Determinants of rebel and terrorist organizational structure and the effects of counter-insurgency: Population dynamics and organizational ecology in rebellion

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Abstract

Violent organizations, like rebel groups, adopt a variety of organizational forms: markets, networks, and hierarchy. These forms affect duration of conflict, intensity, success, and vulnerability to intervention. I show violent organizations (and their populations) adopt organizational forms from a set of alternatives in response to both population dynamics and environmental pressures. I use an agent-based model of organizational ecology to show that rebel organizations form as networks when populations are small and rebels believe the risks of defection are low, but shift into more costly, hierarchical organizational forms to protect themselves from defection as these risks increase or the benefits to fighting increase. I also find that those most vulnerable to exploitation are more likely to join hierarchies at relatively lower levels of risk than more reconcilable insurgents. Finally, I model counter-insurgency to show the possible dangers of designing COIN and state-building strategies that neglect to account for organizational alternatives.

1 Introduction

There is great variety in the organizational structure of rebel groups. Some are hierarchical and state-like in organization, others flatter and "networked," and some lone actors. While some groups adopt an organizational form for their lifetime, others vary over time. Much has been made of al-Qaeda as a network, but even it has varied from hierarchy to network over its lifetime (Kahler 2009). The organizational structure of some rebellions, like the Eritrean movement during its secessionist war, also changed significantly over the course of the conflict, passing through all three organizational forms: from market, to network, to hierarchy.

Rebel structure affects many aspects of conflict. Coordination (via organizational consolidation) can enable disputes to be settled more quickly (Cunningham 2006), gain concessions (Cunningham 2011, 2014), and conduct deadly attacks (Asal and Rethemeyer 2008). Despite these implications, why rebels structure themselves differently and how those organizations respond to intervention has not been settled and is relatively under-theorized.[1]

There are two aims in this article. First, I model rebel organizational ecology—the set of organizations from which rebels choose—to show that population characteristics and dynamics influence the dominant organizational type adopted. These insights follow from a close look at micro-level (actor) decisions across organizational alternatives faced by members of these populations to help understand how the full range of organizational choices and the choices of other actors shape behavior. I then look at how counter-insurgency and state-building strategies interact with the organizational ecology of rebellion to highlight important lessons for policy in taking the range of organizational alternatives seriously.

While they may do many other things, most essentially, rebels use violence to extract concessions from the state. In using violence and operating illicitly, *individual* rebels face an environment analogous to a prisoner's dilemma in which large scale cooperation to fight increases likelihood of concessions; however, personal participation is costly, creating incen-

[1] Staniland (2014) on cohesion is a notable exception.

tives to free-ride. Additionally, because of their operating environment, these actors and organizations are particularly vulnerable to internal defection. This problem is compounded by any efforts on the part of counter-insurgents to attempt to induce defection through the use of public goods or private incentives. To produce political pressure for concessions in the face of this dilemma, rebels can form organizations as ad hoc "groups of guys" (markets), hierarchical militias with uniforms, ranks, and clear chains of command, or violent networks.[2]

I derive implications about organizational decisions from an agent based model (ABM) of organizations and cooperation applied to rebels groups. I study the factors that lead markets, networks, or hierarchy to be the dominant form of rebel organization that emerges from the set of organizational options (the organizational ecology). Additionally, I look at how specific "types" of rebels within the population are affected by the distribution of types within the population, their beliefs about the population, and the behavior of others in the population to decide to join different types of organizations (which produces the organizational ecology). To preview, I model organizational choice to show how population dynamics alter the organizational ecology a population adopts. I find rebel populations use networks when the population is small while rebel populations composed of more "hardline" members—larger, more ideologically diverse populations are likely to use hierarchies to coordinate and cooperate. These hierarchies are more likely to emerge when the benefits to fighting the state are large and when the hierarchy can minimize risks of defection.

Next, I extend the ABM of rebel organization to examine two highly related policy areas: the effect of counter-insurgency (COIN) on rebel organizational structure, and difficulty of state-building. In both areas I show that accounting for organizational alternatives is a critical, potentially missing, piece of current strategy and intervention policy. Specifically, while rebel hierarchies may be destroyed with comparatively low military efforts, they may give way to more difficult, and costly forms of rebellion to counter. COIN is typically coupled

[2] I will highlight the generality of the problem as well as the particular tensions for violent, illicit organizations.

with a "hearts and minds" strategy that bolsters state services and focuses on state-building. Using the expanded model to account for a "state" organization, I show the pitfalls of the "government in a box" strategy and that it leaves little room for error.

This article proceeds in five parts. In section 2, I describe the stakes for solving the cooperation problem rebels face and describe the cooperation and commitment tensions in the micro-choices they face. Next, I outline the organizational solutions to these tensions, highlighting the shift toward organizational approaches in non-conflict spaces. Section 3 describes the ABM of organizational ecology designed to capture these dynamics. In section 4, I show some of the emergent trends for rebel organization generated by the model. Section 5 extends the basic model to incorporate and model counter-insurgency and illustrate tensions with current COIN and state-building strategy this approach reveals. The final section concludes.

2 Rebel Cooperation Problems and Organizational Solutions

There is a rich and growing literature on how terrorist and rebel groups interact (particularly to negotiate) with other actor actors, typically the state, but also other groups (e.g., Bapat and Bond (2012)). Within the violent actor literature, there is a growing appreciation for the effects and inner workings of these organizations. For example, we know rebels who are able to solve cooperation problems gain significant advantages, both strategically and operationally.[3] Unified groups are more likely to gain self-determination concessions. Logistically, hierarchical groups are better able to conduct deadly attacks (Asal and Rethemeyer 2008, Piazza 2009). Groups that coordinate (or consolidate at the extreme) are able to settle disputes more quickly (Cunningham 2006, Heger and Jung 2017) because of advantages at the negotiation table. Cunningham (2011, 2014) shows whether the group is internally divided alters the concessions granted, but also their ability to settle the dispute.

[3] A note on terminology and scope: I take rebel groups to be political groups that oppose the status quo in a given territory who pursue their goals through violent means. Terrorist and insurgent groups are captured in this theoretical category, despite potentially different tactics.

Recent literature emphasizes the internal trade-offs organizations face as covert organizations. Because they present an existential threat to the state, these organizations operate covertly, as a result they face a key dilemma between secrecy and efficiency. Shapiro (2013) clearly lays out the tension between secrecy and efficiency in examining when terrorist organizations are likely to bureaucratize. We see a similar dynamic in Lindelauf, Borm and Hamers (2009)'s description of the secrecy of communication structure. Bahney et al. (2013), Johnston et al. (2016), Shapiro (2013) show bureaucracy and mechanisms of control are surprisingly common.

Despite these outcomes, comparatively little is known about the pressures that cause rebels to organize differently, with some exceptions. This said, we are not starting from a blank slate. There is an important set of work that looks at the pressures that focuses on the strategic shifts in organization, often as a result of dynamics between leadership and population. Staniland (2014) focuses on the organizational origins and pre-war social structure and leadership ties, in particular on fragmentation and cohesion and the direction of change, rather than how micro decisions alter the adoption of one specific organizational form vs another. Helfstein (2009) finds groups that share homogeneneous characteristics can exist with less organizational structure.[4] Weinstein (2007) shows how need for local support in the population means the organization is more likely to provide public goods (a mark of what I would term hierarchy). Situated between these arguments, I argue the organizational ecology is determined by the strategic environment, which is dictated at least in part by the state's response, as well as population characteristics including size and composition.

I join those working on other substantive issue areas, most commonly in international governance, in applying an ecological framework to problems in international relations. As a result of work in these areas, we know more about the ecology of organizations in other literatures. Abbott, Green and Keohane (2016) are the most recent to adopt an ecological approach to look at populations of organizations, in the global governance space. Specifi-

[4]To preview below, this is similar to the selective affinity effect I model, with the informational element of denser networks.

cally, they work to explain the proliferation of private transnational regulatory organizations compared to a relatively organizationally static population of IGOs. Lehman (2013) examines international regime evolution, focusing on interactions between agents and the overall structure. Jung and Lake (2011) make the case for applying an ecological framework to understanding cooperation. Nyhan and Montgomery (2014) apply similar framework to domestic dynamics within a wholly different issue space: consultants in congressional campaigns.

I build on this new wave of work, tailoring a general model of organizational ecology to examine the specific problem faced by rebel organizations and the micro-decisions of those populations. This setup and modeling technique highlights the role of organizational alternatives available to populations, as well as the importance of population dynamics in shaping and sustaining organizational ecologies.

2.1 The Rebel's Dilemma

Rebel organizations are political and social organizations like many others: actors cooperate to gain policy concessions from a state. Rebel organizations emerge from populations composed of actors with heterogenous preferences and strategies. Unlike many political organizations and actors, both their goals as well as their methods often threaten the security and existence of that state. Sharing information—either in planning an attack, or in passing information about the type of potential rebels—makes the risk of detection, and therefore punishment, by the state great. This risk makes the policy concession "game" between the state and the violent group much more difficult than institutionalized political pressure.

Individuals within the rebel population often would like to share in the burden (and distribute the risk) of rebellion. Additionally, they see benefits from economies of scale in conducting both larger, more complicated attacks, as well as a greater number of attacks, both of which will apply more pressure to the state, but often find cooperation in the face of counter-insurgency difficult. Many rebel movements begin as many small groups with

related, but non-identical goals. Both the Liberation Tigers of Tamil Eelam (LTTE or Tamil Tigers) in Sri Lanka and the Basque group Euskadi Ta Askatasuna (ETA) began as numerous small groups that slowly coalesced into a single larger group.

Rebels, and rebel organizations, face constraints in how they solve this organizational dilemma. They are sensitive to two key problems that recur in many areas of social cooperation: free-riding and defection. Unlike NGOs, political parties, or lobbying groups, rebels—who are both illegal as well as posing an existential threat to the state—face particularly high personal risks to acting, making free-riding attractive. Additionally, would-be rebels also bear a risk of being sold out by a would be cooperative partner; counter-insurgency policies often center on getting one partner to "defect" on the other—for monetary or political concessions (Berman 2009, McLauchlin 2015). Both problems alter composition and size of rebel organizations. The potential for members to be "bought off" alters the strategic space and the organizational ecology.

Examining how this "micro" dilemma aggregates to the ecological level adds nuance to our understanding of how (and potentially *when*) organizational shifts happen. Each rebel must decide if they can stay home, as may be their first choice, go it alone as a lone wolf (or in small "groups of guys") or cooperate operationally and fight in some type of organization. More structured cooperation in networks or hierarchies comes with advantages, but also trade-offs. Networks and hierarchies are better able to assure individuals that their risky behavior, showing up to an attack site or carrying out one stage of a larger attack, is more likely to be met with cooperation.

2.2 The Rebel's Dilemma as a Prisoner's Dilemma

The problem of cooperation rebels face is analogous to a repeated Prisoner's Dilemma (RPD) game (see Figure 1). The intuition of the RPD captures the strategic problem of coordinating attacks. A pair of rebels would benefit if they both show up to fight, working together pursue a larger attack—or coordinated campaign of attacks—but they risk exposure to the state if

they are working toward a larger attack and the other partners in the fight stay home, or fail to hold up their end of the attack. ETA's first attack falls easily into this category. A small group of Basque extremists' botched attempt to target Franco's supporters exposed themselves and others in the larger rebel movement to the repression of the Spanish state. Lack of larger scale cooperation led to an outcome that was worse than either not attacking or a much smaller attack.

There is a strong individual incentive *not* to fight when carrying out rebellion or any illicit activity, even if they might otherwise be ideologically sympathetic. An individual's belief that others in the population can be relied upon to fight is a critical factor in determining behavior in a world without organizations. When there are actors in the population who are unlikely to fight, rebels still want to insulate themselves from the risk of being left "high and dry" in conducting an attack to improve the likelihood of ending up in joint fight outcome.

		$Agent_j$	
		C	D
$Agent_i$	C	R - $k_i j$, R - $k_i j$	S, T
	D	T, S	P, P

Figure 1: **Rebel's Dilemma as a modified Prisoner's Dilemma**
Where the payoffs are ordered $T > R > P > S$ Axelrod (1987). See also Skyrms (2004).

In this analogy there are three potential outcomes for rebel interactions:

- **Mutual Not Fighting** (P, P): Both actors pursue their goals on their own. Working independently, individuals and very small groups of highly motivated actors may survive, and importantly, are able to maintain their personal ideal points. However, they face a lower probability (or no probability) of gaining concessions from the state. In populations without a particularly active or coordinated rebel population, even with large latent sympathy or ideological alignment, this is the most likely outcome. This is even more probable in populations where actors' ideological salience is low, or where

there are very few "ideologues" or hardliners. Timothy McVeigh or Ted Kaczynski pursued their agendas through largely unilateral campaigns. They both bore most of the costs themselves, made no ideological compromises to work with others, but as a result also lacked man-power and formal organization, having never been able to overcome an iterated trust game.

- **Mutual Fight** ($R - k_{ij}$, $R - k_{ij}$): If both actors work in concert, they have a greater probability of gaining concessions, but will have to sacrifice their individual policy preferences (or ideal point) for a common one, k.[5] Cooperative outcomes are likely in populations where large proportions are hardliners—determined to coordinate, even at the risk of being abandoned. The 9/11 bombers worked in concert to execute a plan that would not have been feasible had members of that rebel organization shirked on operational duties. The scale and complexity of tactics available to those who have more personnel at their disposal increases considerably. I will highlight the organizational mechanisms that lead to this outcome below.

- **Suckered or Tempted** (S, T) or (T, S): These are the outcomes of drive many into the "mutual fight" outcome, and make organizations able to manage sustained cooperation even more valuable. If one rebel fights or conducts an attack and the other does not, those that stay home make no ideological concessions, and bear no costs for actually attacking. The inability to cooperate also leads to single, smaller-scale attacks, and while these may yield more concessions than "mutually not fighting," on balance it is unlikely to produce either the quality or quantity concessions possible in the "mutual fight" outcome. However, particularly because of the environment and nature of rebellion, actors that have been exposed, caught, or sold out to the state, may not survive. Those who try to fight, but are exposed, caught, or sold out to the

[5] Discussed more below, each actor has a policy preference k_i, cooperation between two actors requires discounting the value of cooperation by the difference of the ideological distance, such that cooperation is taken to happen at the midpoint. This discount in ideology can also be weighted to reflect actors for whom ideological preferences are extremely important, or not.

state, are left more exposed to counter-insurgents (potentially at the cost of their own survival) and have lost the opportunity to advance their own preferred policy concession in that period. This may be analogous to two situations: an operative fails to complete their assigned task, or an operative informs on the organization to the state. Both are tremendous blows to the rebellion as a whole, and both alter the population composition. Shirking one's duty will cause operational damage to rebel goals, resulting in decreased pressure on the state, but also critically reveals information about the type of actor to the person she was directly interacting with as well as to those who might know that person.[6]

2.3 Organizational Solutions: Markets, Networks and Hierarchies

The dilemma outlined above captures the intuition of the problem actors face in organizing a rebellion at a micro-level. One solution for would-be rebels is to solve this problem collectively, through organization. Although there are many hybrid organizational forms, for both theoretical and analytic clarity, I focus on the three ideal types of social organization: markets, hierarchies, and networks (Arquilla and Ronfeldt 2001, Greif 2006, Powell 1990, Sageman 2008, Williamson 1981). Below, I draw the analogy of these ideal types out to rebel organization structures. An underlying assumption in this analogy is that the more actors in the rebel population who are able to solve the dilemma above and get to the "mutual fight" outcome will leads to more rebellion, which in turn leads to increased pressure on the state to provide concessions.

Conceive of the population to be the set of actors who are geographically or ideologically proximate to the rebel organization. This includes both the supporters of the rebel organization as well non-supporters or those who may be antagonistic to the rebels' purpose, goals, tactics, or even existence.[7] Some rebel organizations emerge in environments that

[6]The dangers of defection in revealing information about the group are highlighted in Berman (2011), Popkin (1979).

[7]In an age of growing digital recruitment and radicalization, the population is even more challenging to

are quite hostile to them (e.g., Timothy McVeigh or the eco-terrorists the Earth Liberation Front). These are examples of lone or small numbers of cooperative people working toward a policy change, but who are very distant ideologically from the median citizen in society. Alternatively, some organizations emerge in populations of entirely sympathetic actors. At its height the Eritrean Liberation Front engaged nearly the entire Eritrean society, with women forming very large proportions of its fighters. Most familiar rebel organizations fall somewhere between these two extremes: a large number of active or potentially sympathetic people, and a large proportion of those who do not support the goals of the rebels, or who actively support the goals of the state it opposes.[8]

The organizational ecology, modeled below, is the *set* of organizations a population adopts and has profound implications for the system, as well as for the welfare (and likely success) of the actors in it. The success and function of one organization depends on the constellation of organizations in the environment as well as the population of actors choosing between organizations. Markets, networks, and hierarchies are typically treated separately rather than as substitutes for one another, particularly in looking at violent organizations; however, one of the primary contributions of this piece is to point out that they do not survive in isolation, but based on their ability to attract members at the expense of the organizational alternatives.

Additionally, I examine how actors within the population are affected by the distribution of types within the population, their beliefs about the population of actors, and the behavior of others in the population (which ultimately produces the organizational ecology). Individual attributes interact with the population to determine the behavior and organizational choice of other actors within a population. Together, I argue organizational ecology and population dynamics have been largely absent from work on the determinants of rebel organizational structure and how those structures are likely to respond to pressure.

pin down concretely; however, the element that is most critical is the likelihood of interaction with others.

[8]Below, these preferences are captured by k, and extremists are closer to 0 or 1, relative to the median in the population (default 0.5).

2.3.1 Rebel Markets

As above, markets are characterized by relatively unconstrained interaction. Cooperation to fight is always possible, but only among actors predisposed to cooperate to fight initially. In the world of rebels, lone actors or small "groups of guys" may pursue their agendas against the state, and may cooperate, but lack of social cooperation on their part may lead to higher rates of defection. These "organizations" are *ad hoc*, flexible, and local (see Sageman (2008)).

Local militia movements or local rebellions are examples of this baseline organizational form. Likewise Timothy McVeigh, who used one-time accomplices and immediately available materials, captures the intuition behind this form of organization. Attacks by market forms of organization may be one-off or sustained, but this is dependent largely on short-term cooperative interactions that themselves may or may not be sustained. Many rebel movements begin in this organizational form in which individuals may coalesce into small, temporary groups.[9] This may lead to one-off, unsustained protests against the state, or events that may be lower personal risk. These "local" groups sometimes consolidate and formalize into other organizational forms, but often do not (in the case of militia movements).

Without taking ideology into account, cooperation will be common among actors who are inclined to fight, by nature. With ideology taken into account, cooperation will be common between actors only when their ideological goals are fairly similar. Even with mutual cooperation as a clear equilibrium, the composition of the population (whether prone to fighting or not), be a critical determinant in whether or not a grassroots, mass rebellion can be coordinated.

2.3.2 Rebel Networks

A core theoretical feature of networks, and key to modeling them here, is their role in transmitting information about who is likely to be a "good" member of the group. Rebels

[9] Often these early forays are linked to some characteristic that reduces the ideological distance between actors— potentially both actors are members of a similar social or ascriptive group.

outside of tight, formal hierarchies are often able to cooperate and coordinate, but do so by passing information to each other about another actor's "reliability." This allows for ideological and behavioral type to be transmitted to those who are going to interact with him. The network allows people to learn who has defected or shirked, more extreme or moderate, and might be likely to be bought off by the state. The cost of information in allowing coordination and cooperation to take place is very important. In rebel contexts, the cost and risk of passing information may be quite substantial in exposing actors to the state. However, the value of information from trusted sources (e.g., family members, classmates, soccer team members, or church members) can allow for cooperative networks to flourish, and prevent rebel members from being left in the lurch. For example, groups based on kinship may allow them to shortcut this problem, particularly early on (Kahler 2009, Peters 2012).

2.3.3 Rebel Hierarchies

Hierarchies are often among the most successful, and certainly most visible, rebel organizations. Centralized enforcement allows hierarchical rebel organizations to specialize their operations in a way those in market and network forms cannot. Because effective enforcement ensures cooperation (and decreases concerns about free-riding or defection to the state), these groups are able to specialize, increasing economies of scale, and by extension pressure on the state. We only observe specialization of tasks in hierarchies—and this specialization happens over time as confidence in hierarchies, and their ability to enforce cooperation, increases.[10] The IRA's units were given highly specialized tasks, but punishments for defection were also severe.[11]

Hierarchy is beneficial to the group and the individual. Larger returns in the form of pressure on the state is good for the organization, and the individuals who see (more

[10] While not modeled directly, for reasons of parsimony, the ability to specialize because enforcement of defection follows directly from Williamson (1979) and the literature on relational contracting that follows.

[11] A meta-specialized units of enforcers were created to ensure cooperation.

immediate) returns to their effort.[12] At a lower, operational level, hierarchy solves the trust game at the core of the rebel's dilemma. It allows for centralized punishment of injuries another member of the organization. In essence, an effective hierarchy alters the behavior of someone in the organization who might *not* have shown up at the bridge otherwise, and preempts someone who might be tempted to inform the state of plans. It makes "good" behavior more likely, lowering the risk for everyone else in the organization.

3 An Agent-Based Model of the Organizational Ecology of Rebellion

Because individual characteristics, histories, and beliefs aggregate to the population level, a closed-form model might not be an appropriate choice. Instead, this paper uses an agent-based model (ABM) to simulate how a wide array of populations adopt, and change organizational forms, and the implications for rebel organization. I join work using computational techniques to study violent populations and core issues in the international system (e.g., Bennett and Pechenkina (2017), Cederman (2003), Weidmann (2016)).

ABMs are formal theoretical tools; unlike closed-form formal models, which generally focus on a small number of actors in a well-defined strategic setting to focus on strategy, the model here shifts attention to the attributes of the *population* of interacting agents (i.e., rebels).[13] This treatment takes both a broader (population and ecological) as well as a more micro view of the problem than commonly seen in conflict. Models of these sorts have been applied by ecologists who study the effects of changes in populations on ecosystems: how does an increase in the wolf population change the deer population, and how does a decline in the deer population change the underlying resource base for other flora and fauna? For further discussion see Carroll (2016). For applications of ecology to political science see, for example, Abbott, Green and Keohane (2016). The most important and interesting implications come from variation in the size and composition of the rebel population as well as the role and

[12] Additionally, hierarchies are more likely to be effective at governing and providing social services (See Berman (2009), Heger and Jung (2017), Johnston et al. (2016), Wagstaff and Jung (2017)

[13] To gain the flexibility in the population, I allow agents only a limited number of simple, fixed strategies.

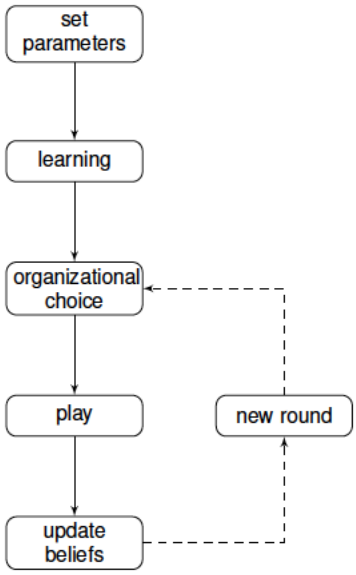

Figure 2: Schematic of the stages and order of the ABM

response of the state to the rebels as proxied by several parameters: starting population size and composition, as well as payoff structure for interactions.

This section briefly describes the model. The core model has three stages: initialization, organizational choice, and play. Each are described below in sequence. Figure 2 depicts the phases described below.

3.1 Initialization and learning

In the first phase, the user specifies the initial population in which the rebellion is taking place, and the underlying cooperation problem. Payoffs for the four outcomes to the Rebel's Dilemma (see 1) are set in the initialization phase: T, R, P, and S.

I focus on three basic strategies types to compose the population: always fight (ALLC), never fight (ALLD), and "swing" type that follows a tit-for-tat strategy (TFT). From the rebel perspective ALLC and TFT are "nice" strategies that begin by cooperating to fight with new actors, while ALLD is a "nasty" strategy—the most reluctant to fight. Below, I refer to nice and nasty populations as defined by the relative proportions of these two sets of agents.

Perhaps counter-intuitively, "nice" means likely to cooperate within the rebel movement. Nice populations are highly cooperative toward rebel goals; indeed, these are the types of actors who will *always* fight. ALLCs are ideologues, always willing to cooperate in pursuit of an attack. These are the most committed members of the rebel organization who are *so committed* they are willing to pay high personal costs to increase the probability of cooperation. TFTs are "joiners," members of the rebel population willing to fight but who will not fight alone. The TFTs are the "swing" population in many respects, they might fight if others are fighting, and will be reliable in that sense, but if the rest of the rebel fighters are *not* fighting, they will stay home. These actors are "reconcilables" Kilcullen (2009), those most likely to be "bought-off" by counter-insurgency forces or integrated into mainstream politics.

The ALLDs are the members of the rebel population who are most reluctant to fight. If given any choice they would not cooperate, not join a larger rebel movement: the most difficult to recruit. These are the child soldiers, those who are coerced into service of the rebel organization, but who otherwise would not participate. They may also be members of the "general population" who are within rebel territory or reach and who cooperate only under threat of greater harm. These people have been bought off, threatened, held hostage, or become dependent on the public goods and services that many rebel organizations provide such as education and healthcare (e.g., Hamas, LTTE). These members join the organization not because they "want" to, but because it is the least bad alternative.

Once the initial parameters are set, agents interact according to the structure depicted in 1 for a short number of rounds, allowing them to begin to form beliefs about the population.

3.2 Organizational Choice

Once the learning period concludes, the main simulation of interest begins and continues for a fixed number of rounds. A round is defined by two actions: the organizational choice of each agent for that round and the actual play in that round. Agents begin each round

by calculating their expected utility for joining each type of organization and select the one they calculate will yield the highest return. The expected utility for market interactions is the same as an agent would get in play during the learning phase described above.[14]

3.2.1 Modeling organizations

Markets are the organizational form implied in a "standard" prisoner's dilemma. Within markets, cooperation to fight is possible, even likely, in some populations, but most likely between actors playing "nice" strategies or those that at least begin by cooperating with others. While markets are important in their own sense as an organizational form, they also serve as a default option and baseline organization against which other organizational forms can be compared. All agents interact in the market if they do not choose another organization.

I model networks as organizations with two primary functions: providing information that allows players to acquire information beyond the two-player structure, and connecting players repeatedly: "selective affinity." Both features are often understood as mechanisms to acquire information on agents from other agents with whom an agent has cooperated in the past. Intuitively, networks allow one agent, say i, to ask a defined number of agents with whom it has previously cooperated if they have played agent j, and if so what j did (cooperate or defect in the PD) and what is j's ideal point (p_j). With this information, agent i can then decide whether to cooperate or defect with j. Thus, networks provide information that supplements the information i may have acquired through its own past interactions with j. The primary effect of information from the network is to prevent agents from being "suckered" in the first round of play with any new agent. I focus on the information transmission function of networks.[15] Often treated as a defining attribute of networks, here reciprocity is an emergent property of the agents who tend to select themselves into networks (see Powell (1990, p.303) and Podolny and Page (1998, p.59). Only agents that possess a contingent strategy will

[14]See expected utility calculations in the Appendix.

[15]Information sharing can be understood as a form of indirect reciprocity. See Nowak and Sigmund (2005).

ever choose to join a network for its informational mechanism, and having joined they will receive information from the other agents, update their knowledge of the particular agent they are paired with in this round of play, and play reciprocally. Participating in a network is always costly; represented here as a fee (ϕ) subtracted from the agent's payoffs no matter the outcome of the game. This fee is intended to capture the transactions costs of networking, variously interpreted as the opportunity costs of providing information, engaging in activities intended to develop social capital, and sending costly signals of commitment to the group necessary to establish trust or reputation. In order to account for the risk associated with passing illegal information, the network cost is relatively high. Agents may join a network and gain information about other agents even if those other agents are themselves choosing a market or hierarchy. In such a case, the networked agent plays with the information acquired from past cooperators, but the other agent plays using only its private knowledge.

Networks are a way to "buy" information or a greater probability of an amenable partner in the future. Essentially networks buy players information, either through personal experience or the experience of their "friends," about the behavior of the actor with whom they are interacting. With Selective affinity, players are able to pick a partner they like, with a known probability.

Agents within the hierarchy cooperate with one another subject to punishments for defection. If an agent defects, it receives the temptation (T) payoff minus the punishment, while the other receives the sucker's payoff (S).[16]

A second key attribute of hierarchy is the ability of the third party—the ruler, leader, or boss—to command legitimately certain actions by their members. The model represents this authority by assuming cooperation occurs at the hierarch's ideal point *(p_h)*. Thus, payoffs for cooperation in an intra-hierarchy interaction are adjusted by the difference not between their individual preferences, but each agent's ideal point and that assigned for the hierarchy as a whole *($k_{ih} = w(—p_i\text{-}p_h—)$)*. In this way, agents are understood to subordinate themselves

[16]When both agents in a hierarchy defect simultaneously they each receive the DD payoff minus the punishment. With the default settings in the ABM, mutual defection is typically rare but remains a possibility.

to the preferences of the hierarch.

Agents in the hierarchy who interact with those outside play as in the market. Thus, cooperation is mandated and subject to centralized enforcement *only* with other members of one's own hierarchy. In other words, the rule of law represented in cooperation at the hierarchy's ideal point and centralized punishment for defection does not apply "extra-territorially," beyond the members of the same hierarchy.

The utility for entering a hierarchy depends on the proportion of the population in the hierarchy the player will join (θ), weighed against the likelihood of cooperation within the hierarchy (q), the punishment for defection (v), and the ideal point of the hierarchy (p_h).

3.3 Play

After agents choose their organization for that round, the next stage is actual play within each organization. As in the learning phase, agents are randomly paired, or, if selected into the affinity world, paired accordingly. If a player selects the market it plays its fixed strategy. For non-contingent strategy types (ALLC and ALLD), information from the network is irrelevant, since they play the same move regardless of the type of other agent. These agents select the network purely for the affinity benefits: the likelihood of being paired with a desirable partner. Since only contingent strategy types (TFT) can potentially benefit from information on other agents, only these agents will use the query mechanism. If a TFT agent selects the network, it queries the specified past cooperators about the agent with whom it has been randomly paired and be given a number [0,1] representing the probability of cooperation to expect from that partner. If that agent believes the other agent is likely to cooperate (the probability is ≥ 0.5), it will cooperate, otherwise the agent defects. The information returned from the network is treated as equivalent to the agent's own beliefs about the randomly paired agent acquired through direct play. That is, if agent i has no past play with agent , and it receives a signal from the network that j cooperates 0.7, it will update its belief about j's type to 0.7. Similarly, if i believes on the basis of a single

Table 1: Play by Strategy and Organization

Strategy/Organization	Market	Network	Hierarchy
ALLC	Fight (Cooperate)	Fight (Cooperate)	Fight alongside members of Hierarchy at rate q, else Fight in the market
ALLD	Not fight (Defect)	Not fight (Defect)	Fight alongside other members of Hierarchy at rate q, else Not fight
TFT	Fight if paired with an unknown actor, else do what agent did in previous round	Fight if it believes opponent will fight	Fight alongside members of the hierarchy at rate q, else play TFT

past interaction that j cooperates 1.0 and it receives a signal from the network that j has cooperated with five networked agents at a rate of 0.7, it revises its belief about j to 0.75—weighting its own experience equally with those received from the network. In this way, I assume all agents are sincere in their reporting and are known to be so by all other agents.[17]

If the agent joins the hierarchy, its play depends on whether or not it is matched with another player in the hierarchy, either through random draw, or affinity in the hierarchy. If the two players belong to the same hierarchy, the agent will cooperate at the rate that the hierarchy enforces (q). If the agent defects ($1 - q$), it will be punished at the defined level (v). If a player is matched with a player outside of its hierarchy, it will play as if in the market.

[17]This is an important assumption. If agents lie or even communicate poorly (e.g., perform the kinds of minor distortions familiar to children from the "telephone game"), networks may actually harm rather than increase utility by causing contingent players to engage in bouts of mutual punishment (See Downs, Rocke and Siverson (1986)). Redundant responses from the network are not discounted or discarded. Intuitively, in real interactions we often do not know exactly where a friend of a friend received their information about some other actor. Given the strategy types examined here are pure, this assumption has no consequence for any of the results. If a strategy type plays C (fight) or D (not fight) probabilistically,redundant responses will lead to biased estimates of the agent's type, although on average beliefs will still converge to the true type.

Real payoffs are calculated as a function of the outcome of play, adjusted for the players' ideal points (κ) if the outcome was cooperative, punishments, and fees prescribed by their organizations. Actual payoffs can differ from expected payoffs, but are on average the same.

The primary interest here is in organizational ecology, specifically, the organizations selected overall and by specific strategy types under varying parameters and the real payoffs of the agents. The overall strategy is to simulate organizational choice and payoffs under varying conditions by incrementing the selected parameter values over some range. Incrementing one parameter at a time is roughly equivalent to comparative static predictions in closed form models. Because several parameters are randomly assigned according to specified distributions in the initialization phase, and agents are randomly paired at each round of play in both the learning and organizational phases, no two simulations will be identical. For the results below, unless noted otherwise, I replicate the simulation 10 times for each increment of each parameter and report the average of the results.

4 Theoretical illustrations of Rebel Organizations

The organizational ecology of rebels has often been characterized as networks or hierarchies.[18] The literature divides rebel groups primarily into either networked (or flat) organizations, or hierarchies of one type or another. The structure of the organization has profound implications for counter-terror and counter-insurgency strategies, but the factors that will cause these organizations to shift are largely unknown.

Here, I illustrate several insights of the ABM to the organizational ecology of rebel organizations. In many cases, but particularly that of rebellions which are composed of many individuals and potentially many organizations, the interactions are rarely reducible to two unitary actors. In order to study behavior in and adoption of different forms social organizations—namely markets, networks and hierarchies—population models such as this are particularly valuable. These models are able to show the value of explaining phase

[18] For example Sageman (2004).

shifts in behavior that can have important consequences. I show the emergent properties from the simulations whose implications are tested below. Each of the figures below can be thought of as a comparative static result, I sweep a single parameter and trace changes in the organizational ecology of the rebel actors.

4.1 The potential frailty of networks

In contrast to much of the conventional wisdom on the utility of networks for rebels (Kahler 2009, Sageman 2004, 2008), one of the implications here is that under certain circumstances networks can be quite fragile. In the simulations illustrated in Figure 3, I sweep the size of the population and look at when TFT agents likely to use the network, select that organizational form. The figure illustrates clearly that the larger the rebel population, the less likely networks are to be selected by agents.

While it might be intuitive to assume larger populations favor networks as it takes more iterations of the game for agents to acquire direct knowledge of other agents, therefore making networks more valuable. Yet, as illustrated by these simulations larger populations *also* mean that the network is less likely to return information useful to the agent about the agent with whom it is randomly paired. Indeed, as the number of actors in the population increases, the probability of receiving useful information falls.[19] In very large rebel populations, "small" networks are of little value and not chosen. Essentially, if the fellow insurgent with whom you are interacting is unknown to you and to many of your trusted colleagues, you are unlikely to trust them to cooperate or you will be unwilling to pay a high ϕ to try to discover their type. Additionally, as ϕ increases, the cost of passing information in a clandestine environment quickly overwhelms the benefit if markets or hierarchies are viable alternatives. Ultimately, when the set of agents with whom an agent may interact is large, the preferred organizational form quickly becomes either market or hierarchy.

This pattern indicates networks are most valuable in smaller populations. It may also

[19] In all cases, allowing duplicates reduces the probability of a useful response. In the model, I do not adjust the expected utility of networks for redundant responses.

suggest that while they might be quite durable in time, there are natural limits on the size of "networked" violent organizations. While the media portrayal of "terror networks" is ubiquitous, it is worth looking at the actual number of participants. What we may be observing could be a network of hierarchies in which the connections are between a few in the upper echelons, not across the grassroots membership of the rebel organization. Additionally, it is worth noting ALLCs do not use the network. They are either in the market (working as lone actors with their own interpretation and implementation of violent ideology) or move directly into the hierarchy.

The early experiences of the Eritrean rebel groups trace through this organizational path. The Eritrean Liberation Movement (ELM) was the dominant rebel group in the 1960s. However, its networked structure of "highly secret cells and lack of clear and quick communication" ((Iyob 1997, p.104)) created operational difficulties as the constituency of Eritrean rebels expanded. Though passing information is one of the key functions of a network, passing information in the rebel setting comes with significant cost and risk, exposing these actors to the state. As the population expands, fewer actors have direct links with everyone in the potential rebel population. In high cost interactions such as these, actors in small populations might know everyone in the population (or know someone who knows them), through a religious organization or sports club, but as the population grows, transmitting information to more and more people compounds the problem of cooperation at the base.

The Eritrean rebel organizations confronted this problem: their population outstripped its organizational capacity, given the risks. It solved this problem organizationally with the more hierarchic Eritrean Liberation Front (ELF), superseding the ELM. This transition happened as the costs of an underground organization in an era of increasing state surveillance quickly began to outpace the benefits (Iyob 1997). The networked ELM gave way to the more centralized ELF, as both the costs of communication as well as the size of the Eritrean

audience grew.[20]

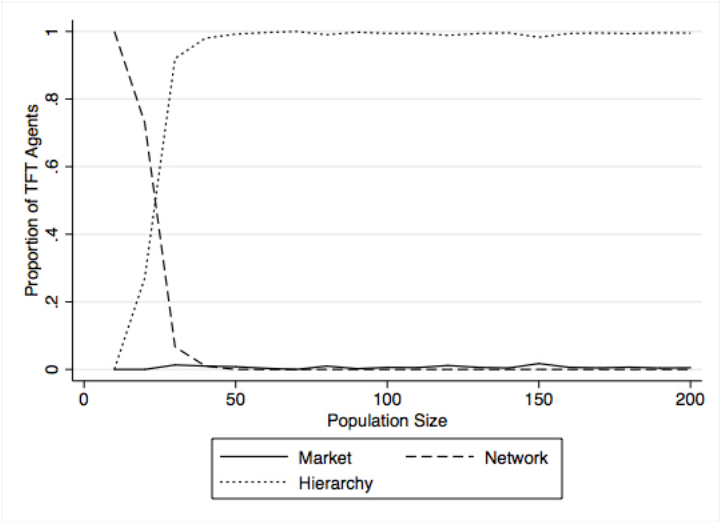

Figure 3: When rebel networks might be fragile. This simulation shows TFT organizational choice as population size increases. [21]

Taken together, the first implication of the model is that: *More agents will join the hierarchy as the rebel population increases.*

4.2 When are rebel hierarchies dominant?

If networks may be more fragile than initially suspected, we now turn to the conditions that lead hierarchies to dominate the organizational ecology. Asal and Rethemeyer (2008), Heger, Jung and Wong (2012) show that hierarchical organizations are the most lethal, and the most capable of inflicting damage. These findings indicate that the hierarchical organizational form, and the behavior of agents within hierarchies are particularly important to study when looking at the organizational patterns of rebels. Specifically, this requires unpacking the entrance and exit of different "types" of actors into the hierarchy. In both the Basque and Eritrean conflicts, networks and markets gave way to hierarchies in the way Figure 3 suggests.

[20] After this point ELF became increasingly centralized, divided territorially with officers responsible for security, logistics and health care within each zone (Iyob 1995: 111).

The model helps to explain hierarchy as an equilibrium of many egoistic actors. Given high enough incentives to act against the state, even population that is sufficiently uncooperative toward the rebel goals, agents join a hierarchy and submit to its possible punishments in order to secure the benefits it facilitates. By enforcing cooperation between agents, hierarchy improves their expected utility such that they chose to subordinate themselves to centralized rule. The larger the exogenous probability of defection and the larger the punishments for defection, the more "reluctant" agents are to join the hierarchy. But given a sufficiently nasty population, agents of all types will eventually subordinate themselves to hierarchy. Nonetheless, there are several important implications.

Figure 4 shows the order in which agents of different types enter the hierarchy, as the population becomes increasingly nasty (along the x-axis). The most "hardline" rebels (ALLCs) seek the safety of the hierarchy first, while those resisting (ALLD) linger in the market in order to exploit hardliners trying to "recruit" them.[22] Forming a hierarchy is the only way in which ALLCs will ever see payoffs that are greater than the mutual defection (P) outcome as the population becomes more uncooperative. They are willing to join hierarchies that might be less efficient, have larger penalties and taxes, or which are ideologically distant. In rebel organizations, these are the most committed members of the organization.

TFT agents are the next "wave" of agents to enter into the hierarchy. These agents enter after all the ALLC agents, after the probability of being "suckered" into showing up at the bridge alone has passed, but only if you do so in the hierarchy. TFT actors that enter the hierarchy at this point are able to sustain cooperation with both the ALLD agents (who are fellow hierarchy members) as well as ALLC agents both within the hierarchy, as well as those remaining in the market. Although not as committed to the cause as the ALLCs, they are sympathetic to the goals. Many of ETA's early members advocated a non-violent approach, but acquiesced to a strategy of violence later, mirroring this consolidation.

ALLD agents enter the hierarchy quickly after the TFTs. Entering the hierarchy means

[22] See also Figure **??**.

they will enjoy (with near certainty) the benefits of cooperation in the hierarchy. At the point the ALLDs join the vulnerability that drives the rest of the agents into the hierarchy first now creates a herd effect, illustrating the intuition behind looking at population dynamics. These agents will be eager to leave if there is a viable alternative organization (likely another hierarchy). The variation due to composition of the population provides the second implication: *Given benefits to cooperating against the state, more agents will join the hierarchy as the population becomes increasingly "nasty" and prone to defection.*

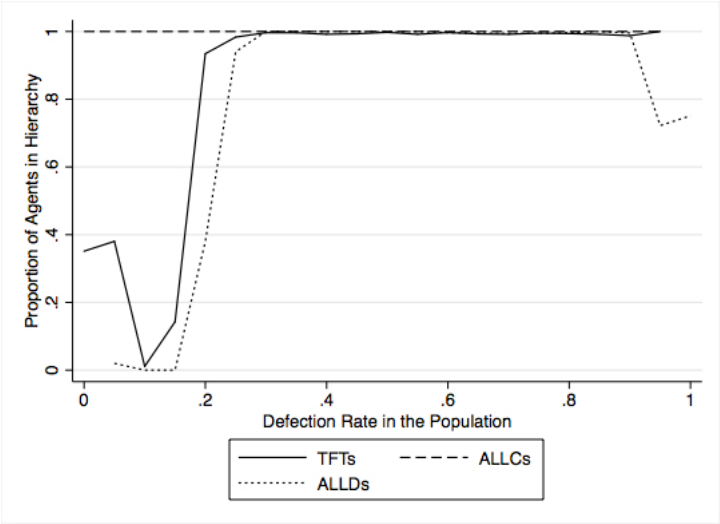

Figure 4: Proportion of different strategy types joining hierarchy as the population becomes increasingly uncooperative.[23]

4.3 Why are rebel hierarchies dominant?

The analogy to the Prisoner's Dilemma is premised on the idea that mutual cooperation among rebel groups can lead to advantages, and those advantages can translate into success, either tactically or in extracting political concessions. In fact, as the benefits to cooperation increase, hierarchy becomes ever more attractive to rebels.

The expected magnitude of these gains becomes particularly important here. This is an area that the government has more control over. Their response is represented in the magnitude of the mutual fight payoff (R). Figure 5 shows changes in the organizational choice

as the benefits to cooperation are decremented from 3.5 to 1.0. Theoretically, these benefits are a result of both the concessions granted and the likelihood of obtaining concessions. Against strong states, the net magnitude of cooperation (the size of the cooperative outcome, the concession granted from the state) decreases while against weak states, the size of the concession increases.

This focus on expected concessions is the crucial difference driving the shift in organizational structure that we observe between Eritrea and Afghanistan. Even as the costs to continuing rebellion increased in both states, rebel forces in Eritrea coalesced into a single hierarchic organization, while immediately after the Afghan invasion in late 2001, Al Qaeda seemed to fracture.

In the late 1970s, as the EPLF began to hold territory on its own against a weakened Ethiopian government. Instead, the hierarchical Eritrean People's Liberation Force (EPLF) was solidified from the factions of various groups (Pool 2001, 64) as the size of the prize—a state of their own—came into focus. In Afghanistan, al Qaeda's hierarchy broke down in the face of ever increasing costs imposed on the organization, and diminishing returns. The organization flattened to focus on survival. Similarly the Ugandan rebel group the Lord's Resistance Army (LRA) began as a larger hierarchical structure then disbanded after attacks to smaller bands of fighters.[24]

Figure 5 shows if gains to cooperation are minimal, the incentive to cooperate in hierarchy is fairly low. Only as potential gains to cooperation jump (significantly) do TFT agents see the utility of either network or hierarchy. Essentially, the costs associated with either of the two "formal" organizations are only worth it when the gains offset them. It also shows there are fairly sharp cut-points at which the hierarchy will become a viable and popular organization. As would be expected from the prior analysis, ALLCs are likely to see gains from sustainable cooperation as more valuable earlier. They leave the market for the hierarchy unanimously. TFTs leave the market and the network for the hierarchy next, and

[24] http://news.bbc.co.uk/2/hi/africa/7885885.stm

lastly the ALLDs.

An interesting policy implication emerges: by lowering the potential "gains" to a middling range, governments may be able to satisfice a majority of the population that is vulnerable to being recruited into the hierarchy (depending on the distribution of agents). Legalizing political parties is one such avenue; if there is a legal avenue, groups may find they have less to gain from violence. They may be able to use mainstream politics to "buy off" those who would be satisfied with a moderate solution. In the Basque case, the 1960s and 1970s were an era of profound internal disagreement about the nature of Basque rebellion. The Marxist factions of the movement were eventually shut out of cooperation within the main movement. These factions integrated into mainstream Spanish politics. While this did not end the rebellion, the acceptance of this branch of the Basque movement into institutionalized political contestation in Spain, essentially eliminated a portion of the rebel population.

A stronger rebel group vis-à-vis the state would also affect the expected utility of cooperation. All else equal stronger rebels should be able to have a higher probability of extracting concessions from a weaker government, which should lead to the perception of higher payoffs for mutual cooperation. Strong rebel groups should be more likely to organize hierarchically.

This insight about the utility of hierarchy in sufficiently nasty populations has broad application to rebels. Any environment in which the population cannot be counted on to reciprocate cooperation voluntarily will tend to be organized hierarchically, even when the "hierarch" is not necessarily representative of the policy preferences of society, or even the subset of that group. This patterns leads to the following implication:

More actors join the hierarchy as the benefits to fighting increase.

4.4 Changing Incentives to Fight

To this point, the state has been largely black-boxed, a fairly extreme assumption. Indeed, intuitively, one of the key determinants of an individual rebel's organizational choice and

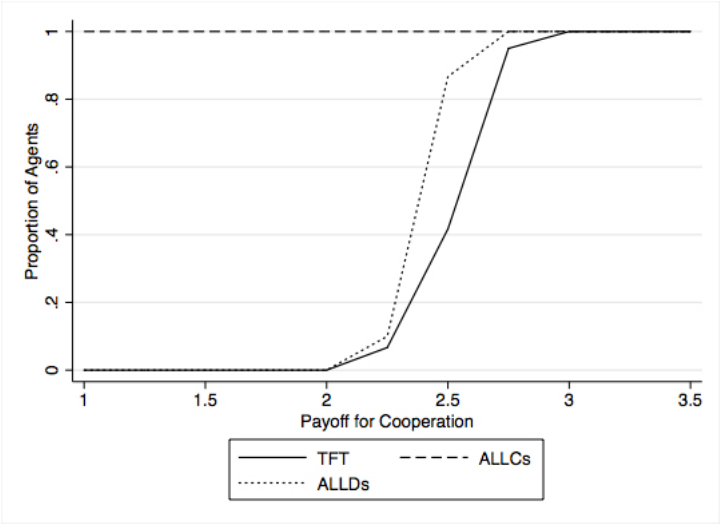

Figure 5: Benefits to Cooperation. Hierarchy membership by strategy type. [25]

behavior is the fear of defection, and personally paying the costs of defection. States can alter the incentives for individual actors, and therefore the strategic space, by making the T outcome more attractive. This can be done by buying off individual rebels through a variety of mechanisms including policy concessions (Cunningham 2011) or bribing them for information (Berman 2009).

The effect of this shift is stark. Figures 6 and 7 highlight this dynamic, which has very interesting counter-insurgency implications for states. When the incentives or inducements to defect are low, actors of all types join the hierarchy. They get a high payoff from cooperation, and avoid mutual defection, which is now a relatively bad outcome. There is no true temptation to defect against someone who is cooperating if the value is sufficiently low. In a sufficiently uncooperative population ALLC agents, the hardliners, will never leave the hierarchy, no matter how large these incentives get—they can never be bought off. However, as the incentive to defect gets sufficiently large, agents do leave the hierarchy in waves. First the ALLD agents will leave, lured easily by slightly higher than "normal" payoffs in the market—this would be a small policy inducement or a small bribe. TFT agents require a larger payoff, but will also quickly leave the hierarchy. Taken together, these results, illustrated most clearly in Figure 7 indicate a (narrow) range of payoffs or concessions that a

state can make that will hollow out the hierarchy, leaving only hardline ALLC agents.[26] The reluctant, ALLD, actors who need only a small inducement to leave the hierarchy are happy to do so if the state can change the incentive structure; TFT agents who will go into the network or are willing to interact with the ALLDs in the market will leave the hierarchy for a smaller payoff. This indicates there are two levels of payoffs a state or counter-insurgency policy must be willing to make to separate the hardliners from those who joined out of a lack of alternatives. The key implication is *Fewer agents join the hierarchy, and persuadable agents leave the hierarchy, as the incentive to defect increases.*

This implication is consistent with the Petreus Doctrine and the cornerstone of modern counter-insurgency policy—a "hearts and minds" approach that argues that non-kinetic COIN (e.g., goods and services)—can alter these calculations and help separate out the reconcilable rebels in the population. It also highlights the key insight from Berman (2009): rebels are very sensitive to internal defection.

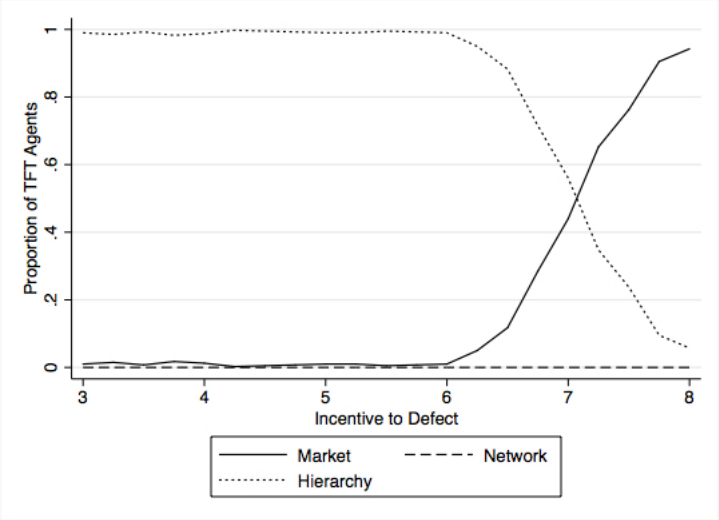

Figure 6: TFTs are reported here. As the incentive to defect is low, agents are in the hierarchy, including the TFTS.[27]

One of the second order effects of the phenomena depicted in Figures 7 and 7 is that not only does the size of the organization change, but its composition as well. Inducements that bleed the organization of "moderates" who can be re-incorporated into the state, either

[26]Potential concessions like a legalized political party are often observed.

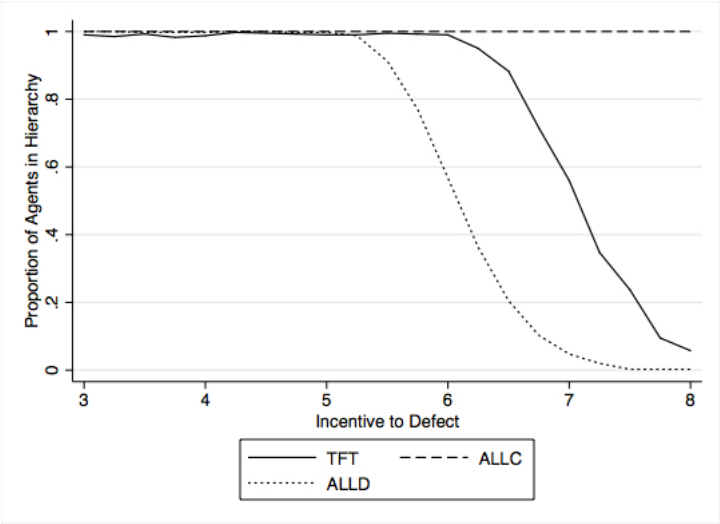

Figure 7: Exit from hierarchy by strategy as Incentive to defect increases.[28]

wholesale or as part of a licit opposition party, leave an organization (for some alternative, either network or hierarchy) of the most committed members and for whom inducements are least likely to prove successful. In the next section I turn to how COIN itself might be modeled, with an eye toward the importance of careful consideration of organizational alternatives in designing strategy.[29]

5 Simulating COIN and state-building

In addition to explaining how micro-dynamics aggregate, one of the advantages and the real power of ABMs is to simulate interactions of several moving parts, beyond comparative statics where one parameter is swept as in the simulations above. In this section I apply the model to take a theoretical look at how to simulate counter-insurgency intervention and state-building in those circumstances.

The assumption intervention affects the organization of rebellion has driven most state (both foreign and domestic) intervention in internal conflicts. Indeed, two of the most recent examples of large-scale American intervention—Iraq and Afghanistan—focused on the decapitation of non-state hierarchies from the start. Thinking about this problem in

[29]This dynamic is consistent with the logic of credit claiming described in Abrhams and Conrad (2017).

terms of organizational ecology helps us understand that intervention strategies that target these hierarchies may have the unanticipated side-effect of producing networked rebellions. In short, in destroying hierarchies, interveners have to be careful what they wish for.

Simulations of how COIN affects rebel organizational structure highlight where thinking about organizational ecology and using tools like ABMs may prove inconsistent with current COIN goals and dominant thinking. The model described in Section 3 is a relatively general model of cooperation and organizations, not designed to look only at rebels. However, there are clear analogies to the variables in the model that can be used to capture the effects that intervention would have, and most critically, how those variables will affect organizational choice. The major change to the architecture of the model is the introduction of a fourth organization—another hierarchy, to represent the state. In all other ways the simulations work as described above, but with the changes to the parameters described below, to model the effect of COIN on the ground:

Increases the benefits to fighting. Intervention increases the benefits to cooperation. The presence of COIN forces, boots on the ground, make it more difficult for rebels to cooperate with others, but also more valuable, meaning it is more important than ever for rebels to use organizations to cooperate.[30]

Increasing costs of hierarchy The second effect of intervention is to increase the costs of organizing as a hierarchy, particularly relative to networks. As with the first effect, this results from more "boots on the ground" making hierarchies easier to identify, and more valuable to disrupt. Members of rebel hierarchies are exposed, and more likely to be identified and killed in the presence of counter-insurgency. Additionally, disruption and destruction of these organizations is the core goal of contemporary hearts and minds COIN campaigns. From above, as the risks of being in the hierarchy, being identified and targeted become too high, the hierarchy gives way to a network. Indeed, the Marja offensive had this precise effect. As several thousand Marines and Afghan strops essentially sat on top of the

[30]In the presence of significant intervention footprint, only the most dedicated of actors would attempt "lone actor" attacks.

Taliban, all who were not committed members quickly left the organization.[31]

Increase the payoffs to not fight. Increasing incentives to defect from the organization is one of the core principles of contemporary COIN and the Petreus Doctrine. Incentives, in the form of material inducements or services, to inform on or defect against the insurgent group are the cornerstone of this strategy. This change, coupled with changing the benefits to fighting is also a part of the "accidental guerilla" dynamic Kilcullen (2009), in which part-time rebels are sensitive to the costs and benefits to fighting or not fighting– either increasing or decreasing those costs. Some of the early strategy in Afghanistan involved briefcases full of cash to get information on the local members of the hierarchy and to buy the support of tribal leaders or warlords.[32]

I show what happens when all three effects of intervention happen simultaneously, since there is really no way to separate them out in reality. These effects are displayed in Figure 8.[33] The x-axis shows what happens as simultaneously the benefits to fighting in the face of boots on the ground increase, as the costs of being caught and killed in the hierarchy are increased relative to the costs of being in a network , and as a hearts and minds campaign of payoffs to potentially swing people increase (rewards for information, and public works projects were both major prongs in the strategy in Iraq under Patreus). Here, "low" levels of counterinsurgency effort indicates low values of all three: small increase in the benefits to fighting, small increase in the costs of hierarchy, and a small increase in the payoffs for defection. Over the course of the simulation, each of the three is incremented up.[34]

What we see in Figure 8 is in many ways intuitive, but also interesting in terms of thinking about organizational ecology. Part of strategy in terms of intervention in terms of payoffs for information, payoffs to defect against the rebellion, we see what we would intuitively

[31] http://www.nytimes.com/2010/02/13/world/asia/13afghan.html

[32] Sometimes, through the Afghan government officials. http://www.nytimes.com/2013/04/29/world/asia/cia-delivers-cash-to-afghan-leaders-office.html

[33] Simultaneous changes in cooperative payoff—increased by 0.05 each of the 20 iterations, incentives to defect—increased by 0.05 each of the 20 iterations, and cost of rebel hierarchy, increased by 0.01 each of the 20 iterations. [Seed 491451].

[34] It is worth noting that the first effect works in the opposite direction, but is quickly subsumed by the other two effects working in concert.

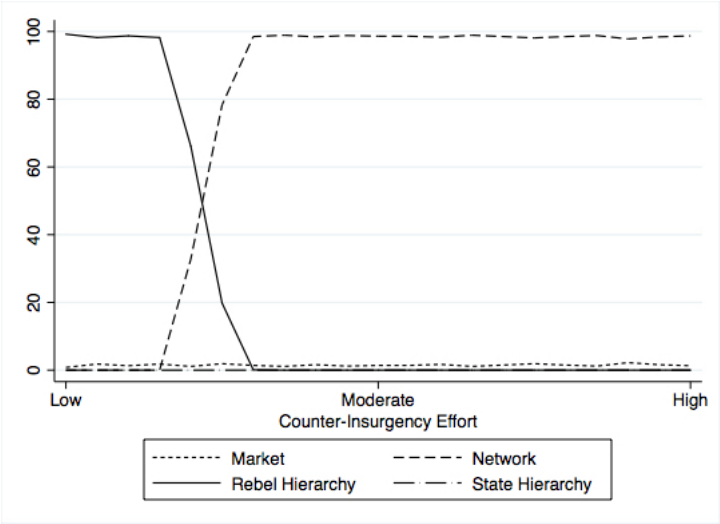

Figure 8: Effects of counter-insurgency on rebel organizational ecology.

expect. The reluctant actors will leave the hierarchy with small inducements, this makes the hierarchy less valuable for the "reluctant" and "swing" actors, and they will turn to the network[35] and the market, leaving only the hardline actors in the hierarchy.

A potential cause for caution quickly becomes apparent. The "good" news is there is initial success in driving rebels out of the hierarchy, as expected. These effects can happen with a relatively "light" counter-insurgency footprint, that increases these variables slightly, but simultaneously. It also means progress in damaging rebel hierarchies is likely to come quickly and visibly, leading to the temptation to declare "mission accomplished" or the end of "major combat" early on.

However, as noted, this decline in the hierarchy happens quickly and at low values of COIN. The second effect Figure 8 reveals is *where* those driven out of the hierarchy go. The simulations of COIN reveal though is that it is likely that many actors are not moving into "no rebellion," but rather into networked forms of violence, which are much costlier to fight. Networked rebellions must be dealt with piecemeal—rather than via decapitation (Johnston 2012).[36]

[35]This effect is consistent with Chai (1993).

[36]This tradeoff between connectivity and security is similar to the one demonstrated in Enders and Jindapon (2010).

5.1 Why state-building might not be "enough"

The effect highlighted above, in which COIN effort destroys the rebel hierarchy in favor of rebel networks, neglects the other goal of COIN: state-building. State and state-capacity building is the prong of COIN not robustly modeled above. The "state" is not perfect at ensuring internal cooperation and with high benefits. As a result, we observe it has difficulty getting off the ground and inducing rebels to transition into the state from the rebel hierarchy.[37]

A secondary effect is highlighted above: hierarchies can do very well and be quite robust, but this is most likely when they have a large proportion of the available population participating. Indeed, this may be a big part of why we see autocracies survive for such a long time. In effect by creating a large "bloc" of enforced cooperation, if you dont start off in a hierarchy, *and* you give people time to establish cooperation in the network or market, it will be very difficult for an alternative (state or rebel) hierarchy to get a foothold.

Ideally, COIN "should" work as simulated in Figure 9, where the demise of a rebel hierarchy is quickly met with the building of a state hierarchy that is able to enforce internal cooperation well and at a moderate ideal point. In Figure 9 I model the same rebel hierarchy, which we observe a nearly identical decline as above in Figure 8. In addition to that hierarchy, as above, I also model a State hierarchy as an organizational alternative. The modification to note here is that the state hierarchy is nearly "perfect."[38] In essence seeing the theorized "switch" from rebel hierarchy to state that bypasses the network and leaves only the most committed rebels in the market is a difficult result to produce, requiring implementing an OECD style "government in a box."[39] This means a near perfect state needs to be built quickly, effectively, and critically, get get large-scale buy-in from the population immediately.

[37] In recent work Bennett and Pechenkina (2017) look at the balance of kinetic and non-kinetic COIN.

[38] Specifications for COIN are identical as above, but State enforcement is 0.99, with a relatively small tax rate (0.1).

[39] Indeed, General Stanley McCrystal used the following language "We've got a government in a box, ready to roll in," described the Marja offensive strategy. http://www.nytimes.com/2010/02/13/world/asia/13kabul.html

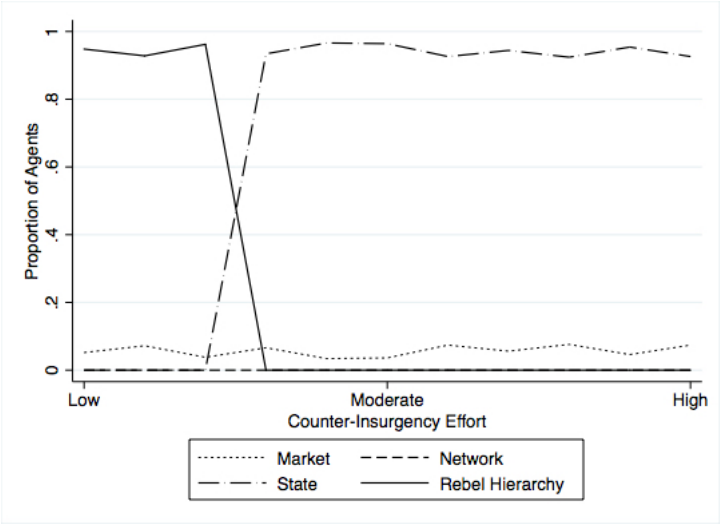

Figure 9: Ideal Counter-Insurgency and State-Building

Recent experience in Iraq indicates that non-state groups are likely to get a toe-hold in governance precisely where there isn't a robust state, meaning contexts least likely to support the "perfect" state after after. Governance in these spaces is likely to be particularly contested both by states and interveners, but also by violent groups. In the last two decades the city of Mosul in Iraq has flipped between state, coalition, ISIS governance, and back. While conjecture, it does not seem unreasonable to think that the "bar" might be higher for a new state to enter in such a context is not operating in a fresh governance space.

Indeed, the constellation of factors needed to induce a "perfect" switch as seen in Figure 9 are theoretically possible, but extremely costly and unlikely.[40] Understandably, it is risky for people to buy into a new state if we are thinking about implementing government in a box. The inducements to defect will have to be larger, and the security of enforcement will have to be larger. As many have noted, state-building rarely happens from "scratch" and bolstering the existing institutions is a difficult, risky, labor-intensive, and protracted task.

Instead, as born out in the cases of Iraq and Afghanistan in recent decades, COIN that first destroys rebel hierarchies is unlikely to transition immediately into perfectly (or even

[40]These simulations require essentially a perfectly functioning, low-tax state, immediately; indeed, as COIN is underway. As follows from understanding the dominance of hierarchies (Sections 4.2 and 4.3), there is some herding.

well-) functioning governments. As a result, the success in meeting the vision of "hearts and minds" doctrine is at best both difficult and costly. Intervention creates conditions that are very hard to fight and that will potentially create a more costly, more protracted fight, coupled with difficult state-building, which may exacerbate the increasingly difficult fight.[41] Thinking about organizational alternatives and organizational ecology where these policies are implemented sheds light on the vulnerabilities of the approach.

6 Conclusion

The importance of the organizational structure of rebel, insurgent, and terrorist groups is widely acknowledged, and attention on this aspect of conflict is growing. Indeed, it has been shown to affect many aspects and outcomes of conflict dynamics. I show that an ecological approach to rebel organizations highlights many potential pitfalls to understanding cooperation and intervention. The rebel application is particularly stark, but the model and underlying problem of social organization recurs in many other issue areas: economic organization, political mobilization, international organization and governance. In the application above, I hope to have demonstrated there is still great theoretical room to understand the complicated interplay that produces the particular organizational form. This has importance for an academic understanding, but also in understanding how, when and why counter-insurgency works (and does not).

The particular theoretical technique employed here emphasizes the importance of thinking both about individual actors and population composition, as well as considering carefully the role of organizational ecology. The set of organizations a given population, at a given time, adopts is a response to organizational characteristics, population characteristics, and the environment that is exogenously set, as well as aspects that are altered by intervention forces.

Organizational alternatives matter in thinking about rebel ecology, but the importance

[41] See Wimberley (2007).

becomes sharp when put in the context of understanding how interventions and counter-insurgency strategy that explicitly seeks to disrupt an organization. The examples modeled in the final section above highlight the potential pitfalls of not taking organizational alternatives seriously in intervention and state-building. Indeed, in any study where organizations matter, must consider about all three organizations as alternatives to one another.

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A Expected Utility Calculations

This section defines and explains the expected utility calculations that agents make when deciding to join a market, hierarchy or network. In addition to the user-defined parameters summarized in the table below, agents are defined by their probability of cooperation (γ), which is either fixed (ALLC $\gamma = 1$ and ALLD $\gamma = 0$) or variable (TFT $\gamma = 0$ or 1). For purposes of calculating an agent's expected utility (as opposed to the actual payoffs defined above in the text), $\mathrm{k}_{ij} = w(|p_i - \rho — /2)$, where ρ is the agent's belief (continuously updated) about the mean ideal point of the population. For the hierarchy, $\mathrm{k}_{ih} = w|p_i p_h|$.

In addition, the following endogenous variables are created and updated as the simulation unfolds:

β = the agent's belief about the cooperation rate of the population

σ = proportion of the population the agent has not already played

For each agent i:

A.1 Expected Utility in the Market

The payoff for a market interaction is essentially the probability of getting each outcome—based on the probability that the actor itself will cooperate (determined by their strategy type) multiplied by the probability that they believe their opponent will cooperate (determined by their beliefs about the cooperation rate in the population).

$$M = (\gamma\beta R - k_{ij}) + \gamma S(1-\beta) + \beta T(1-\gamma) + P(1-\gamma)(1-\beta) \tag{1}$$

A.2 Expected Utility in the Network

A.2.1 Expected Utility in Network for Fixed Strategy Players

$$\eta Z + M(1-\eta) - \phi$$

(2)

where η is the affinity rate in the network, and Z is the highest payoff in affinity memory (m_a).

A.2.2 Expected Utility in Network for Contingent Strategy Players

The expected utility from the network is essentially the likelihood that the player is picked into the affinity world times the highest payoff in its affinity memory plus the likelihood that it is not and surveys the network. The value of the network is essentially likelihood that the player receives information about its current partner that changes its behavior (in most cases to prevent being suckered, or receiving the CD payoff) plus the likelihood it does not, less the fee imposed to join the network and gain information (ϕ).

Agents choose that organization with the highest expected utility in each round. Actual payoffs may differ from expected payoffs for any individual agent, but on average will be equal.

$$\eta Z + (1-\eta)(\sigma[\frac{m}{n-1}(\sum_{\gamma=1}^{n}\beta\alpha^{\gamma})(\beta R - k_{ij}) + P(1-\beta)] + M(1-\sigma)) - \phi \tag{3}$$

A.3 Expected Utility in the Hierarchy

The utility for entering a hierarchy will depend on the proportion of the population in the hierarchy the player will join (θ), weighed against the likelihood of cooperation within the hierarchy (q), the punishment for defection (v), the tax (τ) and the ideal point of the hierarchy (p_h).

$$\theta\{(q^2R - k_{ih}) + qS(1-q) + [qT(1-q) - v] + [P(1-q)^2 - v]\} - (1-\theta) \tag{4}$$

Table 2: Default Values

Parameter	***Symbol***	***Description***	***Default Value***
General			
Increments		Times the simulation is run incrementing a parameter	20
Repetitions		Times the identical simulation is repeated with different random seeds	5
Rounds		Number of rounds of play	20
Mean for ideal point		Distribution of actors policy preferences in population	0.5
Weight on ideal	W	Weight on policy preferences	1.0
Learning rounds		Set as either number of rounds or population convergence to within a proportion of the true population mean	10 rounds
Agents (Total)			100
All Cooperate		Number of actors of type always cooperate	
All Defect		Number of actors of type always defect	
TFT		Number of actors playing tit-for tat strategy	
Payoffs			
R	R	Payoff for CC outcome	3
S	S	Payoff for CD outcome	0
T	T	Payoff for DC outcome	1

Table 2 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
P	P	Payoff for DD outcome	1
Hierarchy			
Initial size	θ	Proportion of the population in hierarchy. In first round of play, this variable is set exogenously; after the first round, this variable is endogenous and defined as the number of players in the previous round.	10
Penalty	V	Penalty for defection within the hierarchy	0.5
Prob of Cooperation	Q	Rate at which the agents cooperate with other agents in the hierarchy	0.99
Tax	τ	Tax assessed on members of the hierarchy	0.2
Ideal point	p_h	Ideal point of the hierarchy	0.5
Network			
Cost	ϕ	Fee for joining the network	0.3
Width	α	Number of past cooperative partners each agent i can ask for information about agent j	3
Depth	L	Number of levels agent i can survey	3
Memory	m_n	How many past moves each agent remembers within the network	5