribers in column 2, single subscriber firms in column 3, firms with 2-9 total subscribers in column 4, and firms with 10 or more total subscribers in column 5. All regressions include month fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

Table B5: Firm Activity, Entry and Exit - Heterogeneity by Firm Industry (Modal Version)

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A	Modal Active in District (=1)					
Major Violent Event (1 lag)	-0.0011**	-0.0014	0.0002	-0.0023***	-0.0003	-0.0011**
	(0.0005)	(0.0011)	(0.0009)	(0.0006)	(0.0007)	(0.0004)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0171	0.0159	0.0129	0.0166	0.0183	0.0186
Beta/Mean	-0.0625	-0.0835	0.0132	-0.1317	-0.0191	-0.0655
Observations	15816179	3088396	1874801	2017872	1915456	6919654
Adj R2	0.6878	0.6672	0.7062	0.6919	0.6832	0.6927
Panel B	Modal Entry into District (=1)					
Major Violent Event (1 lag)	-0.0004*	0.0006	0.0003	-0.0010**	-0.0003	-0.0009***
	(0.0002)	(0.0004)	(0.0006)	(0.0005)	(0.0005)	(0.0003)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0025	0.0025	0.0017	0.0024	0.0028	0.0026
Beta/Mean	-0.1666	0.2485	0.1377	-0.3958	-0.1331	-0.3758
Observations	15417587	3013660	1829994	1964588	1868573	6740772
Adj R2	0.0685	0.0663	0.0688	0.0669	0.0721	0.0687
Panel C	Modal Exit from District (=1)					
Major Violent Event (1 lag)	0.0006*	0.0008	-0.0007	0.0012	0.0005	0.0007**
	(0.0003)	(0.0007)	(0.0006)	(0.0008)	(0.0015)	(0.0003)
Firm Industry Sample	All	Construction	Trade	Manufacturing	Transport	Other
Mean Outcome	0.0026	0.0027	0.0019	0.0024	0.0029	0.0027
Beta/Mean	0.2325	0.3225	-0.2521	0.4737	0.2014	0.2618
Observations	15417587	3013660	1829994	1964588	1868573	6740772
Adj R2	0.0686	0.0667	0.0689	0.0657	0.0704	0.0696

Notes: Observation is a firm-district-month. All regressions include month fixed effects, district-firm fixed effects, district-season fixed effects, and district linear and quadratic trends. Standard errors clustered at district level. *** p<0.01, ** p<0.05, * p<0.1.

A1 CDR Data Appendix

Our study relies on data from one of Afghanistan's largest private telecommunications operators. The original data contain three different types of information that are used in our empirical analysis. These data do not contain the contents of phone calls and text messages, but rather the metadata about calls and text messages – i.e., information regarding the parties involved in the communication, as well as the timing and location of the communication. As this data is sensitive and confidential, all personally identifying information was removed prior to our analysis. All research was reviewed and approved by the internal review boards at our respective institutions.

A1.1 Three Different Data Sources

Call Detail Records The central data source is *call detail records* (CDRs). These are datasets, originating from the operator's communication logs, that provide basic information about each single call (and text message) in the network. The most important features in the CDRs are: date and time of the calls, caller's unique id, receiver's id, and id of the network antenna where the call was initiated. Approximately 250 million calls and a similar amount of text messages are conducted in the network each month. As we do not observe the antenna id for messages, most of our analysis is solely based on call information.

CDRs allow us the deduce the location of every single cellphone over time, given it is used frequently. It also allows to construct callgraphs, networks of callers and receivers, and in this way analyze the location where the phones of interest are called from. We observe CDRs for 45 months, from April 2013 till December 2016, containing about 2TB of data.

Antenna Locations The second and complementary source of information, is the spatial location of network antennas. Typically several antennas are grouped into one location (such as cellphone tower) and we only use the tower location in this study. There are 1350 towers with known location, these are located in 267 of Afghanistan 398 districts covering all the

cities and most of the rest of more densely populated areas.

Corporate Subscribers The final related dataset is the list of corporate phones. For each month the provider lists which phone id's are registered as business phones, and provides basic information on the firm. From this list, we exclude public and non-profit organizations, such as health, education or media groups, and in case an organization possesses multiple accounts, we merge these into a single one. We refer to these private sector numbers as "corporate subscribers".

As phone numbers occasionally move between different accounts, we disregard numbers that are assigned to multiple business accounts, do not have valid account id, or have other irregularities (this amounts to approximately 0.5% of the business phones). Over the observation period, slightly less than 200,000 phones belong to private organizations out of approximately 10 million distinct numbers in the data. This information allows us to distinguish between general call activity and business-related activity. It also permits to assess the size of the firms (in terms of corporate phones), and their geographic and temporal activity patterns. We further categorize the firms into industry-related "segments" based on the operator's internal categorization. The segments are construction (con), finance (fin), IT and telecommunication (it), manufacturing and trade (trade), security (sec), transportation (trans), and "other". Note that we cannot use the standard ISIC codes because the operator's internal classification is based on a different categorization.

A1.2 Data Processing

A1.2.1 Constructing Panel Data

Our central empirical approach relies on monthly panel data on firm activity by Afghanistan districts, and on similar panels defined on quarters, weeks, and provinces. We count all calls and distinct active subscribers by each firm in each spatio-temporal cell. Based on whether the firm was active in the given cell, we also define it's binary "activity" in the cell.

As expected, activity distributions by firms show a prominent right tail while the activity is rougly constant in time. The median value of firm size (subscribers it posesses) is 4, while it's mean is 52.26 and the maximum value is 10686.

For district-based approach, we further aggregate the firm level data on districts, separately counting for call activity for different activity segments and firm size classes. This forms our base data to describe firm activity. Again, the distributions are highly skewed with Kabul region clearly dominating the the spatial picture but the other major cities are also clearly present.

A1.2.2 Tower-Level Data

In order to analyze short-term responses to particular events (such as the Battle of Kunduz), we count the total number of daily calls per network tower. We compute two separate sets of values: one for all calls (including non-corporate subscriber calls) for analyzing the general population behavior, and the other for corporate subscriber calls, to see if there are any distinct differences between business and general behavior. We do not select non-corporate subscribers for the figure for two reasons. First, as the number of corporate subscribers is only 2% of the total subscribers in the data, it makes only a little difference; and second, presumably a substantial number of phones that are primarily used for business purposes are not registered as such. While we have no information on private use of registered business phones but during quickly evolving disruptive events, like the Battle of Kunduz, private usage may even dominate.

A1.2.3 Individual Locations

We use location of individual firms and towers for two purposes. First, in case of validating the location of firm's headquarters and regional offices, we calculate the modal district (in terms of calls made) of each phone associated with the given firm. We then order the resulting districts by the number of phones in each, and compare the top 5 districts to the

recorded locations of headquarters and regional offices in other administrative and survey data sources. Second, for the Kunduz empirical case analysis we also use an approximation of individual subscriber locations. We compute centroid of cellphone towers where the phone is active during the day-of-interest, while weighting the tower locations by the number of calls by the phone through that respective tower.

A1.3 Figure Explanations

Figure 2: Corporate Line Activity and Killings This depict a district-month call activity principal component. PC is calculated as the PC of log(1 + active firms), log(1 + active subscribers) and log(1 + # of calls) across the district-month cells. The plots depict the PC for April 2013 and also includes GTD kills for May 2012-April 2013 as small red dots. The dots are jittered to make their density more easily recognizable.

Figure 3: Calling Activity Inside and Outside Kunduz (2015 & 2016) Indicate the total usage of cellphone towers (count of outgoing calls) by all, and by business phones during 2×12 week window. Towers up to 10km from the center are green, 10-70km orange. All phones include all phones, including corporate subscribers. The center is defined as the centroid of the towers in the corresponding district (in practice it locates the center into the major city). The usage is normalized with respect to the mean and standard deviation of the corresponding time series. The normalization is performed over 12-week window.

Figure A3: Daily Locations of Corporate Lines Subscribers - Kunduz 2015 We plot the centroid of distinct corporate subscribers that are active in the region during the given day. We select a sample of the 150 subscribers who are present on the largest number of days during the period of interest. The days are a) 1 week before the attack; b) 2015-09-28 – the day of attack which occured early morning; c) one week after the attack (during the ongoing battle); and e) 1 month after the attack when Taliban had retreated from the city. In all, there are 6727 phones active in the region between August 15th and November 15th,

2015, but on a given day the number is lower. The centroid is average of the location of the towers the phone has made at least one call, weighted by the number of calls in these towers.

Figure A2: Mobile Tower Locations near Kunduz The maps of the towers for the corresponding usage graphs. Towers up to 10km from the center are green, 10-70km orange, same colors as used on the usage graphs. The center is defined as the centroid of the towers in the corresponding district (in practice it locates the center into the major city).

A2 Kunduz Case Study Appendix

With a population of approximately 300,000 (about one-tenth the size of Kabul), Kunduz is the capital of Kunduz province, which borders Tajikistan in the North. Kunduz is primarily agricultural, with a complex irrigation network, but it has also served as a transit point for illicit drugs flowing toward Russia and then Europe. The province is ethnically diverse, home to Pashtuns, Uzbeks and Tajiks among others.

Kunduz has a long history of business activity. In the 1960s, it was home to one of Afghanistan's largest textile mills. During the 2000s, trade and services, along with manufacturing, provided an estimated one-third of household incomes (*Kunduz: Socio-Economic Profile*, n.d.). Kunduz also has a history of conflict, much of which revolves around a combination of land and ethnic disputes. Associated with this conflict has been a fragmentation of power, making it difficult for local authorities to defend the province and city.[24]

In an effort to stabilize Afghanistan following the collapse of the Taliban, a series of Provincial Reconstruction Teams (PRTs) were established around the country by the member-states of the International Security Assistance Force (ISAF).[25] At the same time, USAID established a development program in the region. Between 2002-2011, $125 million was provided for a wide range of programs, including in the area of business development. Indeed, USAID had an explicit objective in Kunduz to "create a developed business climate that enables private investment, job creation, and financial independence" (USAID, 2011).

During the early 2000s, however, conflicts between different ethnic groups continued to fester in Kunduz, as the Pashtuns argued they had been displaced from their land by Tajik-led forces (what constitutes an individuals land in Afghanistan remains contested given the weak property rights regime). According to one report, "the justice system in Kunduz is

[24]Kunduz was the first city to fall to the mujahidin in 1988 and then the first city in the north to fall to the Taliban in the 1990s. The Taliban were driven from the city by the mujahidin in November 2001 with the support of American forces participating in Operation Enduring Freedom (Devlin et al., 2009).

[25]Germany was given responsibility for Kunduz in 2003, and 450 soldiers of the German Armed Forces were initially assigned to the region. By 2008 "around 570 German soldiers as well as about ten civilian staff chiefly representatives of the Foreign Office (AA) and the Federal Ministry of the Interior (BMI) were deployed in the PRT Kunduz" (VENRO, 2009).

barely functioning and instead the local population prefers to use the informal justice system" (Devlin et al., 2009). Given this background, the Taliban have been able to maintain pressure on Kunduz despite the success of Operation Enduring Freedom in removing them from power in Kabul.

The Taliban renewed their offensive against Kunduz on 24 April 2015 by striking at four districts outside the city. By the end of that week they controlled several major suburbs. In response, the Government of Afghanistan dispatched ANA forces, supported by U.S. fighter jets. Still, throughout the summer the Taliban continued to make gains around the city. On the morning of 28 September, Taliban troops routed the government troops that were holding the city. The following day, the ANA launched a counterattack with support from US special forces and airstrikes. Fierce fighting continued to October 13, with claims and counter-claims about who controlled the city. Nonetheless, on 13 October the Taliban withdrew, citing "the prospect of additional casualties and ammunition expenditure" (Nordland, October 13, 2015).