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Coordination and security: How mobile communications affect insurgency

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Abstract

Recent work has shown that the introduction of mobile communications can substantially alter the course of conflict. In Afghanistan and India targeting mobile communications is a central part of the insurgent campaigns. The opposite was true in Iraq. There insurgents instead threatened providers who did not do enough to maintain mobile phone networks. These differences likely arise from two competing effects of mobile communications: they make it easier for antigovernment actors to coordinate collective action, thereby increasing violence, *and* for pro-government civilians to collaborate with security forces allowing them to more effectively suppress rebels, thereby decreasing violence. To study these competing effects we analyze a formal model of insurgent action in which changes in the communications environment alter both (i) the ability of rebels to impose costs on civilians who cooperate with the government and (ii) the information flow to government forces seeking to suppress rebellion with military action. Our analysis highlights the importance of the threat of information sharing by non-combatants in reducing violence and offers some guidelines for policymakers in thinking about how much to support ICT development in conflict zones. In particular, we show that officials can generate reasonable expectations about whether expanding ICT access will exacerbate conflict or reduce it by assessing the relative gains to both sides from changes in ICT access along several simple dimensions.

Keywords

collective action, ICT, insurgency

Recent work has shown that the introduction of mobile communications can substantially lower the intensity of conflict under some circumstances (Shapiro & Weidmann, 2015) but may increase the risks of certain forms of violent political action under others (Pierskalla & Hollenbach, 2013). In Afghanistan, targeting mobile communications has become a central part of the Taliban campaign, presumably because they feel a connected population is a problem. Taliban officials have issued decrees ordering all cell phone towers be turned off during nightly hours in an attempt to prevent villagers from calling in tips to the military forces (Trofimov, 2010) and have attacked and destroyed cell phone towers for the same purpose. Naxalite rebels in India have similarly targeted mobile communications infrastructure and the government has responded by planning to put new towers in Naxalite-affected areas on Central Reserve Police Force and state police force bases to ensure they are protected.[1]

The opposite was true in Iraq. Press reports labeled cell phones an ‘explosive tool for insurgents’ (*Washington Times*, 2005) and some argued that mobile communications enabled a ‘networked insurgency’ in Iraq (Muckian, 2006). That cell phones can be key infrastructure for insurgent communication is corroborated by the observation that while insurgents in Iraq frequently attacked water and electricity networks, they carefully spared the cell phone network (Brand, 2007), and even

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[1] Author interview, Chhattisgarh, 11 August 2014.

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threatened telecommunication companies for not doing enough to maintain their network (Blakely, 2005). Thai authorities believed phones to be a boon to insurgents and introduced new identification standards for mobile phones in 2005 exactly because of the phones' perceived utility for separatist insurgents in southern Thailand (*Bangkok Post*, 2005a,b).

These differences arise from the twin effects of mobile communications: they make it easier for antigovernment actors to coordinate and solve collective action problems, but they can also help government forces repress activism. Mobile phones can make it safer for pro-government civilians to collaborate with security forces; further, governments around the world have varying capacities to tap mobile communications, meaning that potential activists using cell phones create new intelligence collection opportunities for government forces.

To assess how the trade-offs inherent in the introduction of mobile communications resolve we analyze a game-theoretic model of antigovernment collective action. In the model, changes in the communications environment alter the ability of rebels to impose costs on civilians who cooperate with the government as well as the information flow to government forces seeking to suppress the rebellion with military action. The model allows us to characterize the conditions under which introducing mobile communications will help reduce violence and when doing so will not. The model also provide some basic guidelines for policymakers in thinking about whether or not they should support ICT development in conflict zones. Most notably, it highlights the importance of the *threat* of information sharing in reducing violence. When information channels to government are strong relative to gains to rebels' collective action, we expect to see the introduction of cell phones reduce violence *even if not much more information is shared*. This is because of what the population would do if rebels were to increase violence beyond the level the community finds tolerable.

Our results suggest at least one answer to the empirical puzzle that some antigovernment organizations support expanding mobile communications while others oppose them. Antigovernment activists in some places have a theory of political change that entails conducting attacks that will spark a reaction by the government which will then catalyze popular action.[2] This logic applies to Al-Qaeda in Iraq, whose goal in attacking Shia targets in 2006 was, at least in part, to provoke militias allied with state leaders (e.g. the Shia militia Jaish al-Mahdi) into targeting Sunni populations. Given that theory of change, environmental shifts that make it easier for the population to self-organize sound like they would be a boon to the cause.[3] In other places, antigovernment activists seek to build mass movements – rural Afghanistan for the Taliban, potentially – and avoiding government repression that might inhibit the slow growth of participation is the goal. This makes the presence of cellular communications a liability.

Before introducing our game-theoretic model, we first provide basic background on the expansion of mobile communications opportunities and summarize recent work on the impact of communications expansion on conflict and political mobilization.

Background

A broad range of research has highlighted the beneficial economic impacts of cellular communications. Research has shown that improved mobile communications can enhance market performance in Indian fishing communities (Jensen, 2007) and reduce price dispersion in grain markets in Niger (Aker, 2010). More recent work has shown that mobile communications open up a broad range of options for holding politicians to account, including by facilitating inexpensive election monitoring (Callen & Long, forthcoming), by allowing easier citizen reporting of electoral irregularities (Aker, Collier & Vicente, 2013), and by opening up opportunities for enhancing the performance of government bureaucrats through easier auditing of their activities (Callen et al., 2013).

In the area of political mobilization the effects of increasing mobile communications are less clear. Theories of insurgent violence and collective action provide conflicting predictions about the impact of introducing cellular communications into areas with ongoing violence. In particular, in the context of the recent uprising in the Arab world, modern communication tools – and in particular cellphone technology – are frequently mentioned as a key catalyst of rebellion because they facilitate collective action. The argument is that by making it possible for people to coordinate mass protest, these

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[2] See, for example, the 'terrorism as awakening the masses' kind of argument that Russian Marxists used in the 1900s and the 'action-reaction cycle' posited by leftist groups in Europe and South America in the 1970s (Shapiro, 2013).

[3] Though the net impact of increased communications in Iraq was less violence, suggesting there must have been some miscalculation on the insurgents' part there.

technologies play a key role in toppling autocratic regimes and paving the way for democracy (Diamond, 2010; Shirky, 2011). This thinking is rooted in the social movements literature, which has shown that efficient communication critically affects a movement's capability for organizational mobilization (Garrett & Edwards, 2007).

Using data from Iraq, however, Shapiro & Weidmann (2015) show that increased cellular coverage is associated with reduced levels of insurgent violence, the major form of collective action in that conflict. And many insurgent groups clearly agree, hence the targeting of cellular infrastructure in places like Afghanistan and the Naxalite regions of India. Why the difference? One possible explanation is that in the context of insurgent mobilization, the critical constraint on the level of violence is not always the maximum productive capacity of the insurgency, but rather sometimes arises from the endogenous choice by insurgents to produce violence up to a certain level at which point further violence is deemed counterproductive. Berman, Shapiro & Felter (2011) model this optimal level of violence as one that is increasing in the ability of insurgents to retaliate against those who share information with the government, an ability that Shapiro & Weidmann (2015) argue is decreasing in the availability of mobile communications. Iraq, of course, is an unusual case in many respects, including the fact that collective political action took such a sanguinary form and that government capacity to act on information regarding political activists was exceptionally high due to the massive US military presence.

The best evidence to date on the average impact of mobile communications on conflict in more representative settings is collected by Pierskalla & Hollenbach (2013), who study the impact of introducing mobile communications on 55x55 km grid cells in Africa. They find that the introduction of new cellular coverage is associated with a .5 to 1 percentage point increase in the probability of an armed conflict event being recorded in the UCDP Georeferenced Event Dataset (UCDP GED) (Sundberg & Melander, 2013). Combined with the results in Shapiro & Weidmann (2015) this study raises the interesting possibility that the impact of communications may differ on the extensive and intensive margins, making it more likely that non-zero violence is observed but, conditional on there being violence within an area, increased communications may reduce its intensity.

Of course, in many settings the likelihood that violence is reported is inextricably linked to telephone density, making drawing empirical conclusions challenging. In situations where measurement of outcomes is extremely likely to be intimately tied into values of the key explanatory variable, having theoretical models which generate a rich set of testable hypotheses about heterogeneous treatment effects is particularly useful. We therefore turn to developing such a model.

Model

We take as a starting point the 'Hearts-and-Minds' model from Berman, Shapiro & Felter (2011) and modify it to serve our purposes in two major ways. First, we assume that communications can influence the ability of rebels to retaliate, rebels' costs of producing violence, and the ability of government to translate intelligence into operational success. Second, as our interest is in understanding the effect of communications on violence and not on governments' allocation decisions, for simplicity we eliminate government as a strategic player in the model. Government still plays a role in determining control of territory, but we abstract away from the specifics of its resource allocation decisions to allow a tighter focus on the impact of ICT. In this section we first elaborate on the model and then discuss its equilibrium and comparative statics informally. A formal derivation of the equilibrium and all comparative statics can be found in the online appendix[4]. Our goal with the model is to illustrate the changes in equilibrium levels of violence and information sharing we should expect from expanding communications opportunities if we believe that introducing ICT: (1) helps insurgents to more efficiently produce violence; (2) makes it safer for the population to share information; and (3) increases the baseline level of information on insurgents that the government has from collecting signals intelligence on insurgents.

Order of play

Our model is a sequential game with moves as follows:

(1) The rebel group, denoted R and treated as a unitary actor, chooses the level of violence it would like to produce, denoted v.

(2) The community, denoted C and treated as a unitary actor corresponding to the representative community member, chooses how much information, denoted i, to share with the government.

(3) Uncertainty over territorial control is resolved and payoffs are received.

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[4] The online appendix is available at http://www.prio.no/jpr/datasets.

The order of play is motivated by the mobility of the different factors. The representative community member can decide to share information or not at the very last moment. In contrast, rebel violence requires some fixed investment and time in developing local infrastructure for violence.

Uncertainty in the model arises from a lack of foreknowledge as to which actor, rebels or government, will control some territory, as in the original 'Hearts-and-Minds' model from Berman, Shapiro & Felter (2011). The probability that government controls the territory after the last stage of the game is denoted p, and is given by

$$p(i;\gamma,\varepsilon)=\gamma(i+\varepsilon). \tag{1}$$

The first parameter is γ, and it represents the ability of the government to convert intelligence into an increase in the probability of its controlling territory. The government receives information from two types of sources: (i) the community, given by C's decision variable, i, which captures how much information the representative community member shares; and (ii) other sources not tied to community support, given by ε. We refer to (i) as the HUMINT channel, for human intelligence, and (ii) as the SIGINT channel, though the latter can be a function of many things beside signals intelligence. SIGINT is generally increasing in the availability of cell phones.[5] The community may provide information up to the amount left over after government has used other sources (formally, $i \in [0, 1-\varepsilon]$ if both i and γ are in $[0,1]$ and $\varepsilon \in [0,1]$). More information of any type increases the government's chance of holding territory, and more information accessible without community action decreases the government's reliance on the community. The relative importance of each source of information is likely to vary by case. In the last stage of the model either the rebels or the government gain control of the territory. If the rebels gain control they produce violence, v, which imposes some costs on the community.[6]

Utilities

Community. The community gets expected utility from public goods and disutility from violence and retaliation as follows:

$$\begin{aligned}&EU_C(i,v;c,g,n,r,\alpha,\gamma,\varepsilon)\\&=u(c+g-n)p(i;\gamma,\varepsilon)+u(c-v)(1-p(i;\gamma,\varepsilon))\\&-(1-\alpha)ri.\end{aligned} \tag{2}$$

This expected utility function represents two sources of utility. The first two terms correspond to consumption. The first term is consumption conditional on the government controlling the territory. It comprises: a baseline level, c; public goods arising from government spending should it control the territory, g; and the community's preference to have the rebels and not the government control the territory, n. The second term is consumption conditional on the rebels controlling the territory. It comprises: a baseline level, c; and the negative impact from violence if rebels control the territory, v. As detailed above, p is the probability the government controls the territory.[7]

The third term represents the cost the rebels make the community pay should it share information. Here, r represents the rebels' ability to retaliate for information sharing; this retaliation occurs with probability $(1-\alpha)$ where α is positive if there are cell phones. In other words, the presence of cell phones can help shield the

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[5] Assuming insurgents use them weakly more when there is more coverage, which they must by construction. Note that this function differs from that in Berman, Shapiro & Felter (2011) in two ways: (i) it replaces a contest success function based on government's counterinsurgency decision with a parameter, γ, related to government's effectiveness at counterinsurgency; and (ii) it adds a parameter, ε, to capture the effect of SIGINT. By varying the parameter γ we vary the effect of counterinsurgency, in the same manner changing the costs to government of counterinsurgency would in the model of Berman, Shapiro & Felter (2011). There, reduced costs lead to increased investment in forces, and more forces mean the government can do more with the same amount of information (more raids, more follow-ups with human sources, etc.). Thus, including γ minimizes the impact of removing the government as an actor in our model.

[6] Note that while we refer to v as violence throughout, our model is actually agnostic about whether the thing the rebels produce is violence or something else. All that is required is that this thing be something that the rebels like and the community doesn't, and that it occurs only when the rebels control the territory. Thus, v could be the output of any type of collective action. This approach decouples the production of violence from the probability government controls territory at the end of the day. This is appropriate for modeling contests between rebels and high-capacity governments (which includes external allies supporting the government as Coalition forces did in Iraq) that could control the territory with near certainty if they had all the information on rebels. Its appropriateness is lower for thinking about capacity-constrained governments.

[7] Here C's subutility function u is assumed to be increasing and concave.

community from retaliation, as it is able to share information more secretly.[8]

Rebels. Rebels get utility from producing violence, if they control the territory, arising from the costs this violence imposes on the government. Rebels also pay some cost for mobilizing to produce violence regardless of who controls the territory, so that

$$U_R(v, i; \tau, \gamma, \varepsilon) = A(v)(1 - p(i; \gamma, \varepsilon)) - B(v(1 - \tau)). \tag{3}$$

We assume rebels get decreasing returns to violence but pay ever increasing costs of producing violence. Rebel costs of mobilization are decreasing in the extent of communications technology, denoted τ, following standard assumptions that ICT eases the challenge of coordinating collective action.[9]

Before moving on, we offer a couple of notes. First, our approach decouples the production of violence from the probability government controls territory. This is appropriate for modeling contests between rebels and high-capacity governments that could surely control the territory with high probability if they had all the information on rebels. Its appropriateness is less for thinking about capacity-constrained governments (potentially in combination with foreign supporters) in which conflict is less asymmetric. The model thus applies to a broad range of settings, including: student movements against wealthy democracies or autocracies with strong police forces; and insurgents fighting militarily competent states such as Colombia, Iraq (including Coalition Force), Pakistan (which has demonstrated great capacity when it chooses to), the Philippines, or the United Kingdom in Northern Ireland (historically of course). This is not the right model for thinking about the impact of ICT on civil wars and insurgencies against low-capacity states (e.g. the conflict in the Democratic Republic of Congo.)[10]

Second, we treat the interaction of community, rebels, and government as fundamentally asymmetric. The community can share information with government, but not with rebels. We do this because we believe that in most cases this is the better substantive assumption. The community, sharing the same geography as the rebels, is likely to have more and better information on the rebels than the government does, but not better information on the government than the rebels do, given that the community has no special closeness to the government. We do, however, implicitly include potential information sharing by the community with the rebels in the rebels' production cost. The more such sharing exists, the lower the rebels' cost of producing violence.

Best response functions and equilibria

We solve the game by backwards induction beginning with C in order to find a subgame perfect equilibrium. A formal solution can be found in the online appendix. Here we discuss the unique equilibrium intuitively.

First, consider the second stage, in which the community acts. The key thing to note here is that, because the community's utility is linear in the information it shares, in equilibrium it will either share all available information or no information. We find that there is a cutoff, denoted $\bar{v}$, such that whenever $v > \bar{v}$, the community shares all available information (i.e. $i^* = 1 - \varepsilon$), while when $v \leq \bar{v}$, the community shares no information (i.e. $i^* = 0$).[11] The most important thing to note here is that this cutoff, $\bar{v}$, is also the greatest level of violence the rebels can produce and still not have information sharing by the community.

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[8] This term is an addition to community's utility in the model of Berman, Shapiro & Felter (2011). We assume for convenience that a community indifferent between all levels of information sharing chooses not to share information. This affects nothing save in a knife-edged case and simplifies our analysis.

[9] Formally, $A'(\cdot) > 0$ and $A''(\cdot) < 0$ so that rebels get decreasing returns to violence, and $B'(\cdot) > 0$ and $B''(\cdot) > 0$ so that rebels have convex costs of producing violence. The rebels' utility differs from that in Berman, Shapiro & Felter (2011) in the addition of τ, so that ICT can affect the production of violence in our model. We assume that the marginal cost of violence is sufficiently small at $v = 0$ such that $v = 0$ does not maximize U_R at any level of i. In other words, it is always beneficial for the rebels to mobilize for some level of violence, no matter how small. While not essential for our model, this assumption ensures that the rebels remain a potential source of violence, in line with the substantive scenarios we intend to model.

[10] The applicability of the model to situations where government force-projection capacity is substantial but ultimately limited – current conflicts between the Islamic State (formerly ISIS) and the Iraqi and Syrian governments likely varies by location. In areas such as Baghdad or Damascus, where state forces have freedom of movement, our model would apply. In areas along the border between Iraq and Syria, where government forces cannot operate, the model is not applicable.

[11] The cutoff $\bar{v}$ also depends on c, g, n, and r, but as these are parameters and v is R's decision variable, it is more important to frame it in terms of v.

Now move to the first stage. R's best response balances the direct gains from increased violence against both the direct costs of producing violence at that level and the possible decrease in the likelihood that R controls territory due to shared information brought on by violence. There are two potential levels to consider, depending on what C will do. If C will share full information, then R maximizes its utility under the expectation that information will be shared. We call this level of violence $\hat{v}$. If C will not share information, then R maximizes its utility under the expectation that information will not be shared. We call this level of violence $\tilde{v}$. Since the value of investing in violence is lower when the probability of rebel victory is lower due to the population's sharing information, we have that $\tilde{v} \geq \hat{v}$.

To discern the best response function for R, and so figure out what R will do in equilibrium, we must consider three cases. First, $\tilde{v}$ might not exceed the cutoff $\bar{v}$. In other words, R might be able to employ its optimal level of violence in the absence of information sharing without inducing sharing by the community at a later date. In this case R does so and achieves its best outcome.

Second, $\tilde{v}$ might exceed the cutoff $\bar{v}$, but $\hat{v}$ might not. In other words, its optimal level of violence absent information sharing induces information sharing, making this level of violence not optimal; additionally, the lower level of violence, $\hat{v}$, which is optimal in the presence of information sharing, does *not* induce information sharing and so is also not optimal. Since R's utility is still increasing at $\hat{v}$ in the absence of information sharing in this case, R wants to increase violence as much as possible without inducing sharing. This level is $\bar{v}$, and R chooses to produce violence at this level in this case.

Finally, $\hat{v}$ might exceed $\bar{v}$, implying that both optima induce sharing. In this case R has a decision to make. It can commit just enough violence to prevent sharing, $\bar{v}$, as in the previous case, or it can accept the inevitable sharing and choose the optimal level of violence in this case, $\hat{v}$. Which it chooses to do depends on which produces the greatest utility, and that will depend on the parameters of the model.

Putting these together produces the following best response function for R:

$$v^* = \begin{cases} \tilde{v}, & \textit{if } \bar{v} \geq \tilde{v}, \\ \bar{v}, & \textit{if } \tilde{v} > \bar{v} \geq \hat{v}, \\ \bar{v}, & \textit{if } \hat{v} > \bar{v} \textit{ and } U_R|_{\bar{v}} \geq U_R|_{\hat{v}}, \\ \hat{v}, & \textit{otherwise}. \end{cases}$$

Equilibrium

The best response functions for each actor determine the equilibrium, as they specify when information is shared and what level of violence is chosen as functions of the parameters of the model. But it helps to clarify this in words. The rebels choose one of three levels of violence, depending on the anticipated decision of the community to share information or not. They can avoid sharing by either taking advantage of a permissive community (the first case) or choosing just enough violence to prevent a community response (the second and third cases). These latter two cases occur whenever the decrease due to shared information in the rebels' chance of holding territory outweighs their benefit from violence. But when the latter outweighs the former, the rebels accept sharing and increase violence over what would be required to avoid sharing. Note that although information sharing occurs rarely in the model, the *threat* of information sharing is sufficient to tamp down levels of rebel violence.

We illustrate these cases with the following two figures. Each figure includes three different possible levels of the cutoff $\bar{v}$: $\bar{v}_{low}, \bar{v}_{med}, \bar{v}_{high}$. In both cases, the rebels prefer $\tilde{v}$ to $\bar{v}_{high}$, as their utility is higher at the former than the latter. Since the former is available given the high cutoff, the rebels choose this optimal value and no information is shared. Further, in both cases the rebels prefer $\bar{v}_{med}$ to $\hat{v}$ for the same reasons. Since $\tilde{v}$ is not available because information would be shared at that level of violence, they go with the best they can get, $\bar{v}_{med}$.

What they do at the cutoff of $\bar{v}_{low}$ depends on the relative shapes of the utility curves, including the parameter γ. The bigger γ, the larger the cost to the rebels of information sharing, and so the larger separation we would expect to see between R's utility curves corresponding to information sharing and no information sharing. In Figure 1, the case of information sharing drops utility sufficiently to make the utility at $\bar{v}_{low}$ higher than the utility at the greater level of violence, $\hat{v}$; consequently, the rebels employ a reduced violence of $\bar{v}_{low}$ to avoid information sharing. In Figure 2, in contrast, the reduction in utility due to information sharing is comparatively mild and the rebels obtain greater utility from the higher level of violence, $\hat{v}$, even though this results in information sharing by the community. Note that this last case is the only time information is actually shared in equilibrium.

Comparative statics

Though equilibrium behavior can give us a sense of the incentives and trade-offs involved, empirically we are

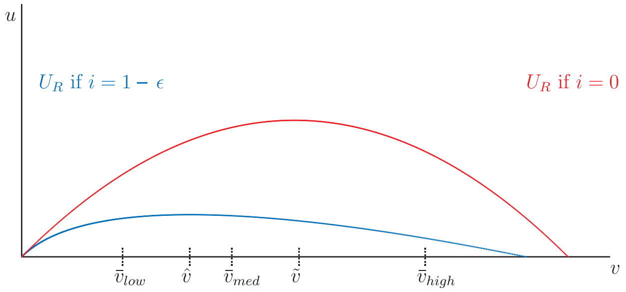

Figure 1. No information sharing

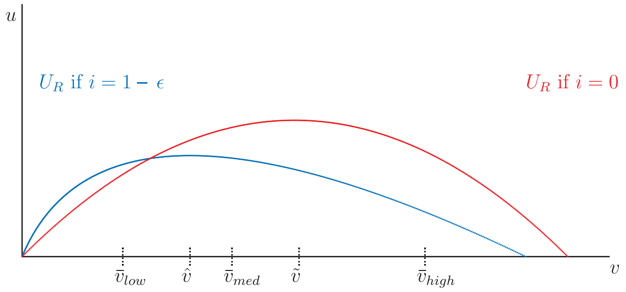

Figure 2. Potential information sharing

most interested in the effects of the parameters on equilibrium behavior. We begin by summarizing the effects of those parameters most closely related to mobile communications, then we briefly discuss the logic behind the effects of all parameters. A formal presentation of all comparative statics can be found in the online appendix.

- α: It allows the community to more easily pass information to the government while avoiding retaliation. This generally leads to less rebel violence, other than in one specific case that can arise only when the community is very likely to share information regardless of R's actions.
- τ: It allows the rebels to produce violence more cheaply. This generally leads to more rebel violence, other than possibly in the same specific case.
- γ: It allows the government to better use information in attempting to control territory. This generally leads to less rebel violence, other than possibly in the same specific case.
- ε: It improves signals intelligence in general, reducing the government's reliance on community-derived human intelligence. This generally leads to less rebel violence.

Before going further we return to the fundamental question: what is the likely effect of introducing or expanding ICT in places with ongoing or potential conflict? Each of the four parameters in this list relates to ICT, but all are likely to change simultaneously with changes in the ICT infrastructure. This makes it difficult to assess a single net effect of ICT. We do not view this as a negative; a significant insight arising from our analysis is that ICT has multiple, competing effects that must be assessed in order to understand the role of ICT in conflict, and that different contexts produce different net effects of ICT.

Sometimes, these effects point in one direction. In Afghanistan, for example, expanded cellular coverage certainly increased ISAF's ability to collect on communications (higher ε) and also made it possible for the community to pass information more safely (higher α) as evidenced by the Taliban's prohibition on towers operating during the evening in some areas. It is less clear, however, whether the introduction of cell phones in Afghanistan aided insurgent violence production, possibly because insurgents avoided cell phones due to the ease of intercepting phone calls. Thus in Afghanistan we would expect the introduction of ICT to reduce violence. Turning to Syria, though, the changes in ICT penetration during the war would have different impacts. In the Syrian conflict the battle lines are relatively clear and the government's ability to precisely target rebels is fairly low. As ICT penetration has gone down, particularly in rebel-held areas, the main impact would be to make it harder for rebels to organize (lower τ), thereby increasing the costs of producing violence. The net effect would be less violence.

Other cases are harder to parse *a priori*. In Thailand, for example, government forces are not excluded from rebel territory and the government's signals intelligence capacity is not as high as that of ISAF in Afghanistan (where it anecdotally led insurgents to avoid using cell phones), and thus the expansion of ICT could simultaneously increase α, τ, and γ. In such cases, we can get a handle on the net effect of introducing ICT by conceptualizing a new parameter, ICT penetration, which would drive variation in each of the four ICT parameters above. We can then ask how varying this new parameter affects the net impact of ICT on violence and information sharing or, more simply, what would happen if this new parameter were zero, implying an absence of mobile technology. As the former question would rely upon context-specific assumptions on the manner in which ICT penetration altered our four ICT parameters, we'll briefly address it.

To see what would happen in the absence of mobile technology, we must analyze the effect of this on each of our four parameters. First, consider α. Without mobile technology, the community cannot avoid retaliation from the rebels should it pass along information to the government. This will diminish information shared and generally lead to more rebel violence. The costlier the retaliation, r, the more this will be true. In the extreme, if r is large enough, HUMINT will fall to zero, and rebels will produce violence at their optimal level in the absence of information sharing, $\hat{v}$. What will happen then depends on the degree to which the government is reliant on ICT for SIGINT. If this is its sole source of information, then ε will be zero as well, and government will have no chance of holding territory in our model. The parameter γ will have no effect in this case on the outcome. More realistically, ε will be non-zero due to other SIGINT sources, but less than it would be in the presence of ICT, rendering γ less important and leading to a greater chance of the rebels holding territory. So from the intelligence side, no mobile communications are bad for the government, and lead to greater rebel success. How bad this is for government depends on the last ICT parameter, τ. If a lack of ICT drives costs for violence production very high, pushing τ lower, then government does not fare too badly even given rebel control. However, if it is easy to communicate absent ICT, so that the lack thereof does not appreciably raise the costs of producing violence, then government fares less well as the rebels can do real damage. Thus, we see that our model brings into stark focus the dual effects of ICT: it makes intelligence gathering easier while making insurgent groups more effective at producing violence. Which effect dominates will depend on context, as we have noted.

A key part of that context is how people in a society are connected before the expansion on two dimensions: (1) how easy it is for people within a society to communicate; and (2) the ability of the government to intercept those communications. In areas that are poorly policed by the state where there are dense local communications networks – for example, rural areas with extensive transportation options such as the Niger Delta – then communication about collective action absent ICT might be comparatively easy and secure. When ICT comes in it will do little to improve the efficiency of collective action, but may provide security forces with new ways to collect information on the population, and we would therefore expect a decline in violence. In areas where communication is hard absent ICT – for example, urban areas where setting up roadblocks and surveillance is easy but the ability of the government to use ICT for intelligence is low (either because services are provided from neighboring countries or because their technical capabilities are weak), such as Syria – then we would expect an increase in violence as ICT expands. The model thus highlights the potential for dramatic variation across cases depending on the initial communications environment.

Now we move to considering the effect of each parameter individually, starting with those that only directly affect the degree to which the community shares information. These parameters are c, g, n, r, and α, each of which only affects the degree to which the condition for full sharing of information is likely to be satisfied. Due to decreasing returns to the community, increasing baseline consumption, c, the degree to which the community prefers the rebels, n, and the rebels' ability to retaliate, r, all make the condition less likely to hold, meaning the community becomes weakly less likely to share information with the government as each of these parameters increases. In contrast, increasing each of the amount of public goods provided by government, g, and the chance that the community can avoid retaliation for revealing information, α, makes the condition more likely to hold, leading to weakly more information shared.

The effect of each of these on equilibrium violence is more complex. First, we find that making the condition less likely to hold increases the cutoff $\bar{v}$, while making the condition more likely to hold decreases $\bar{v}$. Second, we note that the effect of an increase in $\bar{v}$ on violence depends not only on R's direct response to the change in $\bar{v}$, but also on the underlying change in information revelation by C. The short answer (a longer answer is in the online appendix) is that typically an increase in $\bar{v}$ results in either no change or an increase in equilibrium violence, but in one specific case can actually result in a *decrease* in equilibrium violence.[12] Thus, increasing c, n, and r generally increases violence, while increasing g and α generally decreases violence. And altering any of these parameters generally has no effect on information sharing in equilibrium. When that one condition is met, however, information shared either decreases to zero (for c, n, and r) or increases to full (for g and α).

Next consider τ, which affects the marginal cost of producing violence, and so only affects R's decision. Increasing τ has no direct effect on $\bar{v}$ or C's decision, but

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[12] As described completely below, that one case arises when the rebels previously chose high violence leading to information sharing, but with the increased tolerance of the community for violence shift to a slightly lower level that saves them the costs of information sharing while providing most of the benefits from the prior higher level of violence.

it does raise both $\hat{v}$ and $\tilde{v}$ as it shifts down the marginal cost of producing violence. This leads in general to more violence with no change in information sharing, other than in the same specific case in which information sharing increases to full.

Now turn to γ, which represents the degree to which information can be translated into military success for the government. This parameter affects each of $\hat{v}$, $\tilde{v}$, and $\bar{v}$, but it affects them all independently and its behavior on them is consistent: an increase in γ decreases each of them. For the first two this occurs because the marginal benefits curve for engaging in violence shifts downward as R is less likely to be able to control territory and thereby accrue these benefits. For the third this occurs because it becomes more favorable for C to share full information. This implies that in almost all cases equilibrium violence decreases as γ increases while information sharing stays the same.[13]

Finally, consider ε, the level of information accessible to the government from sources other than the community – signals intelligence, for example. Increasing this does not affect $\bar{v}$, but it does decrease the level of information the community can provide when it chooses to provide full information, that is, when $i^* = 1 - \varepsilon$. This has no effect on $\hat{v}$, since all information is provided in this case, regardless of the source. But it does shift down the marginal benefit curve for producing violence in the absence of information, which decreases $\tilde{v}$, since now there is relatively less chance of taking advantage of this level of violence. As compared to changes in $\hat{v}$ or $\bar{v}$, this has little effect. In all cases, increasing ε weakly decreases equilibrium violence and leaves the level of information sharing unchanged.

Conclusion

We explore the effect on conflict of introducing mobile communications technology via a model of insurgent action. Our model extends information-centric models of insurgent collective action to account for two channels by which introducing expanded technological communications opportunities may affect conflict: (1) they can make collective action easier for insurgents; but (2) they can ease a government's intelligence collection challenge by either creating direct channels for collection (the SIGINT channel) or by making it harder for insurgents to know who is sharing information with the government which makes it safer for non-participants to do so (the HUMINT channel). This enables it to provide important insights into the role of communications technology in the production of violence, in that it highlights the role in reducing violence played by the threat of information sharing *even when information is not shared*. Further, it separates out the various mechanisms through which information technology can play a role and identifies the independent effect of each mechanism on levels of violence.

Anecdotally, increased cellular communications coverage can have both effects outlined in our model. Sometimes, it supports counterinsurgent efforts that reduce violence. Cell phone monitoring, the SIGINT channel, helped US forces kill several senior Al-Qaeda in Iraq (AQI) leaders including Abu Musab al-Zarqawi and many other AQI leaders (as well as Osama Bin Laden in Pakistan) (Perry et al., 2006). Introducing cell phones also increased HUMINT. In early Spring 2007, for example, a special operations task in the Anbar province of Iraq worked with the Iraqi telecommunications firm Iraqna to re-establish cell phone coverage west of Fallujah for the first time in two years. As a result the intelligence gathering and passing capabilities of the anti-insurgent movement grew dramatically, enabling a range of anti-insurgent operations by Coalition forces.[14] That response is exactly what our model would predict in settings where the marginal increase in insurgent productivity from providing coverage is low but the increase in the ability of people to report without risking retaliation is high. Tip lines in Iraq were, in fact, advertised as a way for civilians to 'fight the war in secret' by providing information to Coalition forces (Miles, 2004) and there are many examples of civilians using tip lines to inform on insurgents (e.g. Lynch, 2006).

But cellular coverage can also facilitate the production of violence. As Pierskalla & Hollenbach (2013) note, there are a host of ways in which mobile communications can facilitate collective action, including reducing the amount of free-riding within groups. In Iraq, cellular coverage opened up a range of options for setting off improvised explosive devices (IEDs), including calling phones to detonate bombs, setting fuses that would detonate when Coalition jammers terminated a call, and using mobile phones to allow spotters to tell operatives controlling an explosive via a command line when to set it off. The potential military advantages insurgents saw from cell phones in Iraq led them to push providers to

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[13] See the online appendix for two cases in which this is not true.

[14] Author interview, Commander Ryan Shann (United States Navy), 23 October 2012.

extend coverage. In 2005 the chairman of the Iraqi National Communications and Media Commission reported companies were being 'threatened by terrorists for delays in setting up masts' because '[t]errorists like mobile companies' (see Blakely, 2005).

Because the anecdotal evidence on the impact of cell phones is so contradictory, and because the statistical evidence points to different effects in different contexts, a theoretical model is useful for assessing when we should expect cellular coverage to facilitate or inhibit rebel violence. Our model suggests a series of questions one can ask which are grounded in the specifics of the tactical environment and can be evaluated in specific contexts by domain experts:

- Do the insurgents have a strong ability to detect and punish people who share information in the absence of cellular coverage but not when people can text or call in tips at convenient times (big α)? If so, one would expect large gains in HUMINT from the introduction of cell phones and a reduction in equilibrium violence.
- Does the government have significant SIGINT capacity (high ε) and the force projection tools (precision-guided munitions, drones, airmobile special operations forces, etc.) to take advantage of it (large γ)? If the answers is 'yes', then we should expect reductions in violence as cellular coverage is introduced.[15]
- Do the insurgents use tactics that are facilitated by cellular communications, such as IED attacks (big τ)? If so, it is more likely that introducing cellular coverage will lead to increased violence.

Based on an assessment of those factors, one can generate predictions about whether enhancing mobile communications opportunities will lead to more or less violence in any given scenario. Thus while the model's parameters cannot be coded in comparable ways across conflicts, the model does provide a useful way for thinking through the conditions under which mobile communications will have different effects on conflict.

Replication data

The online appendix can be found at http://www.prio.no/jpr/datasets.

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[15] Assuming of course that insurgents lack the ability to enforce communications security on their fighters (i.e. to keep them from talking about work on their cell phones).

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