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Organizational Ecology and Population Dynamics in Politics: An Agent-Based Model

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The dissertation of Danielle F. Jung is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

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DEDICATION

For my parents.

EPIGRAPH

Organizations are the main vehicles for action in society.

—James S. Coleman

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT OF THE DISSERTATION

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Professor David A. Lake, Chair

Markets, networks and hierarchies are the three core forms of social organization. They recur at all levels of social interaction as solutions to problems of cooperation. Disparate actors—from states, to "dark" actors like rebel groups, to voters—use these organizations to solve their cooperative problems. This dissertation uses a general agent-based model (ABM) to examine how organizations affect cooperation and welfare across several issues. Humans form organizations to enhance cooperation and wellbeing. Markets, networks, and hierarchies are the recurrent forms of social organization, but are typically studied in isolation. I use an ABM to look at when different types of actors choose to join (and thereby create) different organizations. The conditions that drive these choices include individual, population, and organizational attributes. Orga-

nizations allow for social actors to guard against exploitation, increase the likelihood of cooperation, and by extension increase social welfare.

I apply insights from the ABM to three topics: rebel organizations, alliance formation, and voter turnout in emerging democracies. I show rebel organizations form as networks when insurgents think the risks of defection are low, but shift into hierarchic organizations to protect themselves from defection as these risks increase. This finding has implications for counter insurgency policy. I also find that those most vulnerable to exploitation in rebel populations, such as child soldiers with no network to leverage, are more likely to join hierarchies at lower levels of risk than less vulnerable insurgents. Likewise, I apply the model to alliance formation, finding that "nice" states will join constraining organizations in higher numbers than their "nasty" counterparts. Finally, I study how voters in emerging democracies will use multiple organizations to promote high levels of turnout—bootstrapping the population into high levels of cooperation through social networks as well as institutional mechanisms. Embracing this multi-organizational approach in consolidating democracies can increase long-term political participation in many areas, both formal and informal.

Chapter 1

Introduction

Markets, networks and hierarchies are the three core forms of social organization. They recur at all levels of social interaction as solutions to problems of cooperation. Disparate actors—from states, to "dark" actors like rebel groups, to voters—use these organizations to cooperate.

Humans form organizations to enhance cooperation and well being. Cooperation within anarchy, or markets, is difficult and infrequent, keeping social welfare at low levels. Humans form networks to acquire information about others and, in some cases, to select partners with whom they have cooperated in the past. Networks are chosen by individuals when they are inexpensive and populations are small, but especially by actors who can use information about a potential partner to determine their behavior. Humans also join hierarchies because they can enforce cooperation. Even though they are themselves threatened with the prospect of punishment for following their self-interest, actors enter hierarchies for the greater benefits from cooperation induced by such organizations. Indeed, the nicest agents, those most inclined to cooperate with others, enter the hierarchy first for the protection it affords them. Hierarchies are particularly effective when the population is nasty, in which cooperation is especially difficulty and actors are prone to defection. Organizations allow for social actors—particularly vulnerable ones—to guard against exploitation and to increase the likelihood of cooperation, and by extension welfare.

I argue forms of social organization result from the organizational alternatives, the population of actors, and the interaction between the two. These two factors—

organizational ecology and population dynamics— drive how actors, and populations use markets, networks and hierarchies to solve their cooperation problems, and by extension their welfare and survival. The literature typically treats these organizations separately, comparing networks and hierarchies to markets (or anarchy), but not to each other. The literature on transnational policy networks, for instance, does not consider hierarchy as an alternative. Similarly, the literatures on international organizations do not examine when states choose that form relative to networks. Each literature tests its solution to the problem of cooperation relative to anarchy or the "market," but seldom are organizational alternatives considered as substitutes for one another. While these organizations can coexist, organizational choice is a zero-sum game at the margin: if an actor choose one, he or she is not choosing another organization for that interaction. As more agents use networks, fewer are available to create a large block of enforced cooperation within a hierarchy, or to interact in the unconstrained market. Organizations do not survive and prosper in isolation as early work has implied. I argue that they survive or not based on their ability to attract members, at the expense of the organizational alternatives, within a given population.The agent-based model (ABM) that forms the core of my dissertation is designed to study actors' choice of alternative organizations under a range of environmental and organizational characteristics. In short, I treat organizations within an ecological approach.

The second focus of the dissertation is on dynamics within the populations of actors forming these organizations. The survival of organizations varies largely based on the size and composition of the population. I find that small populations, where actors have a higher likelihood of returning valuable information from a "friend," favor networks over markets and hierarchies. As these populations grow and become more anonymous, agents will turn to the market, and increasingly the hierarchy to enhance their prospects for cooperation. Likewise, nasty or uncooperative populations favor hierarchies over markets and networks, where agents rely more heavily on "third party" enforcement to produce cooperation. Nicer populations are able to achieve high levels of cooperation in the anarchic market, or though networks that pass information about actors' past behavior. Specific actors within the population are also 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). Together these individual attributes interact with the population to determine the behavior and organizational choice of any actor within a population. I find nice actors in nasty populations join the hierarchy in greater numbers, and do so earlier than their nasty counterparts. These actors are likely the most vulnerable in the population, and do so to avoid exploitation. The same actor in a more cooperative population would likely opt to join the network or the market. Conversely, nasty actors will remain in the market to exploit nice actors, and will join the hierarchy only when it is the dominant form of organization. Likewise, pessimistic actors, who believe the population is nastier than it really is, join hierarchies, while their optimistic counterparts join markets or networks.

1.1 Findings

Studying organizational ecology and population dynamics produces both theoretical contributions to the study of social organization, as well as insights into various literatures. I present some of the major findings here.

This is the first model and theory to focus on markets, networks and hierarchies as viable alternatives to one another. This approach allows for broad application to many political problems, including those outside of international relations. Taking organizational ecology and population dynamics together, the ABM is uniquely suited to capture these social dynamics. The ABM is able to track the efficacy of organizations in contrast to one another, as well as the interaction with distributions of strategy types within a population, and individual choice and welfare. Many of the problems of cooperation involve populations of actors, and are not easily reducible to two unitary actors. The dissertation shows that forms of social organization result from the dynamics between organizations and population. The ABM, built from solid micro-foundations and simple rules of interaction, allows tremendous insight into complex behavioral patterns.

The most interesting properties involve interactions between population properties and organizational properties. I find organizational ecologies can become quickly entrenched, particularly in "nasty" populations. In these populations, agents enter hierarchies because they cannot find cooperative partners outside the hierarchy, this increases the value of the hierarchy further, making it difficult for cooperation to thrive in the market or network. Likewise, because actors do not update their beliefs about the population in the hierarchy, in relatively "nasty" populations, nice and pessimistic agents join the hierarchy's protection, but their beliefs about the population freeze as they remain there, further reinforcing that decision.

In addition to insights that advance the study of rebellion, security organizations, and voting, when taken as a whole, the applications in the last part of the dissertation show the power of a general ABM. Rebels, states, and voters all make organizational decisions based on organizational ecology and population dynamics.

I show that rebel organizations form as networks when the population is small or they think the risks of defection are low. Rebels shift into hierarchic organizations to insulate and protect themselves when risks increase, potentially because the state has increased the incentives for rebels to defect. This finding has tremendous implications for counter-insurgency policy. Alliance and collective security organization formation rests heavily on how states see themselves fitting into the overall population, and how they view their security prospects as a result, i.e., the organizational ecology of the security environment and the population dynamics of the international system. In particular, population dynamics drive vulnerable states to join constraining organizations earlier and in higher numbers than their "nasty" counterparts. Finally, I show how voters in emerging democracies use multiple organizations to promote high levels of turnout. Voters bootstrap the population into high levels of cooperation through social networks as well as formal institutions like political parties. Embracing this multi-organizational ecology in consolidating democracies can lead to long term political participation in many fora, both formal and informal.

1.2 Agent based modeling

In the dissertation, I emphasize how the characteristics of different agents within the population and the organizations interact to produce the organizational ecology. An agent based model is a particularly well suited tool to study these factors. It is difficult to model large numbers of actors elegantly in closed-form formal models. Additionally, often the secondary characteristics of actors, the population, or the population's decisions, allow for interesting insights into their organizational choices.

This dissertation requires a discussion of two very different literatures: organizations and organizational ecology, and agent based modeling. I discuss organizations in Chapter 2. Here I outline the state of the literature on agent based modeling.

Agent based modeling came into the mainstream in political science with Axelrod's Prisoner's Dilemma tournaments (1981). The intuition into cooperation problems, and the possibility of spontaneous order in the international system are powerful insights that capture much of political science today. Axelrod's later work, and that of Nowak and Sigmund 1993; 2005 advance the study of cooperation, the evolution of strategies in evolution. Work on complexity in social sciences (Miller & Page 2007, Axelrod 1997) and complex adaptive systems.

Agent based models have added nuance to our understanding of many problems in politics, particularly in understanding how large populations interact within their environments. These models have focused on two questions that have long captivated students of International Relations: the emergence of states and understanding changes in the system through war. Models of the underpinnings of state and nation formation and disintegration (as well as their geo-political boundaries) has been one of the most exciting work to emerge from this agenda (Cederman 1997, Cederman 1994, Cederman 2002). Likewise the size (Cederman, 2003) and severity of wars (Cederman et al., 2011) have advanced conflict studies. Agent based models are also particularly well-equipped to study fractionalization within populations. Work on ethnicity and other social attributes (Cederman et al. (2010), Weidemann and Salahyan 2010, Kennedy et al. 2010).

Within agent based modeling, there is a divide in modeling philosophy between creating general models that can be applied to a wide range of problems, or creating highly situationally-specific models to represent a precise environment in the real world. The model I present here falls squarely into the former camp. Modeling as a theoretical technique in general abstracts from many of the details to focus on underlying characteristics. Agent based modeling adds some complexity to that study by looking at large, often evolving, populations over time. My goal in this dissertation is to present a model whose principles extend to many problems and populations beyond those directly studied here.

1.3 Outline of Dissertation

Chapter 2 introduces organizational ecology, population dynamics and the key characteristics of markets, networks and hierarchies. These three organizations are found in many areas of political cooperation. Economic transactions occur in arms-length markets between anomic buyers and sellers, hierarchically-ordered corporations, or networks of co-ethnic traders. Insurgencies are carried out by ad hoc "groups of guys" who come together to plot and carry out attacks, by militias with commanders, ranks and insignias, or by networks of loosely connected cells. Social movements can arise in spontaneous, uncoordinated protests, as top-down disciplined organizations, or through tightly linked policy entrepreneurs who mobilize followers. Countries cooperate with one another under anarchy, in supranational organizations, and in small, deeply interdependent or "networked" groups of states. The scope and innovation of both organizational ecology and population dynamics are introduced. I review the literature associated with markets or anarchy, hierarchies, and networks and offer an "ideal type" conception of each. In markets, agents are anomic, not subject to outside enforcement; in hierarchies, actors are threatened with third party oversight and punishment, creating cooperation internal to the hierarchy; and in networks, agents can acquire information on other agents through their social relations (previous cooperative interactions) and through repeated interactions with players of their choosing (what I call selective affinity).

In Chapter 3, I outline an agent based model of organizational ecology and offer general principles of organizational ecology, identifying conditions under which populations and different strategy types within those populations are likely to shift from hierarchies to networks or markets, and vice versa. This ABM is the first of its kind to deal with problems of organizational ecology. It was built from the ground up to explore a general class of problems and their emergent properties. It was not designed to model any one problem of cooperation, but to capture broad classes of problems. Actors face a cooperation problem (here the PD) when interacting with other—potentially unknown—actors in the population and must decide how to behave and within what organizational structure: in an anarchic market without protections, in a network where the actor can gain information about past behavior from others with whom they have cooperative relationships, or in a hierarchy with third party enforcement. While any 2x2 game can be modeled, using the PD allows for the model to build on the intuition from a broad set of literatures.

I outline some of the major implications of the model. The organizational ecology is shaped by variation in the size and composition of the population. Small populations favor networks. Nasty populations favor hierarchies. Shifts in the strategic setting that increase the benefits to mutual cooperation or the temptation to exploit also drive agents of all types from the market and network into the hierarchy. Individual actors' characteristics, particularly type and beliefs about the dominant type in the population, shape the population dynamics. Nice actors will join hierarchies earlier than their less cooperative counterparts. Pessimistic actors, who believe the population is nastier than it is, also use the hierarchy more than their optimistic counterparts, even those of the same strategy.

Chapter 4 extends the core model to incorporate the organizational ecology and population dynamics of rebel groups. I find that the variation in size and composition of the rebel population are critical factors in determining the organizational ecology. Rebel networks thrive in small populations, while larger populations are more likely to turn to centralized enforcement to manage a large, and often disparate set of rebels. Looking at the size of the active members, as well as the proportion of rebels within the general population, I show that rebel organizations form as networks when they think the risks of defection are low, but shift into hierarchic organizations to insulate and protect themselves from defection. This finding has tremendous implications for counter insurgency policy. I also show that the population dynamics affect the choice and behavior of rebels. Those most vulnerable to exploitation in rebel populations, with no network to leverage—child soldiers—enter hierarchies first. In addition, the role and response of the state in responding to oppositions can determine when moderate members of the population are willing and able to leave opposition movements. I test these dynamics empirically using the Uppsala Extended Armed Conflict Database. I find that networks can be very fragile in situations where communication is costly and risky. Additionally, as the opposition population grows larger or less cooperative, opposition hierarchies are more likely. The state also has a clear and important role in violent opposition organization: the greater the probability of opposition victory, and the greater the expectation of concessions, the more likely actors are to organize in hierarchies over markets or networks. This finding has clear contributions for counter-opposition strategy and policy.

Chapter 5 applies insights from the model to the adoption of formal alliances and collective security organizations. A type of hierarchy, alliances and treaties are one of the core organizations in the international system. Provision of security is often characterized by the Prisoner's Dilemma. The ABM predicts that agents join hierarchies in waves, with "nice" types, fearing exploitation being the first to enter very costly (and less effective) organizations, followed by "nasty" types who are less likely to cooperate. I use the ATOP data to test these predictions empirically. The dependent variable of interest is the probability of joining an asymmetric alliance or treaty organization. "Nice" states are those with histories of high levels of international cooperation. The population dynamics show that these weak or nice states join alliances or treaty organizations with more provisions, and more costly provisions, before their aggressive or nasty counterparts.

High levels of cooperation can be achieved through the use of multiple organizations. Chapter 6 focuses on a puzzle in political organization: turnout. Voting is costly and individual votes do not prove pivotal to outcomes, but we still observe high rates of turnout in Africa's transitioning democracies. This chapter identifies a new mechanism, social sanctions from community members, to explain voting turnout. The ABM described in Chapter 3 is modified and applied to generate predictions derived from theories of turnout: vote buying through patronage, voting out of a sense of ethnic attachment, and social sanctioning. All three mechanisms can be captured in the ABM by shifting the strategic setting. Voting is an individual investment in collective goods, requiring community members to cooperate and coordinate to vote and field electoral winners. Cooperation rates within the population as a whole is the crucial variable of interest. Turnout is a problem in which populations rely on multiple organizations to produce high levels of cooperation. The model's propositions are tested using novel data from a pre-election survey conducted before Ghana's 2008 general election. I find social sanctioning, and the social nature of voting in emerging democracies, is a critical explanation for turnout.

Chapter 7 concludes, offering a theory based extension to intervention and state building, as well as a discussion of scope and limitations and future directions.

Chapter 2

Organizations, Organizational Ecology, and Population Dynamics

In rural Shasta County, where transaction costs are assuredly non-zero... conflicts are generally resolved beyond [the shadow of the law]. Most rural residents are consciously committed to an overaching norm of cooperation among neighbors.
— Ellickson (53–4)

2.1 Introduction

Ellickson describes a population of actors—ranchers in northern California—who exist under a set of federal, state and county regulations designed to arbitrate any disputes that result from trespassing cattle. These neighbor-ranchers have three choices in how they might interact with one another, particularly when their cattle stray into another's land: first, they might go it alone, making situation specific, one-off decisions about how to treat each neighbor (a market). Their second option is to create a network of cooperation amongst fellow "friendly" (cooperative) neighbors. The third available option is to rely on the legal framework, allowing agents of the state to adjudicate disputes and impose punishments (hierarchy). These ranchers have created networks of cooperation to solve disputes involving cattle trespass, rather than rely on hierarchical adjudication by the state.

Neighbor-ranchers of the type Ellickson describes have settled on an organizational solution to their problem. The cooperative population has created networks of reciprocity to head off any disputes over infringement. Neighbors board any stray cattle that cannot immediately be returned, with the expectation that fellow ranchers will do the same with any of their own trespassing cattle. The power of their network is cast in particular relief because this organizational solution is privileged above existing legal frameworks. Indeed, rarely, if ever, do they resort to legal recourse to solve trespass disputes.

Humans form organizations to enhance cooperation and well being. Markets, networks, and hierarchies are the recurrent forms of social organization. In the dissertation I use an agent based model (ABM) to look at populations and examine how the set of organizations they adopt to increase cooperation and welfare, their organizational ecology, is affected by the organizational alternatives as well as by the population of actors. "Nice" populations (and actors) are inclined to be cooperative, but populations that are populated by "nasty," uncooperative actors will not see high levels of cooperation without organizations.[1]

Because most populations we study are not composed exclusively of "nice" actors, some risk of exploitation almost always exists. As a result, cooperation within anarchy, or markets, is often difficult and infrequent, keeping social welfare at sub-optimal levels. Humans form networks to acquire information about others and, in some cases, to select partners with whom they have cooperated in the past. Networks are chosen by individuals when they are cheap and populations are small, at least initially, but most particularly by agents who alter their behavior to play a contingent strategy. Networks affect welfare by allowing those in networks to use information provided from their network to prevent exploitation in initial interactions. Humans also join hierarchies because they can enforce cooperation. Even though they are themselves threatened with the prospect of punishment for following their self-interest, actors enter hierarchies because of the greater benefits from cooperation. Indeed, the nicest agents, those most inclined to cooperate with others, enter the hierarchy first for the protection it affords them. Hierarchies are particularly effective when the population is nasty. Actors will be

[1] Throughout the dissertation I refer to "nice" and "nasty" actors. In this chapter they are synonymous with cooperative and uncooperative players, but in subsequent chapters I will add significant detail to these strategies.

willing to join costly (both ideologically distant as well as high tax rate) hierarchies in order to protect themselves from exploitation by nasty others.

Markets, networks and hierarchies are the three primary forms of social organization that recur at all levels of social interaction (see Powell 1990, Rondfeldt 1996). Economic transactions occur in arms-length markets between anomic buyers and sellers, hierarchically-ordered corporations (Williamson 1981, 1996, 1979) or networks of co-ethnic traders (Rauch & Trindade 1999, Greif 2006) or, in Japan, of production *keiretsu*. Insurgencies are carried out by lone actors or ad hoc relationships amongst actors who come together briefly to plot and carry out attacks (Sageman, 2008), by militias with commanders, ranks and insignias, or by networks of loosely connected cells (Arquilla & Ronfeldt, 2001). Social movements can arise in spontaneous, uncoordinated protests, as top-down disciplined organizations, or through tightly linked policy entrepreneurs who mobilize followers. Countries cooperate with one another under anarchy, in supranational organizations, and in deeply interdependent networks of states (Kahler, 2009). Voters cooperate out of an intrinsic sense of duty (Riker & Ordeshook, 1968), through ethnic networks (Horowitz, 1985), or under hierarchic party organizations (Duverger, 1963). This dissertation examines how populations, and actors within populations, choose organizational solutions—specifically, markets, hierarchies and networks—to solve problems of cooperation. In later chapters, I apply the model of organizational ecology and population dynamics to three very different issue areas: rebel organizations, alliances, and turnout.

The dissertation has two highly interconnected goals: unpacking the organizational ecology and population dynamics. The organizational ecology is the set of organizations a *population* adopts and has profound implications for the system, as well as for the welfare 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. They do not survive in isolation, but based on their ability to attract members at the expense of the organizational alternatives.

The second major focus of the dissertation is population dynamics, looking at how specific *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). Together these individual attributes interact with the population to determine the behavior and organizational choice of any actor within a population. I find nice actors in nasty populations join the hierarchy in greater numbers, and do so earlier than their nasty counterparts. These actors are likely the most vulnerable in the population, and join to avoid exploitation. The same actor in a more cooperative population would likely opt to join the network or the market. Conversely, nasty actors will remain in the market to exploit nice actors, and will join the hierarchy only when it is the dominant form of organization. Likewise, pessimistic actors, who believe the population is nastier than it really is, join hierarchies, while their optimistic counterparts join markets or networks.

This chapter outlines the theoretical foundations of the three organizations and introduces the concepts and underpinnings of organizational ecology and population dynamics. The chapter proceeds as follows. Section 2 describes common cooperation problems, my introduction of ideology to think about cooperation problems, and tweaks to the payoff structure. Section 3 outlines the core behind organizational dynamics that will be modeled and tested in subsequent chapters. Section 4 describes the three core organizational forms: markets, networks and hierarchies. I highlight the key theoretical qualities of each and preview how they will be modeled. Section 5 concludes.

2.2 Cooperation Problems

Cooperation problems may be easy or difficult to solve, but they lie at the crux of many bargaining and contract problems in political science and economics (

Stein (1982) outlines the distinction between collaboration and coordination regimes. Collaboration regimes, such as the solutions to tragedies of the commons that Ostrom (1990) discusses, solve dilemmas of common interests. Coordination regimes are designed to solve dilemmas of common aversions. These cases are those in which it is better to standardize amongst actors. Some coordination problems, such as standardizing a side of the road for driving, are easier to solve than others, such as picking a national language tends to be a battle of the sexes but there are strongly held preferences for one's own language (Skyrms 1996; 2004).

Many of the most interesting situations in politics though are collaboration dilemmas, where social welfare and social interests directly conflict with individual interests. Environmental common pool resource problems (Ostrom 1990; Gibson 2000) are this type of problem. Within the tragedy of the commons, individuals have incentives to defect in the short term to reap immediate benefits, but society as a whole is better off managing a resource to prevent over-exploitation.

The repeated prisoner's dilemma has been used to capture a broad class of collaboration problems. The analogy has been used to describe interactions in security and economics. Though there are gains for all actors if mutual cooperation can be sustained, because of the incentive to unilaterally defect and the costs of being defected against, all players have a dominant strategy to defect. This race to mutual defection drives socially, and potentially individually, sub-optimal outcomes. The desire to overcome these inefficiencies created by situations like these is what drives organizational solutions and the reason organizations are the "main vehicles for action in society" (Coleman 1974).

2.2.1 Ideology

I add to our general intuition about cooperative games by introducing ideology. Theoretically and, and later in the model, actors are permitted to have heterogeneous political preferences. The intuition behind this addition is that cooperation does not mean the same thing for all actors. Actors who are ideologically similar will get "more" out of cooperating than will those who are ideologically distant. Assuming that cooperation occurs at the weighted median of their ideal points, two "left" actors, for instance, gain greater utility from cooperating with one another than might one "left" and one "right" actor. If cooperation means working together to promote a political cause, two left actors will pursue a policy closer to their preferences than would a left and right actor, for whom the median would be further from their ideal points.

The overall effect of including ideology is that any positive weight on ideological preferences will decrease the likelihood of mutual cooperation, at least at the margins. In extreme situations, where ideological preferences are weighted heavily, this amendment can alter the core structure of the interaction, making non-cooperation preferable to cooperation with someone who is sufficiently ideologically distant.[2]

2.2.2 Scope and Applicability

A brief note on scope and applicability. While this dissertation uses the classic payoff orderings of the Prisoner's Dilemma to characterize cooperation problems, I do not restrict potential the theoretical implications to this subclass of problems. Indeed, many classes of problems, particularly those with multiple equilibria are of particular interest, and will be the focus of other work.

In addition to adding ideology to intuitive cooperation problems, I also find that changes to the payoff structure can make cooperation problems more acute.[3] Heightening the incentives to defect, or the payoffs to cooperation while still remaining in the same class of problems may not change the equilibria of a particular situation, but it most certainly can impact the organizational ecology in dramatic ways. For example, as the incentive to defect becomes greater, actors believe they are in greater danger of being exploited (as indeed they are). These beliefs cause them to seek more binding assurances of cooperation in the hierarchy. I see this dynamic in both the behavior of rebels as well as voters in emerging democracies.

2.3 Organizational Ecology and Population Dynamics

This dissertation is centered around two major themes: organizational ecology and population dynamics. Together these concepts form the backbone of the dissertation and produce questions related to when and why a population will adopt a specific set of organizations, or how they achieve cooperation. The modeling exercise described in the following chapter, and the applications parse who joins organizations, when, or to what ends. Here, I introduce these concepts and preview the major findings.

[2]The introduction of ideology and the manner in which it is modeled will be described in detail in the chapter that follows as well as more technically in the Appendix.

[3]The net effect of ideology, is the alter the relative payoffs. Including ideology decreases the utility mutual cooperation compared to mutual defection. Exogenous shifts in the various outcomes can produce the same net effect. This will be discussed in greater detail in the following chapter and in the Technical Appendix.

2.3.1 Organizational Ecology

The organizational ecology is the set of organizations adopted by a population. The shift from focusing on a single organization to all three is the first novel contribution of the dissertation, never before have they been treated together under one theoretical umbrella. Social organizational theory, and political science specifically, have all dealt with markets, networks and hierarchies extensively. However, this work has been myopic, focusing on one of these organizations at a time.

The literature typically treats these organizations separately, comparing networks and hierarchies to markets (or anarchy), but not to each other. The literature on transnational policy networks, for instance, does not consider hierarchy as an alternative. Similarly, the literatures on international organizations do not examine when states choose formal organizations relative to networks. Each literature tests its solution to the problem of cooperation relative to anarchy or the "market," but seldom are organizational alternatives considered as substitutes for one another. While these organizations can coexist, organizational choice is a zero-sum game: one form thrives at the expense of the others. As more agents use networks, fewer are available to create a large block of enforced cooperation within a hierarchy, or to interact in the unconstrained market.

Organizations do not survive and prosper in isolation as early work has implied. An organization thrives (or not) based on its ability to attract members of a population to join it, at the expense of the organizational alternatives. The agent-based model (ABM) that forms the core of my dissertation is designed to study actors' choice of alternative organizations under a range of environmental and organizational characteristics. In short, I treat organizations within an ecological approach.

I build the work on organizational ecology from sociology (Hannan & Freeman 1993, Carroll 1984). This literature views organizations and populations within an ecological framework. They focus on the growth and demise of organizations within populations, with an eye toward the role of the environment in shaping organizational selection and the fitness of intra-organizational characteristics. I share the ecological treatment of the problem. My work extends this basic analytic framework, allows for the organizational characteristics to shape the population and further organizational choices, and applies these theories to problems in political science.

The ecological set up allows for the three organizations to be pitted against each other in different settings and different populations. Just as the equilibrium solution depends as much on what is off the equilibrium path as what is on it, the organization or set of organizations adopted by a population depend on the organizational alternatives populations do not choose.

Certain ecologies can be become entrenched easily. In particular, hierarchies often become dominant. The appeal of a hierarchy, whose purpose is to enforce cooperation amongst members, is directly related to the number of members. As the hierarchy grows in membership, so does its attractiveness. This can lure in even those actors who were initially disposed to join the market or the network. As the hierarchy becomes more of a juggernaut, it will push out the organizational alternatives.[4]

Across international relations, we know that the organizational ecology, or the set of organizations adopted by a particular population to solve a cooperation problem has effects on security, policy, aggregate welfare, and questions of distribution. For example, the literature shows hierarchical rebel groups are more likely to be successful and to launch larger attacks than are networked oppositions. In Chapter 4 I show that rebel hierarchies are more likely to be adopted in uncooperative or "nasty" populations. Taken together, this finding produces powerful policy implications.

An ecological view allows for analysis of the survival and popularity of organizations, but also for study of the choice and welfare of individuals within the ecology. This allows for important conclusions about the nature of organizational ecology, organizational choice, and population welfare. Broadly, I find the robustness and survival of organizations is contingent on both the population of organizations and, critically, the population of actors.

The dissertation looks most particularly at the effect of changes in the structure of interaction, organizational characteristics, as well as the population of actors on the organizational ecology. This framework allows the organizational ecology to be the product of both the population of organizations as well as the population of actors choosing between organizations.

[4]Some of this ecological "stickiness" is captured by construction in the modeling decisions discussed in the next chapter, and some is the result of emergent ecological properties.

2.3.2 Population Dynamics

The second major focus of the dissertation is population dynamics. I look at how specific *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). Together these individual attributes interact with the population to determine the behavior and organizational choice of any actor within a population.

I find nice actors in nasty populations join the hierarchy in greater numbers, and do so earlier than their nasty counterparts. These actors are likely the most vulnerable in the population, and do so to avoid exploitation. The same actor in a more cooperative population would likely opt to join the network or the market. Conversely, nasty actors will remain in the market to exploit nice actors, and will join the hierarchy only when it is the dominant form of organization. Likewise, pessimistic actors, who believe the population is nastier than it really is, join hierarchies, while their optimistic counterparts join markets or networks.

An actor playing a contingent strategy (such as tit-for-tat) will behave differently depending on the population in which it finds itself. In an extremely nice population, this actor will likely forgo the network and the hierarchy, and participate in the market, likely with many cooperative interactions. In a relatively nice or moderately nice population, this same actor will likely join the network to safeguard against the possibility of being exploited by one of the unknown nasty actors and increase the probability of being able to choose their own partner. In a nasty, or extremely uncooperative population, this actor will join the hierarchy for the enforced cooperation.

As will be explored in greater detail below and in subsequent chapters, populations can be sensitive to relatively minor shifts, leading to dramatically different organizational ecologies. These results may be the difference between a hierarchical rebel organization or a fragmented networked one; a democratic state or an autocratic one; an alliance with broad or narrow ideological appeal.

The composition of the starting population is one of the most critical factors in determining the organizational ecology, but individual actors are mindful of their welfare and make their organizational choice with the rest of the population, and their experiences with the rest of the population, in mind. The distribution of behavior, any particularly actor's beliefs about what that distribution (are they optimistic about cooperation or pessimistic), as well as their beliefs about the organizational choice of others will all impact an actor's desire to be in the market, the network or the hierarchy.

In the chapter that follows, I translate ideal type conceptions of each of the three forms of social organization to model how populations (and individuals within populations) create various organizational ecologies to increase their welfare and prospects for cooperation.

2.3.3 Using an Agent-Based Model

Taken together, the ecological approach I describe above, as well as the emphasis on population dynamics and individual choice within a population, mean an agent based model is a uniquely suited tool to address these questions. In short, it "is a way of doing thought experiments that, because of complex interactions, may have nonobvious conclusions" (Axelrod 1997:4). Agent based modeling provides a rigorous, deductive approach to generating propositions about the effects of population dynamics on the organizational ecology adopted to solve problems of cooperation. This allows for variations in the organizational properties, initial populations and strategic setting to be varied. I track both the organizations and population level shifts as well as individual agents' organizational choice and behavior.

Both the organizational ecology as well as the population dynamics are emergent properties of the choices made by agents. Most formal models are two-player closed-form game theoretic models. These have provided tremendous insights into behavior, and particularly bargaining between two players. However, because it is difficult to account parsimoniously for many more than two actors, these models generally collapse all "micro" interactions and internal bargaining into a single actor, be it a state, or a branch of government. Agent based modeling can better capture complex population dynamics that two player models cannot.[5]

Agent based modeling has increased in prominence in Political Science, but is

[5]Hierarchies may in some models function as unitary actors in practice, but looking at the breakdown of hierarchies requires understanding the incentives of actors within the organization.

still a relatively new tool.[6] Axelrod's iterated Prisoner's Dilemma tournament (1981) began the major work agent-based models of cooperation in the discipline. Axelrod serves as an intuitive and structural touchstone for a wide swath of literature. Axelrod's great contribution was to point to the role or reciprocity as a preferable, evolutionarily stable strategy to solving the IPD. From the first tournaments, and the broad literature generated since, much has been written about the generalizability of this finding. The evolution of cooperation has been applied to tumor cells (Axelrod, Axelrod, and Plenta 2006), deterrence (Huth 1988), ethnocentrism (Hammond & Axelrod 2006), contracts, negotiations, trade (Dixit 1987) and various biological communities. The finding has been fairly robust for more than two decades.

This model contributes to development of agent-based models of organizations and cooperation in politics. Previous ABMs of cooperation have not included institutional or organizational features while computational models of organizations have focused on intra-organizational features. This is the first ABM to study the choice between organizational forms in a general model of cooperation.

Many problems, particularly organizational problems, cannot be reduced to single unitary actors. Particularly difficult to address with two player games are problems of organizational formation and breakdown. Tipping points and phase shifts, the role of beliefs and organizational properties are all characteristics that can vary significantly depending on many micro-interactions across populations. These variations can create profound differences in the observed organizational ecology.

Taking organizational ecology and population dynamics together, the ABM is uniquely suited to capture these social dynamics. The ABM is able to track the efficacy of organizations in contrast to one another, as well as the interaction with distributions of strategy types within a population, and individual choice and welfare. Many of the problems of cooperation involve populations of actors, and are not easily reducible to two unitary actors. The ABM, built from solid micro-foundations and simple rules of interaction, allows tremendous insight into complex behavioral patterns.

This project deals with the effect of population dynamics for very specific ends:

[6] For models of cooperation and computational models of organizations see Axelrod (1984, 1997), Cederman (1997), Epstein (2007), Kollman, Miller, and Page (2003), and Miller and Page (2007), Prietula, Carley, and Gasser (1998), Ilgen and Hulin (2000), and Chang and Harrington (2006).

what populations and environmental factors favor adoption of different forms of social organization. As will be explored in greater detail below and in subsequent chapters, populations can be sensitive to relatively minor shifts, leading to dramatically different organizational ecologies/environments. In the section that follows, I summarize outline the three organizational forms and the key characteristics that will be built into the assumptions of the model.

2.4 Organizational Solutions: Markets, Networks and Hierarchies

This section outlines the three primary forms of social organization that facilitate cooperation: markets, networks and hierarchies. Because there are extensive literatures dealing with each form individually, caveats in the conception of each are instantly attached. However, the goal of this project is not to be the single authority on any one organizational form, nor to settling nuanced debates within conceptions or markets, networks, or hierarchies.

In this section, I present an ideal type for each organization. These ideal types are then used to compare across organizations to look more closely at when phase shifts from networks to markets or from markets to hierarchy are likely to occur. I distill each of the three organizations down to core characteristics and assumptions, which will be used to frame the ideal type to model. Rather than capture the precise features of any one type of organization, the core feature of each is generally representative of the corresponding form across issue areas, applying to states, rebel groups, firms, and political parties.

2.4.1 Markets

Markets are characterized by self-regulation and uncoordinated private choices (Elster 1987: 103-4). Within the context of cooperation problems, markets are the anarchic “state of nature” or a lack of organizations to regulate behavior. This is the baseline against which the potential for enhanced cooperation and welfare provided by networks and hierarchies can be evaluated. Also implicit in this anarchic conception is the inability of markets to correct for suboptimal welfare. Here actors revert to self-help interactions, which are likely not socially efficient.

Situations such as the Prisoner's Dilemma showcase how prone markets are to produce Pareto inefficient outcomes, that is, where cooperation rates are low and welfare can be improved. This problem becomes less acute in other types of games. Cooperation in these situations is possible, but heavily dependent on the precise structure of the interaction, the characteristics of alternative organizations (networks and hierarchies) and composition of actors in the population (are they "nice" and likely to cooperate, or not).

The importance of clarifying the anarchic nature of the market is critical because, although a common term, the concept lacks a fixed analytical definition. Once referring only to a site for trading, since the early 20th century economists have tended to use market as a synonym for exchange, and to focus on variations in market structure, including the numbers of buyers and sellers, the information available to each, and so on. These "markets" are often embedded in larger social organizations, most often the state, implying theyare actually a hybrid form of social organization. Sociologists focus more on production markets (of firms or factors of production), conceived as networks of linked agents. I use neither of these conceptions of market below.[7]

In the purest sense, markets arise between anomic agents who cannot make binding promises. According to Powell (1990, 302; italics added), markets are "the paradigm of individually self-interested, non-cooperative, *unconstrained* social interaction" that engage strictly anomic agents who can form only self-enforcing agreements and know only their own past interactions with each other. In large populations, or for young actors, this may be a very small subset of the population, and provide very little insight into the likelihood of a cooperative exchange. This view of markets as an organization strips the concept of its focus on the exchange of goods but generalizes it to a greater range of interactions. This is the core piece of intuition that will be used to form the basis for implementation in Chapter 3.

[7]On economic and sociological views of markets, see Swedberg 2003, Chapter 5.

To preview the next chapter, markets are the organizational form implied by payoff orderings in a 2x2 interaction with ideology taken into account.[8] For the applications in this dissertation I will use the "standard" repeated Prisoner's Dilemma as the reference point. While there are advantages to using another game– for example the Stag Hunt orderings, the Prisoner's Dilemma has formed so much of the basis for all cooperation problems that it comes with an intuition that is unlikely to be matched. Cooperation is possible, even likely in some populations, particularly where the incentives for defection are not acute; however cooperation is most likely to be observed between actors playing "nice" strategies or those that at least begin by cooperating with others.

These anarchic markets relationships are equivalent to what economists would term spot market exchanges. Buyers and sellers interact with equal probability of meeting one another. There is a benefit to taking the good and not paying, and a cost to producing the good and not being paid. Likewise, buyers and sellers are both better off exchanging than not. The payoffs alone provide the primary structure for the interaction.

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 (and the welfare they do or do not create) can be compared. There is, by construction, but also theoretically, *always* a market. Markets are unique in being universal, a default organization. While I assume that actors must interact with one another (there is no way to "opt out" of interacting) actors are not forced to join one of the formal organizations. Unlike networks and hierarchies, there is no situation where the market will cease to exist. For actors with uncooperative histories, the informational role of the network will have little value. Similarly, if a hierarchy cannot attract or retain a sufficient number of members, it quickly becomes too costly and effectively dies in the population.

Accumulation of beliefs about the population are most easily seen in the market. These exchanges are like a chatroulette[9] or speed-dating style of interaction. Any random partner with whom you interact may be "good" or "bad," but you are not guaranteed to have to interact with them again, particularly in a large population. If you do, you will remember your own experience and play accordingly in your next meeting.

[8]In the discussion that will follow in later chapters, these payoffs are: T, R-k, P, S.

[9]Where users are paired randomly with someone else in the population for videochat.

Whether or not you interact with them in the future, the interaction with any one partner will shape your beliefs about the types of people in the population. This is to say that your behavior toward strangers, and your desire to leave the market for the network or hierarchy will be shaped by these interactions. Each individual member of the population behaves according to his or her own perceptions of the world. A speed dater who has had a number of bad interactions with those he or she has met through the process will begin to be more pessimistic about a given stranger in the speed dating population.

Markets can be identified in each of the three applications illustrated in detail in later chapters: rebel organizations, states and voters. Within rebel organizations, markets are lone actors or at best very small, short repeated interactions. These relatively small, very fluid groups are matches of ideologically similar individuals, who get a high payoff to cooperating with one another. Cooperation amongst these individuals is comparatively easy. These actors do not need an external mechanism or incentive to ensure cooperation. Indeed, when cooperation takes place in markets, it is a result of aligned interests. Some dyadic relationships might persist later in a network (having first cooperated within the market). Similarly, some relationships also may be internalized with others in a larger hierarchy, but it is possible for these small groups of activists, or lone actors, to sustain themselves within the market. This and other "grassroots" social movements are likely in populations able to sustain some level of cooperation. The baseline cooperative level will determine the scale of these movements. If only a small proportion of the population is cooperative, then small pockets of cooperation will be all that can be sustained (although they may choose another organizational form because they are a minority); if a large proportion of the population is cooperative then large, mass movements may be sustained.

Amongst states, interacting in the market is akin to the classical anarchic international system (Hobbes 1651, Waltz 1978), the standard view in most work on International Relations. The lack of a defining order and outside enforcement to arbitrate disputes characterizes the market form of interaction. Realists view the international order as always one of markets, a series of ad hoc interactions and self-help. This dissertation will view unconstrained interactions as *one* possible ordering of the international system. Cooperation and cooperative relationships are possible, but only in populations that are initially "nice." If the states—or leaders within states, depending on the assumptions made—are initially uncooperative, the population moves quickly to the one anticipated by Hobbes (). Likewise, in any kind of population with an evolutionary selection mechanism, those states that are nice in a world of all against all will quickly fall victim to those willing to exploit these "kind" states.

Likewise, amongst voters, cooperation in terms of participation on election day to gain public goods, is possible, and even likely where there is a highly developed sense of duty. Absent high levels of duty, or strong norms of participation, without social and political institutions to facilitate cooperation, participation falls off. Those voting out of an inherent sense of duty are the "nice" actors described above. In the absence of a large proportion of the population having such a sense of duty, high—or universal—turnout is a function of the population using other– and potentially multiple other– organizations to solve collective action problems.

The key characteristic of markets that must therefore be captured theoretically is the possibility of unconstrained interactions. Markets are effective organizations for interactions in nice populations, but often become less useful in the face of effective networks or costly hierarchies in less cooperative settings. In such settings information, repeated interaction, and enforced cooperation that networks and hierarchies promise become more useful.

2.4.2 Networks

Networks are most broadly defined as sets of connections (Newman et al. 2006). As structures, these organizations, products of their environments and their members, can have tremendous impacts on outcomes in international relations.[10]

Work on networks, networked structures, and networked structures has captured much of recent work in International Relations and Political Science more generally– both theoretical and empirical– and for good reason.[11] Inherently they are able to cap-

[10] While there is a broad literature on networks both as structures and actors, I focus in the dissertation on networks as structures, in contradistinction to other potential structures. For a discussion on this distinction see Kahler 2009.

[11] For a small sample of key theoretical and empirical applications in networks see Watts 1998 on small-world networks; Barabasi 1999 on scale in networks; Powell 1991; Keck and Sikkink 1998.

ture an almost infinitely wide range of relationships and paths for information, behavior, and form. To preview my modeling approach and the analysis in later chapters, I find this view slightly slippery, and find tremendous value in isolating the tradeoffs between distinct organizational forms. There is, in this view, a clear distinction in the core purposes of the network, which allow it to be clearly differentiated from the market and the hierarchy.

The networks literature is constantly expanding, adding increasing nuance and subtlety to these structures. Proponents of networks will no doubt find fault with any simplification of form and function within networks. Indeed, variation within networks is tremendous and has wide-reaching consequences (Sageman 2004, Kahler 2009, Lake & Wong 2009, Cowey and Mueller 2009, Hafner-Burton & Montgomery 2008). Any work that collapses networks into a single form to be compared to other organizations as this dissertation admittedly aims to do, cannot capture variation within networks (for example, Wong 2008, Watts & Strogatz 1998). Thinking about how variation in network form impacts organizational ecology, would be a clear theoretical extension of this dissertation but is currently well beyond the defined scope.

Networks as organizations must be similarly distilled into core characteristics for analytical simplicity to support the goal of comparing the adoption of networks to that of markets and hierarchies. Within the networks literature, there remains a great deal of disagreement about the correct assumptions. As such, the assumptions made about the primary characteristics of networks are no doubt somewhat controversial in their austerity, but hopefully will serve as a useful ideal type. Were this a model of networks and network function, unpacking the elements of structure and function would be a fundamental first step. However, in trying to generate highly generalizable propositions about the population dynamics that prompt choices between organizations, of which networks are one, this restriction is necessary.

This dissertation focuses on networks as organizations with two primary functions: first, providing information that allows players to build reputations beyond the two-player structure, and second, connecting players and creating more durable relationships, what I call selective affinity. These two characteristics are the most core to all conceptions of networks, and are therefore highly generalizable.

First, networks have been described as "voluntary, reciprocal, and horizontal patterns of communication and exchange" (Keck & Sikkink 1998[8]; Podolny & Page 1998[59]). They are often understood as mechanisms for acquiring information on agents from other agents with whom an agent has cooperated in the past. Intuitively, networks allow a person, say Adam, to ask a defined number of people with whom he has a positive relationship, if they have ever interacted with Betty, who is a stranger to Adam. Adam will find out from his personal network if Betty has been nice or nasty to his friends and if her ideological beliefs are similar or distant from his own. With this information, Adam can then decide whether to cooperate with Betty, or to protect himself from Betty's potential exploitation. Thus, networks provide information that supplements the information Adam may have acquired through its own past interactions. The primary effect of information from the network is to prevent agents from being exploited by strangers. In this conception, the focus is on the information transmission function of networks.[12]

To preview some of the findings, though often treated as a defining attribute of networks, the model in Chapter 3 shows reciprocity is an emergent property of the agents who tend to select themselves into networks (see Powell 1990, 303, and Podolny & Page 1998[59]). Only agents that possess a contingent strategy (defined below) will 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.

The network also allows for some degree of voluntarism, the ability to opt in. Adam only asks and receives information from those with whom there is a tacit degree of cooperation, and potentially reciprocity. This is fairly intuitive, people tend to ask their friends for recommendations on restaurants, friends, dates. These networked relationships are more enduring than those in the market (Podolny & Page 1998).[13] The information transmission network is a personal one, Adam's network is likely to be different than Chris's, though they may overlap, particularly in small populations. The

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

[13] The degree to which networked relationships endure can be specified, shorter memories of mutually cooperative outcomes lead to less enduring relationships, while perfect recall of all interactions in the past would allow for extremely enduring relationships.

informational mechanism is also assumed to be one that produces “nice” or cooperative behavior, because the survey mechanism works only amongst those who are former cooperative partners. Actors with similar cooperative strategy types, create (mutually) cooperative histories. These histories form the core upon which these actors draw when they create their network.[14] If this information transmission mechanism is the only one at work, nasty players, potentially like Betty might be essentially shut out or shunned and cooperative, ideologically similar cliques may emerge. Advocacy networks of the type Keck and Sikkink (1998) or Wong (2009) discuss are examples of these emergent “nice” networks amongst likeminded nodes.

The secondary function of a network is to allow for the probability that agents will choose repeated interactions, specifically with a partner of the actor’s choosing. The intuition behind this is fairly clear, people like to interact with their friends or with people they know—people they know they will get along with, or at least know how they will behave in more uncertain situations (the devil you know), rather than strangers with whom they potentially might disagree or who might be uncooperative or ideologically distant. I call this tendency to want to interact with those with whom an actor has a prior relationship “selective affinity.” The higher the ability to use affinity ties, the more these relationships will matter. Additionally, the likelihood of cliques or clusters being created should increase. The welfare effects for society may also increase, particularly where populations are large, and in the absence of affinity, cooperators might have a difficult time finding each other. Selective Affinity shares some characteristics with the concept of homophily in the networks literature (McPherson et al. 2001). Selective affinity captures the increased interactions between actors with homogeneous characteristics, as implied by homophily. However, selective affinity also has also has a perverse potential outcome in which nice types are repeatedly “picked on” by nasty types, creating “dark” networks (Jung & Lake 2011).

Participating in a network is always costly, however, there are transactions costs to networking and maintaining these relationships. These costs may be 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 nec-

[14]Although “nice” behaviors are defined normatively. As Chapter 4 will argue, cooperation amongst insurgents will be cooperative behavior as well.

essary to establish trust or reputation. People may join the network to gain information about others, even if those other people are not in their network.

Networks are a way to "buy" information or a greater probability of an amenable partner in the future. Essentially networks buy you information, either through personal experience or the experience of your "friends," about the behavior of the actor with whom you are interacting. Actors may choose to be in a network for either or both reasons, but both result in the creation of relational edges.

Networks do not allow an actor to change the underlying structure of an interaction. Two actors still face a simultaneous interaction and must decide how to behave individually, but networks give actors an opportunity to buy more information about with whom they are playing. The "feedback" on sites like Ebay allow for both buyers and sellers to be rated, giving the user an opportunity to gauge how the other party will behave. A buyer may choose a reliable seller with whom she has interacted previously over an unknown. Likewise, social networking sites like Yelp! allow users to become more or less trusted reviewers.

In the 11th century, the Magrhibi traders established networks of co-ethnic traders who relied on reputational mechanisms to overcome commitment problems. Information on other traders, and reciprocity of information flows was the lifeblood that sustained this trading network and allowed those within the network to overcome the commitment problems inherent in trade (Greif 2006, 1993). Agents who cheat or sucker a member of this network establish a reputation as an untrustworthy partner. Rauch (1999) and Rauch and Trindade (1999) also find evidence of similar co-ethnic information flows amongst Chinese traders. Within the system of states, collaborative networks of states through regional organizations see tremendous cooperation (Katzenstein & Shiraishi 1997, Keohane & Nye 1975, Eilstrup-Sangiovanni 2009).

Rebel organizations use networks to pass operational and reputational information between members. Within "dark" organizations of any type– organized crime, gangs, or rebels– the costs of defection are exaggerated. The heightened consequences of defection drive behavior, and measures to safeguard against such an outcome. Networks that provide an additional check on the reliability and ideology of an unknown are particularly valuable in this contexts. Within the world of rebels, the highly secretive

Eritrean Liberation Movement (ELM) in the early 1960s functioned as a network. The ELM was operating within a very dangerous setting in relation to the state. As a result it adopted a clandestine cell structure. The lines of communication were (intentionally) limited, and the costliness— both in time and risk of detection and defection— of communication between cells lead to operational demise when a rival hierarchy was able to internalize communication lines (Iyob 1997). Both the informational and repeated relationships, or selective affinity, are captured in the rebel case.

Similarly, states form deeply interdependent networks through which cooperation and reciprocity are common. Kahler (2009) notes that these structures are redefining cooperation and interactions in the international system. The emphasis on networks in the system of states is particularly heavy on the role of affinity relationships, or the ability to create “enclaves” of cooperation amongst subsets of states.

Particularly in emerging democracies, local, ethnic, or kinship networks form the basis for much of political participation. Indeed, work on political participation in emerging democracies has often highlighted the role of ethnic networks turning out or not for a specific candidate, in essence making elections into an ethnic head counts or census (Horowitz 1985). Likewise, the ability to use selective affinity to isolate oneself amongst cooperative, ideologically similar players is extremely profitable for political entrepreneurs in the politics of mobilization. While political mobilization may be rooted in these kinship networks, or the networks may be used as a shortcut (Chandra 2006), the ability to shorten the distance to a cooperative partner is valuable.

2.4.3 Hierarchy

When the butcher comes to me to buy an animal, he knows that I want to cheat him. But I know that he wants to cheat me. Thus we need, say Peppe [this is, a third party] to make us agree. And we both pay Peppe a percentage of the deal.
– A vaccaro quoted in Gambetta (Gambetta 1996:15)

Third party enforcement is at the core of all definitions of hierarchy. Authority of the ruler over the ruled—specifically, third party enforcement— is the means through which the behavior is changed (aligned) with the hierarchy.

This pattern is repeated across various literatures. Theories of economic organization highlight the advantages of internalizing the production process (Coase 1960, 1988; Klein et al. 1978). Williamson's (1979, 1985) groundbreaking work on industrial organization shares the same key features. Elements of the production process that are vulnerable to hold up are best integrated into the firm. Vertical integration is designed to eliminate internal vulnerability to being suckered. Supplier firms now cooperate under the larger umbrella as directed by the central authority in the firm, the hierarch.

A second key attribute of hierarchy is the ability of the third party—typically the ruler, leader, or boss— to command legitimately certain actions by the members of the organization. Agents are understood to subordinate themselves to the preferences of the hierarch. These actors become agents of the central authority in exchange for the enforcement of cooperation. In the network, actors might alter their behavior based on information received or because they were matched with someone they had selected repeatedly. In the hierarchy, the enforcement of cooperation within the organization— both by the leader as well as the followers— allows for a common expectation of the "value" of that cooperation ideologically. Here, the interaction between two members of the same hierarchy in essence is equivalent to two interactions between each player and the hierarch. As will be explored in subsequent chapters, actors will choose to join organizations at different times based on their individual characteristics and the population's characteristics. In general, I find that actors that are (or perceive themselves to be) more vulnerable to exploitation compared to the rest of the population are the first to join hierarchies and they will be willing to pay higher costs to gain some measure of guaranteed cooperation.

Gambetta's example of the vaccaro and butcher looking to a Mafioso as a third party guarantor of their transaction is a clear use of hierarchic institutions to ensure cooperation. Neither party would be able to resist the temptation to cheat the other, but *both* gain by paying Peppe, the Mafioso, to ensure that a cheater will be punished if the deal is not completed.

This example is a stylized one, but one that assumes voluntary participation by all three actors. Coercion to join a hierarchy may, and often does, occur. However, if the alternatives are less attractive, particularly in an evolutionary world where elimination from the population is possible, survival may dictate that "choosing" a hierarchy is the best of all possible alternatives. Moreover, population dynamics will matter significantly here. As either the population changes, or the organizational ecology shifts, over time, alternate organizational forms will be come both more attractive, but crucially less risky. A citizen living under an authoritarian leader may not have a "choice" of an alternate government that would allow for survival to subsequent rounds under certain circumstances. However, as other members of the population become "nicer" or shift out of the hierarchy in favor of alternative organizations, cooperation, and therefore survival, outside of the hierarchy become more likely.

Rebel organizations often organize in very state-like, hierarchic organizations. Al Qaeda had an extensive bureaucratic arm, complete with expense report forms for members (Shapiro 2008). Similarly, the Eritrean People's Liberation Front (EPLF) ran an extensive and extremely hierarchical organization toward the end of the Eritrean battle for succession. In the final decades, in addition to a regularized military, the EPLF organization was under central command and providing a wide array of goods and services to the people under its auspices. Hospitals, pharmacies, and veterinary clinics were staffed by the EPLF; schools and adult literacy programs were funded by the EPLF. And very telling, taxes were collected by the group as a mechanism to fund these extensive public goods (Pool 1997).[15]

Though the international system is often characterized by anarchic, market-like relationships; however, relationships between states are also often hierarchic (Lake 2009, 1997). The Soviet bloc and later Warsaw Pact, and later the American informal empire in the western hemisphere are clear examples of informal empire established in contradistinction to anarchic relationships. Subordinate states have been observed to cede aspects of their economic and security policy to hierarchs in these informal empires. Less extreme examples come in the form of more and less binding supranational organizations. Recent financial crises within the European Union have led to domestic bailouts, because of a common, sticky commitment to a common currency.

New democracies often co-opt organizational and party structures from their colonial or authoritarian past. These parties often offer incentives, or punishments, for

[15] Hamas has followed a similar path.

non-participation. Remarkably high turnout rates in emerging democracies can be partially traced to repeated interaction within often dominant party mechanisms. Turning out to vote can be viewed as an act of cooperation in part of a repeated interaction with one's community and through one's party.

2.5 Conclusion

This chapter has introduced the major concepts and themes of the dissertation–both focus on the interplay between actor, population and organizations, but also the population dynamics that all three taken together produce. Later chapters will show that together the organizational ecology and population dynamics drive many important consequences, for the population as a whole but also for individual actors with the population, across several issue areas.

The three forms of social organization—markets, networks, and hierarchy—are also introduced. The key characteristics of each organization become the core assumptions that are modeled.

The next chapter presents in detail the agent based model (ABM) designed with the goal of understanding organizational ecology and population dynamics. All remaining chapters explore how different populations produce different organizational ecologies, and how the organizational ecology and initial population affects the choice and welfare of individual agents. Given the goals of understanding how population dynamics affect both individuals as well as organizational ecology at the population level, an ABM is a tool uniquely suited to model these situations.

Chapter 3

An Agent Based Model of Organizational Ecology

[Skid Row] has been described as a sort of Switzerland for drug dealing, where the various gangs who would normally be fighting with each other could come to this area, put aside their differences, sell their drugs, and then commute back to their territories, where perhaps the next day they go back to war with each other...

Back on the streets, officer Joseph says it's true the street gangs band together to control the drug trade on Skid Row.

"It's pretty much a gentlemen's agreement," he explains. "They'll put down their colors and work with the gang that's most prominent here. You have to get the blessing from them to operate. So they'll allow other gang members, it doesn't matter if you're Crip, Blood, Piru, Swan or someone else, they allow you to work for them, and sell your drugs in peace." [1]

[1] http://www.npr.org/templates/story/story.php?storyId=126527647

3.1 Introduction

Social organizations, in the example above hierarchy, can increase cooperation and welfare. Rival gang members would be significantly better off working cooperatively to profit from drug sales. The alternative is non-cooperation, which produces few economic returns and likely conflict with those same actors. These gangs have come to an organizational solution to their dilemma: hierarchy under the auspices of the dominant gang in that territory allows these transactions. The power of this solution is cast in greater relief because outside hierarchy, the same actors are perfectly ready to fight each other.

This chapter presents an agent-based model (ABM) of organizational ecology. In the previous chapter, the core characteristics of each of the three organizations were highlighted. This chapter has two primary tasks: translating those characteristics into an agent based model and outlining some of the core principles of organizational ecology and population dynamics.

Actors in the model face a 2x2 cooperation game[2] when interacting with other—potentially unknown—actors. Each must decide how to behave (cooperate or defect), and select an organization (or not). Actors may choose to be in the market without protections, in the network where the actor can gain information about past behavior from others with whom they have cooperative relationships or select other actors to play, or in the hierarchy with third party enforcement.[3]

Below, the basic model is detailed and general principles of organizational ecology are presented, identifying the conditions under which populations, and strategy types within populations, are likely to shift from joining hierarchy to networks or markets and vice versa. Major implications come from variations in the population size and composition, strategic space, and organizational attributes.

Agent based models are uniquely suited to understanding population dynamics. In situations such as the ones modeled here, complex interactions may produce non-

[2]In this chapter the game is specified to be a Prisoner's Dilemma, this is done for intuitive ease. The model is designed to be able to represent any payoff ordering of T, R-k, P, and S. Allowing the the Prisoner's Dilemma to be the core game studied is a shortcut and allows me build off of Axelrod's canonical work and introduce organizations.

[3]In order to lay out the principles as cleanly as possible there is only one potential hierarchy to join, and all three organizations theoretically are viable at all times.

obvious conclusions. Agent based models are "a way of doing thought experiments" (Axelrod 1997 [4]). Unlike two-player closed form formal models, agent based models allow the user to define and manipulate the initial conditions and watch the population dynamics unfold.

This chapter proceeds in 5 sections. Section 2 describes the basic set up of the cooperation problem, particularly the inclusion of ideology. Section 3 describes how each of the three organizations is modeled. Section 4 describes the model.[4] Section 5 outlines principles of organizational ecology. Section 6 returns to Skid Row and concludes.

3.2 Modeling Cooperation Problems

The model can capture all variations of a 2x2 games. Figure 3.1 shows the basic set-up of the broad class of cooperation problems. The relative values of T, R, P, and S (as well as k, to be discussed more below) determine if the problem is representative of the Prisoner's Dilemma, Stag Hunt, Chicken, or another cooperation problem. They can be varied easily to capture any other 2x2 game, or to accentuate the features within one of the games.

In this chapter—and in most of the rest of the dissertation—I use the repeated Prisoner's Dilemma (RPD) game to represent preferences over outcomes. I use Axelrod's standard PD payoffs here, both because of their ubiquity across various literatures and the intuition that comes with it as a result, as well as to highlight the relative acuteness of the cooperation problems. As Axelrod (1984) and others have shown, this model captures the essential features of a broad class of cooperation problems.

Axelrod's model of cooperation, the tournament approach to looking at the evolutionary fitness of strategies, and the literature that followed from this initial work (Axelrod 1984, Axelrod et al. 2001) have created an underlying intuition for looking at cooperation problems. The simplicity and pervasiveness of the repeated PD provide an excellent baseline. The unrestricted framework of the PD, and the intuition that comes with it, both serves as the initial organization, markets, as well as a category against

[4]For a more detailed description of the model please see the Appendix.

which we can gauge the effects of the other two organizations, networks and hierarchies.

3.2.1 Including Ideology

In addition to this "standard" setup, however, agents are allowed to have individual policy preferences. In thinking about *populations* of political actors rather than just two, including variation in an individual's political preferences or ideology becomes an important amendment in tracking both individual and group attributes.[5]

By allowing individuals to have policy ideal points, the assumption is made that mutual cooperation does not mean the same thing for all actors in the system.[6] The intuition is that cooperation with an actor that shares one's preferences on an issue is different from cooperation with an actor with preferences distant from one's own. Assuming cooperation occurs at the median of their ideal points, two "left" actors, for instance, gain greater utility from cooperating with one another than might one "left" and one "right" actor. If mutual cooperation means working together to promote a particular political cause, two left actors will pursue a cause closer to their preferred outcome than would a left and right actor, for whom the median would be further from their ideal points.[7]

Any positive weight on ideology makes cooperation less likely as it reduces the value of mutual cooperation relative to other possible outcomes. As the weight on preferences increases, agents that might otherwise choose to cooperate will now choose to defect. The primary implication of this amendment to the standard PD game is that actors with more similar preferences will be more likely to cooperate than agents with more dissimilar preferences, all else considered.

In hierarchy, in contrast to agents working at a point between the pair of agents,

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[5]These ideal points are defined along a continuum (0,1).

[6]Note that if the weight on ideal points is set to 0.0, the model functions as a traditional PD.

[7]To anticipate a technical point below, when actors both cooperate, the weighted spatial distance between their ideal points is subtracted from the payoffs from mutual cooperation

$$k_{ij} = w\frac{|p_i - p_j|}{2} \tag{3.1}$$

an agent cooperates at a hierarch's ideal point (p_h) and payoffs for cooperation are adjusted by the difference not between their individual preferences but between each agent's ideal point and that assigned for the hierarchy as a whole.[8] A key attribute of hierarchy is the ability of a third party—typically the ruler, leader, or boss—to command legitimately certain actions by the members of the organization (see below). As this weighted difference increases, mutual cooperation becomes less likely vis-à-vis the other outcomes. As the weight *(w)* on preferences increases, agents that might otherwise choose to cooperate will now choose to defect.

		Agent $_j$ C	Agent $_j$ D
Agent $_i$	C	R-*k*, R-*k*	S, T
	D	T, S	P, P

Figure 3.1: **The modified prisoner's dilemma game.** In the baseline model, payoffs are identical to Axelrod's (1984) payoffs. Mutual cooperation, R, is assigned a value of 3. When actors both cooperate, the weighted spatial distance between their ideal points ($k_{ij} = w(|p_i - p_j|/2)$) is subtracted from the payoffs from mutual cooperation. The value of being suckered, S, is 0, while the value of temptation, T, is 5. Mutual defection P is set at 1.

[8] In the hierarchy the ideological adjustment is:

$$k_{ih} = w|p_i - p_h| \tag{3.2}$$

3.3 Organizational Space: Markets, Networks and Hierarchies

This section describes how the three primary forms of social organization— markets, networks and hierarchies, as described in Chapter 2—are operationalized in the model. Actors choose between each of these organizations.

3.3.1 Markets

Markets are the organizational form implied in a "standard" PD game. Within markets, cooperation 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.

In economic terms, markets in this conception are most closely equivalent to spot market exchanges. Buyers and sellers interact with equal probability of meeting one another. There is a benefit to taking the good and not paying, and a cost to producing the good and not being paid. Likewise, buyers and sellers are both better off exchanging than not. The payoffs alone provide the primary structure for the interaction.

The market is taken as the standard baseline—all agents play in the market if they do not choose another organization.

3.3.2 Networks

Given that a degree of parsimony must be preserved in order to support the modeling exercise, two characteristics capture the basic relationships between networked agents: information and selective affinity. As discussed in Chapter 2, these assumptions might prove somewhat controversial in their austerity, but getting to a working ideal type is a necessary evil.

Networks as organizations have two primary functions: providing information that allows players to acquire information beyond the two-player structure, and connecting players repeatedly, what I call selective affinity. Both are often understood as mechanisms for acquiring 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. In this conception, the focus is on the information transmission function of networks.[9] Often treated as a defining attribute of networks, in this model reciprocity is an emergent property of the agents who tend to select themselves into networks (see Powell 1990, 303, and Podolny and Page 1998, 59). Only agents that possess a contingent strategy (defined below) will 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.

In the network there is some degree of voluntarism: agents only ask and receive information from those with whom there is a tacit degree of cooperation, and potentially reciprocity. These relationships are more enduring than those in the market (Podolny and Page 1998).[10] The information transmission network is a personal one, agent *i's* network is likely to be different than agent *z's*, though they may overlap, particularly in small populations. The information mechanism is also assumed to be one that produces "nice" or cooperative behaviors.[11] Within the world of the repeated PD, and using only the information mechanism, uncooperative players are essentially shut out. Advocacy networks of the type Keck and Sikkink discuss (1998) or Wong (2009) are examples of these "nice" networks amongst likeminded nodes.

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

[10] The degree to which networked relationships endure can be specified, shorter memories of mutually cooperative outcomes lead to less enduring relationships, while perfect recall of all interactions in the past would allow for extremely enduring relationships.

[11] Although "nice" behaviors are defined normatively. As Chapter 4 will argue, cooperation amongst insurgents will be cooperative behavior as well.

The second function of a network, what I call selective affinity, is to allow for repeat interactions, specifically with a partner of the agent's choosing. This is captured by probability (η) of a player being selected into the world of selective affinity. With probability (η), players are able to choose the partner from their most recent partners with whom they received the highest net payoff. Selective Affinity allows a player to establish on going relationships with whom they have a favorable relationship (recent past interactions). Players who select the network do so with the expectation that they will always be able to get information about a potentially unknown partner, and with some probability (0,1) they will be able to pick their partner. Like the information mechanism in the network, this depends on a player's personal history. The highest net payoff is likely to be either a mutually cooperative interaction with someone who is ideologically similar, or in some cases, where the player was able to exploit another player.

Participating in a network is always costly, however, represented in the model 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. 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.

3.3.3 Hierarchies

Third party enforcement is at the core of all definitions of hierarchy. Authority of the ruler over the ruled—specifically, third party enforcement— is the means through which the behavior is changed (aligned) with the hierarch.

In this model, 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).[12] (See Figure 3.1above). Here the probability of cooperation within the hierarchy *(q)* and the magnitude of the punishment *(v)* are treated as exogenous. The intuitive analogy is to agents working in a corporation and tasked to cooperate with their fellow employees, but cooperation within the firm is contingent on factors beyond the agent's control. Some portion of the time, an agent's best efforts to cooperate may nonetheless appear to be a defection for which it is punished. This intuition extends to clans, states, autocracies, and many other hierarchies in which individuals are mandated to cooperate (uphold contracts) with one another and are punished by a central enforcer if they defect. Although random defection at an exogenously defined probability is relatively crude, some such mechanism is necessary to prevent hierarchy from dominating all other organizational forms. This representation also allows investigation into how the probability of defection and levels of punishment affect the expected utility of cooperation under hierarchy.

A second key attribute of hierarchy is the ability of the third party—typically the ruler, leader, or boss—to command legitimately certain actions by the members of the organization. The model represents this authority by assuming cooperation occurs at the hierarch's ideal point (p_h). Thus, payoffs for cooperation for agents in a hierarchical interaction are adjusted by the difference not between their individual preferences but between 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 to the preferences of the hierarch.

Agents in the hierarchy who interact with agents outside the same hierarchy play as in the market. Thus, cooperation is mandated and subject to centralized enforcement only with other members of one's own hierarchy or "group." 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" or beyond the members of the same

[12]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.

hierarchy.

Hierarchies are modeled such that agents can freely enter or leave. This is, admittedly, a significant assumption. However, as noted in Chapter 2, any kind of selection or survival mechanism may force actors to choose an otherwise unfavorable organization. Either population or other viable, preferable organizational alternatives should cause these unfavorable organizations to be quickly abandoned. In a situation where organizations are also able to be eliminated (which this version of the model does not), these would not survive. The modeling goal here is to study organizational choice. While this assumption limits the scope of the model, it is a necessary one to allow agents to choose at every round.

3.4 Modeling Organizational Ecology in an Agent-Based Framework

Here, I outline the ABM in its three stages: initialization, learning, and organizational choice. Figure 3.2 below is a visual representation of the major processes in the model. The expected utility equations for each organization are detailed in the Chapter Appendix and the Technical Appendix.

Figure 3.2 about here

3.4.1 Initialization

The model begins with the specification of 23 user-defined parameters. These parameters and their default values, used in all the simulations presented below unless otherwise specified, are listed in Table 3.1.

Table 3.1: Default Parameters

Parameter	***Symbol***	***Description***	***Default Value***

Table 3.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
General			
Increments		Times the simulation is run incrementing a parameter	25
Repetitions		Times the identical simulation is repeated with different random seeds	25
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	5 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	5
P	P	Payoff for DD outcome	1
Hierarchy			

Table 3.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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 Cooperation	Q	Rate at which the agents cooperate with other agents in the hierarchy	0.95
Tax	τ	Tax assessed on members of the hierarchy	0.3
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
Selective Affinity			
Network Affinity	η	Probability of network players being able to pick their partner	0.1
Affinity Memory	m_a	How far back affinity players can look into their memory	5
Hierarchy Affinity	ι	Probability of hierarchy players being guaranteed a pairing with another member of its hierarchy	0
Evolution			

Table 3.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
Selection			
Rate			
Mechanism		Number of Rounds or cumulative net payoffs	

Payoffs for the various outcomes are assigned: T, R, P, and S.[13] The user specifies the population of actors, specifically the number of actors, distribution of strategy types, and their preferences. Like other game-theoretic ABMs, agents are defined by strategy type. The model focuses on three basic strategies: all cooperate (ALLC), all defect (ALLD), and tit-for-tat (TFT).[14] ALLC and TFT are nice strategies that begin by cooperating with new agents, while ALLD is a nasty strategy. "Nice" and "nasty" populations are defined by the relative proportions of these two sets of agents. Preferences (pi) are defined over a (0,1) space and randomly assigned from a normal distribution. The weight on preferences (w) can also be varied.

The organizational parameters are also set at this stage. Networks are defined by their width *(α)*, the number of other agents each agent can directly ask about the agent it has been randomly paired with, and their depth *(l)*, the number of levels of agents that are polled. A 3x3 α= 3, *l* = 3) network is illustrated in Figure 3.3. Although each agent has a potentially infinite memory of its own interactions with each other agent in the population, the network is limited to a fixed memory *(m)* defined by the number of previous rounds over which it can poll. That is, if memory is set at its default value of five, any agent can poll only those agents with whom it has cooperated in the last five rounds whether they have interacted with the other agent with whom it has been randomly paired in the current round. The longer the memory (the larger *m*) for the network, the more useful information it returns to the agent. The fee for joining the

[13]For all analysis in this chapter, I set cardinal payoffs to the PD game in Axelrod (1984). These payoffs can be manipulated to create any 2x2 game.

[14]Five strategies are specified in the full model: the three described here as well as mix that plays cooperation probabilistically at a specified rate (MIX), and anti-tit-for-tat (ATFT). For simplicity, in all the simulations reported in this chapter I include only varying combinations of ALLC, TFT, and ALLD strategy types. When thinking about nice or nasty types, ATFT is a nasty type, while MIX can be precisely specified as proportion nice or nasty.

network *(ϕ)* is also set. The probability of being selected into the world of selective affinity *(η)*, in which the agent selects the partner with whom it had the highest net payoff in the previous *(m_n)* interactions is also set. With probability (1-η) the agent is paired as it would be in the network otherwise—randomly drawing a partner from the population.

A hierarchy is defined by its assigned ideal point *(p_h)*, the probability that any agent will cooperate with other agents in the hierarchy *(q)*, and the penalty that is imposed on agents for defecting on other agents in the hierarchy *(v)*. All of these parameters are common knowledge. Since the expected utility for joining the hierarchy is contingent on the number of other agents in the hierarchy *(θ)*, in the first round of organizational play the user sets an "advertised" number of agents in the hierarchy, which need not be the same as the actual number of agents who join. In subsequent rounds, agents know the actual number of agents who joined the hierarchy in the previous round.[15] Affinity in the hierarchy follows a similar mechanism to that in the network, the probability *(ι)* which hierarchy members are guaranteed to be paired with another member of the hierarchy in that round. With probability (1-ι) they are paired with a member of the population, who may or may not be a member of the hierarchy.

3.4.2 Learning

Agents begin the simulation with no knowledge of the distribution of the other agents' strategies or the mean ideal point of agents in the population. In the learning phase, agents are randomly paired with other agents with whom they then play a round of the game according to their fixed strategy type with payoffs as specified. Over the course of a specified number of rounds, agents develop beliefs about two parameters from their interactions with other agents. First, they learn about the distribution of other strategy types. Observing their own payoffs, they then back out whether the other agent cooperated or defected, store this action in memory by agent, and update a running estimate of the proportion of cooperators and defectors in the population *(β_i)*. From this, agents learn whether the environment is relatively nice (full of cooperative types)

[15]The model includes the ability to define up to three unique hierarchies. If multiple hierarchies are created, these four parameters are specified for each. In this chapter, I limit all simulations to one hierarchy.

or nasty (full of strategy types likely to defect). Second, when they cooperate with other agents, agents also learn about the distribution of preferences in the population and whether their own preferences are relatively extreme or moderate. Again, knowing only their own preference, agents who cooperate with one another examine their payoffs and back out the ideal point of the other agent, store this knowledge in memory, and then update their beliefs about the mean ideal point in the population (ρ). In this phase of the simulation, agents are restricted to the knowledge they accumulate about other agents through direct play. Interactions in this phase are equivalent to what I later call market interactions.

In this chapter, for simplicity, the number of rounds for the learning period is fixed at five.[16] Each agent develops unique beliefs over the course of play, meaning that even agents with the same strategy type and even very similar or identical ideal points will make different organizational choices in the next stage. Agents who believe the population is nastier than it really is are *pessimists* and agents who believe the population is nicer than in actuality are *optimists*.

3.4.3 Organizational Choice and Play

Once the learning period is concluded, the main simulation of interest begins and continues for a fixed number of rounds. In this phase, 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.[17]

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), and the ideal point of the hierarchy (p_h).

[16] In the model, the number of learning rounds can be defined by either a fixed number or by convergence of the mean estimate (within some specified error rate) to the true mean of the proportion of nice and nasty strategy types within the population.

[17] Expected utility calculations are included in the Chapter Appendix and in the Technical Appendix.

After agents choose the organization they will join for that round, the next stage is actual play within each organization. As in the learning phase, agents are randomly paired with another agent for that round, or, if selected into the affinity world, is 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 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 that all agents are sincere in their reporting and are known to be so by all other agents.[18]

If the agent chooses to join 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

[18]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). In this version of the model, 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 that the strategy types examined here are pure, this assumption has no consequence for any of the results. If a strategy type plays C or D probabilistically (as does MIX), redundant responses will lead to biased estimates of the agent's type, although on average beliefs will still converge to the true type.

Table 3.2: Play by Strategy and Organization

Strategy	Market	Network	Hierarchy
ALLC	Cooperate	Cooperate	Cooperate with members of Hierarchy at rate q, else Cooperate
ALLD	Defect	Defect	Cooperate with members of Hierarchy at rate q, else Defect
TFT	Cooperate if unknown, else do what agent did in previous round	Cooperate if believes opponent will cooperate	Cooperate with members of the hierarchy at rate q, else TFT

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 it were interacting in the market.

Following play, 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.

Although the model described above can be used for many purposes, 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.

3.5 Principles of Organizational Ecology and Population Dynamics

Here, I introduce some of the output of the ABM as well as to highlight some emergent properties. The set presented here are by no means exhaustive, but intended to draw out issues of population and organizational ecology in order to generate a set of principles of organizational ecology and population dynamics.

Some of these properties will be used to generate hypotheses to test empirically in later chapters. Some are fairly intuitive, and validate the core architecture of the model, others are more novel, and highlight the emergent properties to come. By far the most interesting properties, and those that the model is particularly suited to examine, involve interactive elements of both the population and the organizational properties. To preview a finding below, because agents do not update their beliefs about the population, in relatively "nasty" populations, pessimistic, nice agents are driven into the hierarchy for the protection it provides, but because they cannot revise their beliefs about the relative niceness or nastiness of the population, they remain there. Similarly, in populations where all actors have entered the hierarchy en masse— most common in very nasty populations—they are hard-pressed to find cooperative partners outside of the hierarchy, further entrenching the value of the hierarchy in the population, and making it difficult for the market and network to provide vibrant alternative organizations. Both of these examples show the interplay between population and the organizational choices made by particular members of the population.

Broadly speaking, there are three primary categories of variables in the model that predict organizational outcomes and population dynamics: population characteristics, agent characteristics, and organizational characteristics. This section goes through each of these and examines the basic principles of organizational ecology and population dynamics.

A few notes on evaluation. Any particular benchmark imposed is fairly arbitrary. As the simulations that follow show, there are clear phase shifts in which a population moves nearly unanimously from one organization to another. What will always be of note are situations when any of the organizations have no members or when one has all of the population's members. Of similar interest are conditions where all three organizations have members (better yet, parity of membership). As you will see below, during transition moments, I try to tease out *which* agents have separated themselves. To preview findings ahead, I see that agents often separate themselves into organizations based on either strategy type, ideology, or their beliefs about the population. Likewise, "nasty" and "nice" populations can vary, and I look specifically at population composition below.

3.5.1 Organizational Characteristics

For all simulations presented in the dissertation, all three organizations are options for the agents. The organizational ecology is heavily dependent on the organizational properties that determine the set of organizations selected. Many of the properties here are fairly intuitive. Table 3.3 below gives the more intuitive comparative static results as major parameters are increased. I will offer slightly more detailed discussion below, but provide simulation results in the chapter appendix to demonstrate these comparative static results.

Table 3.3: Organizational Properties Comparative Static Results

Parameter	***Comparative Static result as parameter is increased***
Hierarchy	
Initial hierarchy size	As the initial number of members in the hierarchy increases more agents move into the hierarchy more quickly. (See Technical Appendix)
Penalty	As the penalty for defecting against another member of the hierarchy increases, fewer agents join the hierarchy. (See Figure A.6)
Prob of Cooperation	As the Probability of Cooperation increases, more agents join the hierarchy. (Figure A.5)
Tax	As the tax to join the hierarchy increases, fewer agents join the hierarchy. (See Figures A.7 and A.8)

Table 3.3 – Continued

Parameter	***Comparative Static result as parameter is increased***
Ideal point	As the ideal point of the hierarchy becomes more extreme relative to the median population ideal point, fewer agents join the hierarchy. (See Figure A.4)
Network	
Cost	As the cost to join the network increases, fewer agents choose the network. (See Figure A.1)
Width	Initially, more agents join the network as width increases, but agents move into the hierarchy or market as the information mechanism becomes exhausted. (See Figure A.3)
Depth	Initially, more agents join the network as depth increases, but agents move into the hierarchy or market as the information mechanism becomes exhausted. (See Technical Appendix)
Memory	Initially, more agents join the network as agent memory increases, but agents move into the hierarchy or market as the information mechanism becomes exhausted. (See Figure A.2)
Selective Affinity	
Network Affinity	As the rate of affinity increases, more agents join the network. (See Technical Appendix)
Network Affinity Memory	As network affinity memory increases, more agents join the network. (See Technical Appendix)
Hierarchy Affinity	As the rate of hierarchy affinity increases, more agents join the hierarchy. (See Technical Appendix)

The location, effectiveness, and cost of the hierarchy determine who joins the hierarchy, and when they join. Agents of all types will join hierarchies—even those that are relatively extreme– given certain conditions. Hierarchy membership increases with the nastiness of the population. In “nicer” populations, agents enter hierarchies that are situated close to the population mean—around 0.5, and drop out of the hierarchy often for the network toward the extremes. The most vulnerable agents, ALLCs, universally enter the hierarchy first, followed by TFTs, and finally ALLD agents. Nice agents are willing to trade off greater "security" in the hierarchy for ideological distance more quickly than nasty agents.

Hierarchy effectiveness also affects membership overall, as well as timing of membership. Hierarchies that are relatively ineffective at inducing cooperation amongst their own members will get some membership, but become much more populated as the rate of cooperation increases. Repeating the patterns observed above, nice agents are willing to trade off effectiveness more readily than are nasty agents. ALLDs only join hierarchies that are able to sustain high levels of internal cooperation, and only do so when the market is drained of exploitable prey. Related, as the penalty for defecting on another member of your hierarchy increases, membership drops precipitously Intuitively, as the tax on members in the hierarchy increases, agents exit the hierarchy. Nice agents are willing to pay high taxes longest, but all agents leave the hierarchy as that rate grows too high.

The ABM assumes that interactions, and organizational decisions are voluntary. Particularly with hierarchies, we observe actors who have, at best, tenuous exit options and might be better described as in a coercive relationship. While this is not explicitly modeled, the model does show the stickiness of hierarchies, particularly in relation to the other organizations in play. Hierarchies can entrench "nice" players, who are often the actors who pay the highest taxes and suffer the greatest ideological penalty. Hierarchies are particularly difficult to exit when they control a large proportion of the population with whom an agent will interact. For these actors there is no viable alternative to the hierarchy. For actors in the Warsaw pact (e.g., Czechoslovakia)—or gang analogy, who wish to exit, the population of potential cooperative actors with whom it could interact outside of the hierarchy has been diminished (ALLCs and TFTs are the first to enter). Furthermore, in an evolutionary world with a high selection mechanism, exit may lead to death. These actors can be bled dry by hierarchs and their extractive policies, but as long as the hierarch controls a sufficient proportion of those with whom the actor would be likely to interact, the subordinate relationship is preferable to extinction. While these interactions are all modeled as "voluntary," looking at the welfare tells a different story. Particularly in nasty populations, nice types cannot leave the hierarchy until there are enough other cooperators to interact with in the market (or network), they remain "trapped" in the hierarchy because all agents with whom they would like to cooperate with are also in the hierarchy. This interaction between the choices of the population and the relative proportion of actors who join the hierarchy shows how crucial it is to examine the interplay between the actors, the population as a whole, and the full set of organizational alternatives.

Proposition 1: Hierarchies are likely to be extremely stable relative to the other organizations when adopted early in "nice" populations.

The willingness of agents to join hierarchies that are ideologically distant from themselves is an important extension. In nice populations, networks prevail except when an agent is nearly ideologically identical to the hierarchy. However, in nasty populations, the hierarchy becomes an increasingly attractive alternative to markets and networks (and as more agents join an ever growing hierarchy per Proposition 1). Nice types still enter hierarchies at higher rates than do nasty types, at all ideological locations.

This proposition has implications for the survival of (ideologically extreme) hierarchies. Autocracies may thrive in populations that are relatively nasty, or relatively pessimistic. Terrorist or insurgent organizations may be more likely to draft unwilling combatants because of the distribution of strategy types in the population, or even the beliefs about the distribution of strategy types in the population. The model suggests interventions that can change either of those factors are likely to impact the survival of these types of hierarchies.

Proposition 2: More agents join hierarchies that are ideologically close to the median agent, but in nasty populations agents will join relatively extreme hierarchies.

3.5.2 Population Characteristics

Looking at the broadest level, the size and distribution of strategy types affects organizational choices. The questions asked at this level underpin the core intuition that nice populations (i.e., those populated with "nice" or cooperative strategy types) should produce different organizational ecologies than we might expect nasty populations to produce. Likewise, small populations may produce different organizational ecology than larger ones.

Figure 3.4 about here

Figure 3.4 shows organizational choice in a population that grows in size. With a small number of actors, agents start in the network and the more pessimistic agents move into the hierarchy as the population grows, suggesting that hierarchies are more valuable in larger populations and networks decay in larger populations. Intuitively, this is the difference between living in a small town versus a large city. In small populations agents will have many repeated interactions with all members of the population and have better knowledge of population as well as each individual. Here, there is a higher probability of knowing your partner directly, or knowing someone who knows him, allowing you to expect the network to provide valuable information. Agents in large populations will take longer to interact with everyone in the population, if they ever do. Instead they are more likely to be facing a stranger in any given round, making the network less useful than in similarly composed but smaller populations. Larger populations will feel more anonymous to agents, and particularly those whose past interactions have been disproportionately defections. These pessimistic agents view organizations as way to buy into smaller, likely more cooperative worlds. While the informational value of the network is depleted quickly for some agents, those TFT agents use it early on can avoid being suckered. Even after the informational value is gone, agents of all strategy types can use the selective affinity mechanism in the network as a way to increase the probability of being matched with a cooperative agent.

Proposition 3: The network decays as the population grows.

Figure 3.5 about here

Figure 3.5 shows the organizational choice across strategy types as the population moves from nice (populated with ALLCs and TFTs) to nasty (populated with ALLDs). Nice types join the hierarchy to escape exploitation in the market as the likelihood of meeting and being suckered by an ALLD in the market increases. ALLDs are the last to enter into the hierarchy, and do so only when the market is sufficiently devoid of nice types for exploitation. At this point ALLDs interact only with other ALLDs in the market, and see the hierarchy in particular as a way to increase their net payoffs. At extreme levels of defection, some ALLDs will move into the network as a way to cherry-pick nice agents to sucker, on balance though, the nastier the population the higher the proportion of agents in the hierarchy.

Proposition 4: More agents join the hierarchy as the population becomes larger and nastier.

From both the population size, as well as the nastiness of the population simulations, we see agents move into the hierarchy as the nice types are more likely to be exploited and the nasty types are less likely to be able to exploit in the market or network. The hierarchy is a way for vulnerable types, particularly ALLCs, to safeguard themselves, and for nasty types, ALLDs, to tie their hands sufficiently to get some cooperative outcomes. Hierarchies are therefore mostly likely to emerge in nasty or large populations.

3.5.3 Agent Characteristics

Looking at organizational decisions at the level of the agent also matters; indeed, these factors are critical in determining what I have called population dynamics. At the outset agents are defined by two characteristics: their strategy type and their ideal point. After one round of the simulation, agents are defined additionally by their beliefs about the distribution of strategies (β_i) and ideal points in the population (ρ_i). I look at these four characteristics below.

Strategy Type

One of the most basic ways to distinguish agents is to look at decisions based on strategy type. Though agents can be differentiated in several ways, strategy type is the most significant distinguishing characteristic. Figure 3.6, below shows the differentiated entry into the hierarchy, in order of the "niceness" of strategy (i.e., ALLC, TFT, ALLD). Nicer agents are the first to enter into hierarchic relationships; nastier agents are the last to enter into hierarchic relationships. Essentially, nice agents move into the hierarchy to avoid being suckered in the market, nasty agents move into the hierarchy because there is no one *left* to sucker in the market, and there are gains to be had from cooperation with other uncooperative agents.

Figure 3.6 about here

Proposition 5: Nice agents in nasty worlds are the most likely to join a hierarchy.

The likelihood an agent will join an ideologically extreme hierarchy varies based on their strategy type as well. Figure A.4 shows that ALLCs will join an extreme hierarchy and remain there, where TFT agents will choose hierarchies that are close to their own ideal points, and ALLDs are the least likely to join an ideologically distant hierarchy. Chapter 4 explores this dynamic in greater detail.

Proposition 6: Nice agents are the most likely to join an ideologically distant hierarchy.

Ideal Point

One of the major twists on the "standard" cooperation games employed in this model is the introduction of ideology. As the distribution of agents becomes more extreme relative to the hierarchy, agents use the network much more. The selective affinity mechanism in the network is able to take both strategy type as well as ideology into account. Taken together, the likely pairing in the network is more ideologically flexible for a given agent. An ALLC or TFT is likely to be matched not just with another cooperative agent, but a cooperative agent that is the most similar ideologically. This makes the network more ideologically flexible for agents, particularly a boon for relatively extreme agents. Figures 3.7 and 3.8 show that as the population mean approaches the location of the hierarchy in the ideological space (0.5), agents of all types leave the network for the hierarchy. ALLCs leave first and in greatest proportions, followed by TFTs, and relatively insignificantly by ALLDs. Where each agent's network allows them to pick the most ideologically suitable partner, the network is more robust to situations where the agent's ideal point is different from a fixed organization. Based on the exodus from the network to the hierarchy where those ideal points overlap, we can speculate that ceteris paribus "nice" agents in particular, prefer the hierarchy to the network. However, when those agents are distant from the hierarchy, they make significant use of the network.

Figures 3.8 and 3.7 about here

Proposition 7: Ideologically extreme agents are more likely to choose a network than a distant hierarchy.

Given the relatively low default weight on ideology, the finding that hierarchies that are not situated at the population's median ideal point draw fewer agents has potentially significant implications for hierarchical survival. Whether these hierarchies are terrorist groups, political parties, or governments, ideological distant hierarchies seem to require predatory (nasty) populations. The implication here is that nice populations are likely to be resistant (and able to be resistant) to hierarchies that are "undemocratic," by which I mean distant from the population mean. In cooperative populations, agents are able to use the market, and networks to sustain high levels of cooperation.

Proposition 8: Agents are unlikely to choose ideologically distant hierarchies in nice or moderate populations.

Agent Beliefs

In addition to their "hardwired" behavior patterns and ideology, agents develop, and constantly update, beliefs about the rest of the population. We know that agents in the population who have more pessimistic beliefs go into the hierarchy at much higher rates. A simple difference in means test reveals that in the general population, agents in the hierarchy believe the probability of meeting with a cooperative agent to be 0.2 lower than agents in the network and the market.[19] This pattern holds strongly across all strategy types.

Beliefs about the nastiness of the population appear to be a second order characteristic, but one that could significantly affect organizational choice. Agents appear to enter the hierarchy by strategy type, but within strategy types, pessimists are the first to enter.

Proposition 9: Pessimistic agents are more likely to join the hierarchy.

3.5.4 Strategic Setting

The strategic setting, by which I mean the ordering of the outcomes by payoff (T, R, P, S), also affects the organizational ecology. As has been discussed above, including ideology can have an effect similar to those discussed here.[20]

I focus on working from the default setting, while retaining the Prisoner's Dilemma structure for payoffs. While there is certainly much rich material in looking at other games, the focus on the PD was done for the sake of relative comparability to the other principles highlighted above, as well as brevity.

Figure 3.9 about here

As shown in Figure 3.9 when the payoff for mutual cooperation becomes large, agents of all types enter the hierarchy.

Proposition 10: As the payoffs to cooperation increase agents join the hierarchy in greater proportions.

[19] $t = 495.37$, $df = 1.0e+6$. $p < 0.00001$.

[20] Because half of the weighted spatial distance between actors (or the weighted distance between the actor and hierarchy) is subtracted from the mutual cooperation payoff (R). When this distance is large, or the weight on ideology is high, it can potentially reorder the payoffs associated with different outcomes.

Figure 3.10 about here

Figure 3.10 shows as the incentives to defect become large relative to the benefits to cooperation, the ALLD and TFT agents leave the hierarchy for the network, the ALLDs to use the affinity mechanism to find people to sucker, and the TFTs to find cooperative partners and gain information. The ALLCs, the most vulnerable to this type of behavior, remain firmly in the hierarchy.

Proposition 11: As the incentives to defect become large, only the nicest agents remain in the hierarchy.

Figure 3.11 about here.

As the costs of being suckered become extremely high, organizational selection shifts significantly (see Figure 3.11). We see TFT agents in the network at extremely high and low values of the CD outcome, but also find they enter the hierarchy in middling values. ALLCs move from the market to the hierarchy to the network as a group, while ALLDs are split between the network and the hierarchy.

Figure 3.12 about here

Figure 3.12 shows the organizational shifts as the payoff for mutual defection varies. TFT and ALLD agents leave the hierarchy for the network, where they are able to either get a mutually cooperative outcome, or sucker another agent through affinity. ALLCs remain in the hierarchy throughout. In situations where the mutual defection payoff is extremely bad, agents of all types enter the hierarchy to avoid that outcome.

Taken together, hierarchy above can be a carrot or a stick. Agents of all type use it, but it becomes the single organization when either the benefits to using it are very high (as the CC outcome increases), or when the risk to being defected on (DD and CD) become very bad.

Proposition 12: The hierarchy is likely when the benefits of cooperation or the costs of non-cooperation are high.

3.6 Skid Row Revisited and Conclusions

Cooperation between members of different, sometimes rival, gangs in the territory of a single gang points to the power of cooperation when incentives are right. Within the context of the model, the mutually cooperative payoff here is increased relative to the others. In this case, even ideologically extreme hierarchies, in relatively uncooperative (nasty) populations can create high levels of cooperation.

Figure 3.13 below shows that even in situations where the hierarchy's ideal point is extreme (0.2) compared to the mean in the population (0.5), all agents will join the hierarchy, even in this uncooperative world. In fact, this Skid Row solution may only work precisely because of the nastiness of the population. These agents cannot cooperate any other way. In a world where the gangs are not warring rivals, cooperation might be sustained (or not sustained) through a network or even unconstrained interactions in the market. Here, in this very uncooperative world, agents move into the hierarchy en masse as the benefits to mutual cooperation increase. Here, mutual cooperation means economic cooperation under the dominant gang on Skid Row.

Figure 3.13 about here

Even this simple setup using the Prisoner's Dilemma played in a fairly small population shows that networks and hierarchies can be solutions to this cooperation problem. One of the most crucial variables in determining the organizational ecology appears to be the distribution of strategy types. Indeed, the Skid Row case works precisely because it takes place in an uncooperative population, where the only mechanism for extremely uncooperative agents to work together is in a hierarchy. In a nicer population, this solution will likely fall apart in favor of networks or markets. In short, the adage, "keep friends close, and your enemy closer," or the "team of rivals" concept of governance work in specific situations (and are likely the only solution to allow cooperation). As the model moves from a purely theoretical tool, to an applied theoretical tool in subsequent chapters, great care must be taken to ensure that the niceness or nastiness of the population be appropriately captured to maximize external validity. The simulations shown above, and the initial principles of organizational ecology all speak to the importance of organizational design. Moreover, institutions must be designed in light of the population. It is potentially more “dangerous” to have the defectors operating outside of the organization, and if defectors are successfully integrated, it must be ensured they do not have an incentive to leave the organization to exploit. Additionally, nice types may be necessary in some circumstances to “get the ball rolling” and increase the membership in the hierarchy. Hierarchies die quickly without early adopters, and those early adopters are more likely than not to be “nice” types. Networks will remain robust for long periods of time, but they rely heavily on the affinity function, rather than the informational function. Surveying is valuable in the short term but not the long term. Selective affinity can create networks of exploitation or “dark” networks. However, in a non-evolutionary world, these may quickly drive agents into the hierarchy in response.

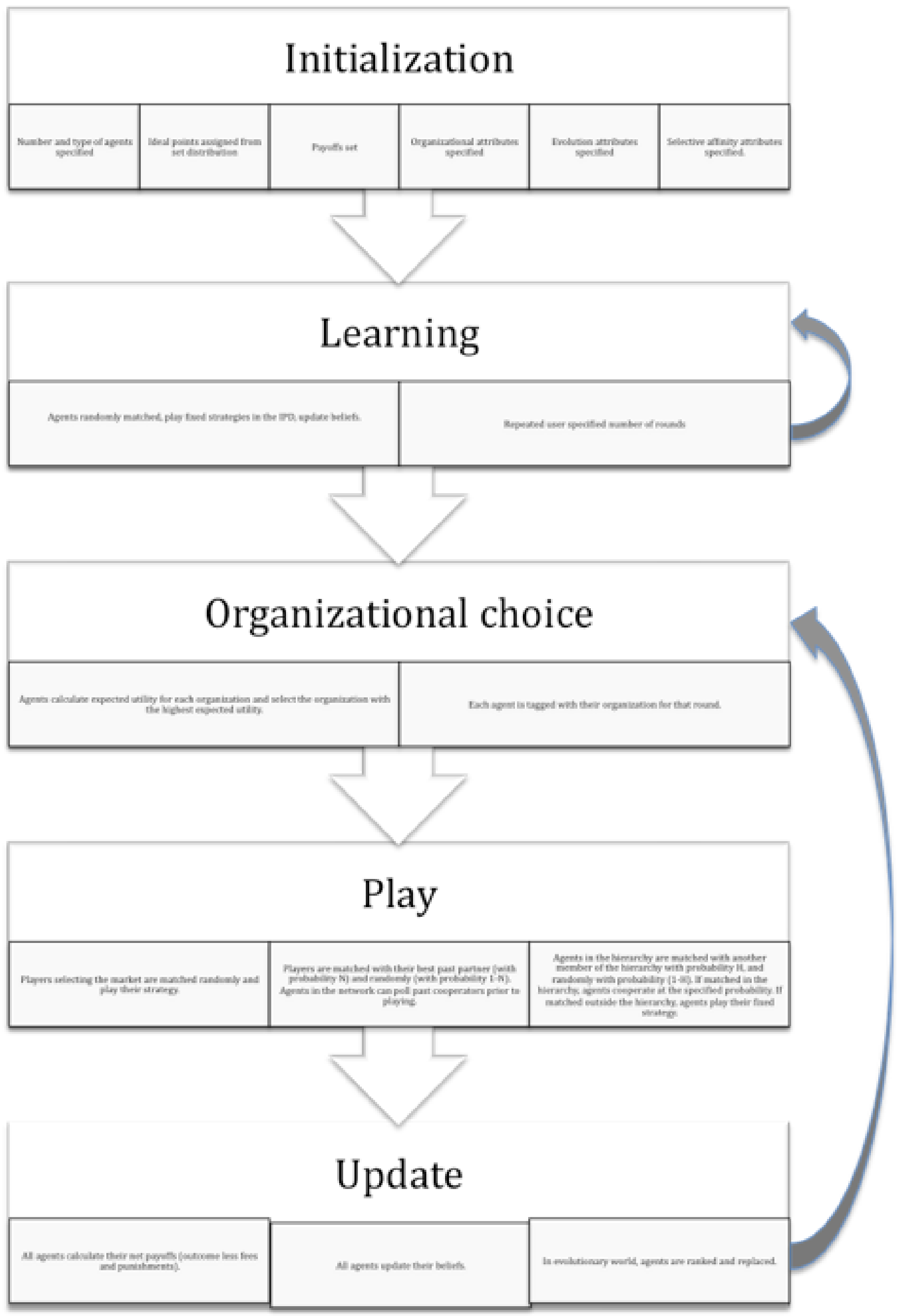

Figure 3.2: Model Structure

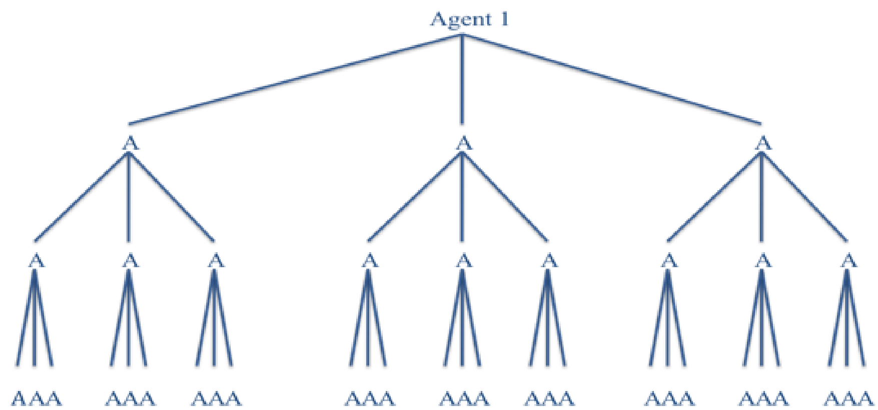

Figure 3.3: Structure of a 3x3 Network

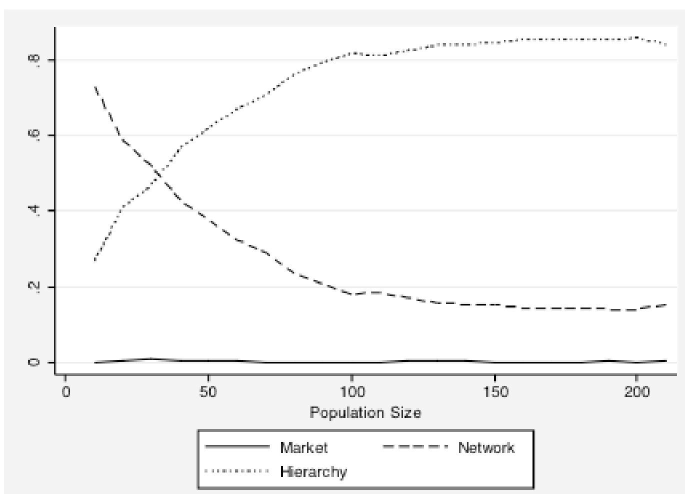

Figure 3.4: Population size and organizational choice. Proportion of agents in each organizational form. As population size increases, agents leave the network for the hierarchy. Agents that go into the hierarchy believe the world is significantly nastier than those that go into the market after leaving the network (t= 410.7722, df = 923998, t<0.0001). Seed: 677586 40 iterations 10 reps, population size increases by 3 TFTs, 1 ALLC, and 6 ALLDs with each increment.

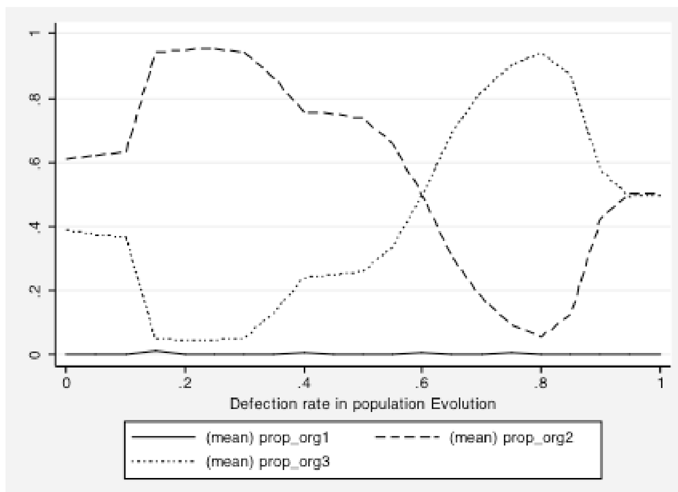

Figure 3.5: Proportion of agents in each organization. ALLCs are the first to join the hierarchy as the proportion of nasty strategy types increases in the population, followed by TFTs and then the most pessimistic ALLDs. After all of the "nice" agents are in the hierarchy, some ALLD agents return to the network to try to sucker the ALLCs and TFTs. Population begins with 40 ALLCs, 60TFTs, and 0 ALLDs. At each increment, the number of ALLDs increases by 5 and the number of ALLCs and TFTs decrease by 2 and 3 respectively. Seed 960552; 21 iterations.

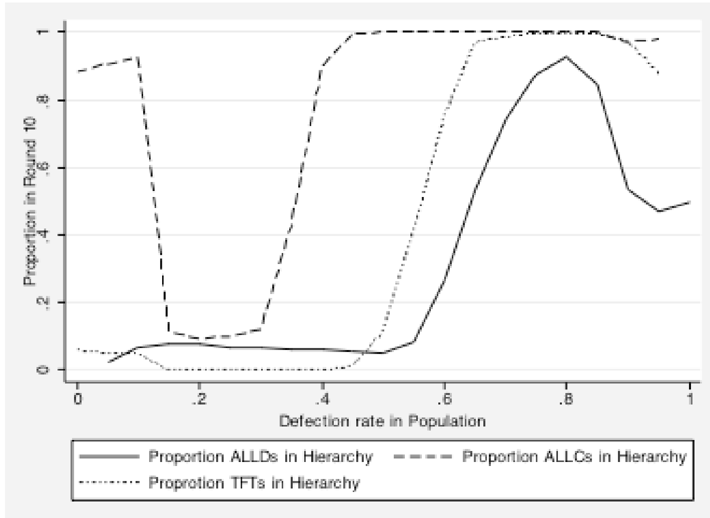

Figure 3.6: Proportion of each strategy type choosing hierarchy as the population becomes increasingly nasty. ALLCs are the first to join the hierarchy as the proportion of nasty strategy types increases in the population, followed by TFTs and then the most pessimistic ALLDs. After all of the "nice" agents are in the hierarchy, some ALLD agents return to the market to try to sucker the ALLCs and TFTs. Population begins with 40 ALLCs, 60TFTs, and 0 ALLDs. At each increment, the number of ALLDs increases by 5 and the number of ALLCs and TFTs decrease by 2 and 3 respectively. Seed 960552; 21 iterations.

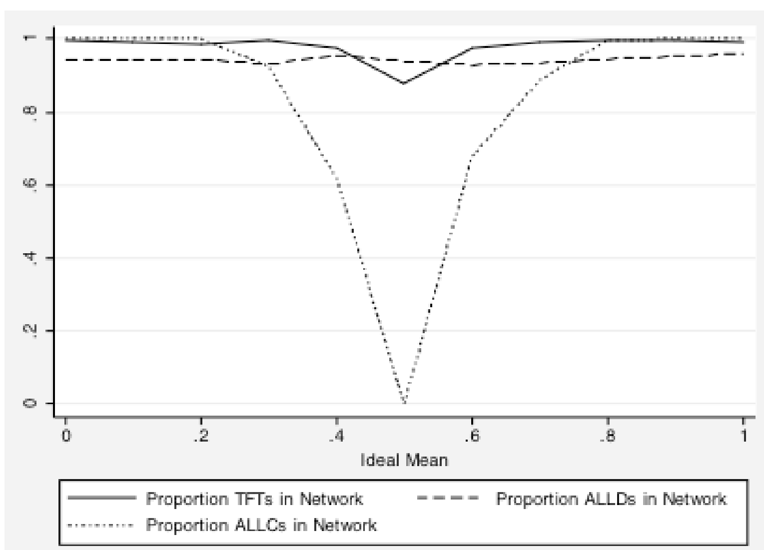

Figure 3.7: Network membership by Strategy type as population mean varies. As the distribution ideal points moves across the parameter space, agents of all types leave the network only for the hierarchy around 0.5. Seed 756209 20ALLCs 50ALLDs 30TFTs; incremented 11 times from 0 by +0.1

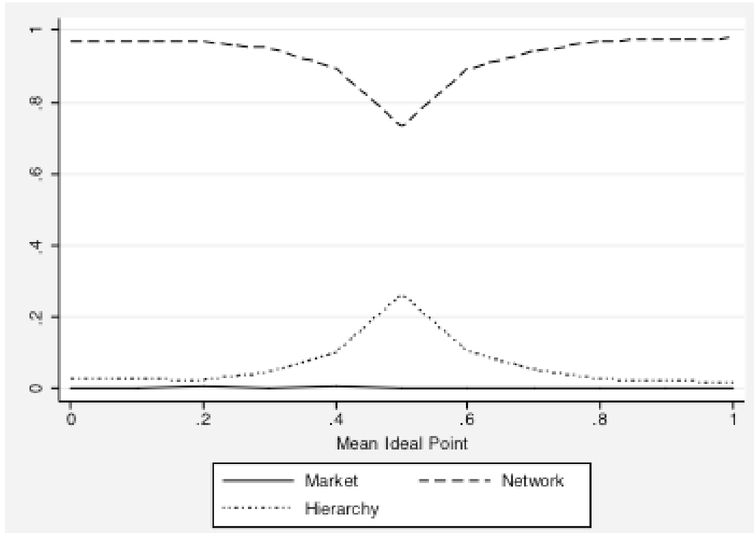

Figure 3.8: Organizational choice as Ideology varies. As the mean ideal point in the population goes from its minimum (0) to its maximum (1), agents only leave the network for the hierarchy as the population mean approaches the hierarchy's mean (0.5). Agents only choose the hierarchy when they have relatively similar ideal points. 756209 50ALLDs 20ALLCs 30TFTs

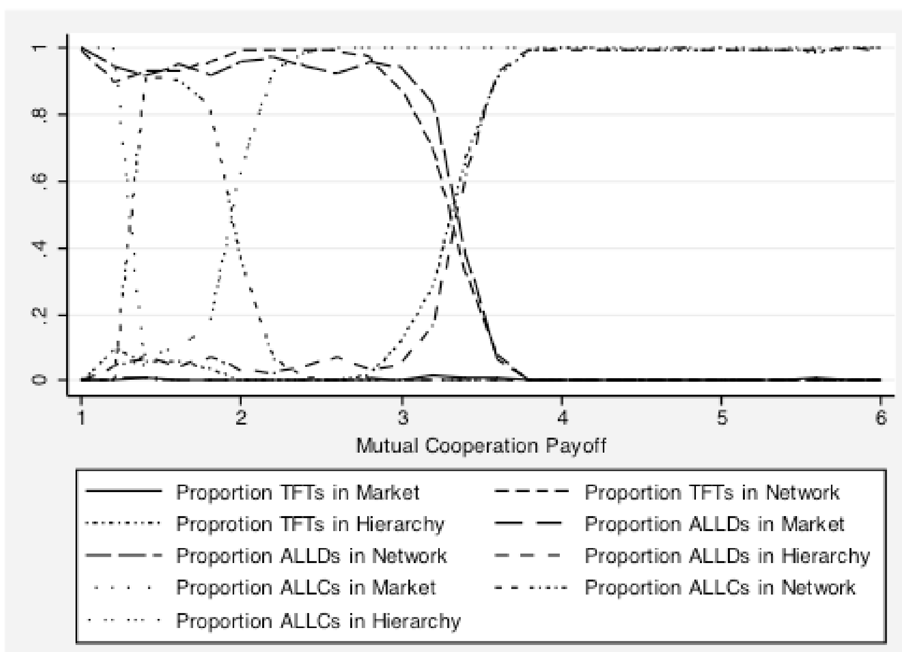

Figure 3.9: Here, all strategy types are tracked through the organizations. The network is valuable for middle and high levels of cooperation, but when they become very large all strategy types move to the hierarchy. Seed:71721

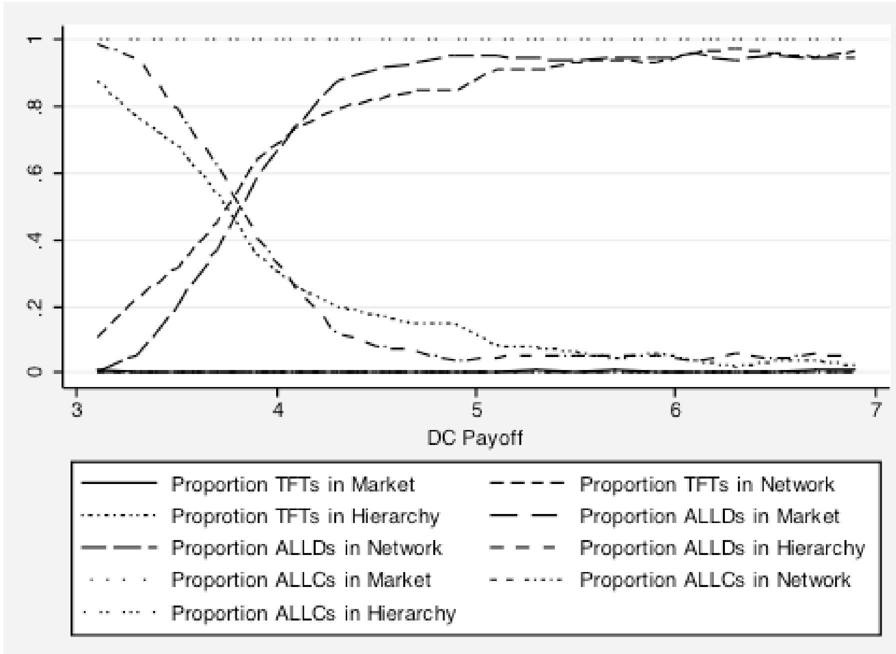

Figure 3.10: ALLDs and TFT agents move from the network to the hierarchy, ALLC agents remain universally in the hierarchy. Seed: 679885

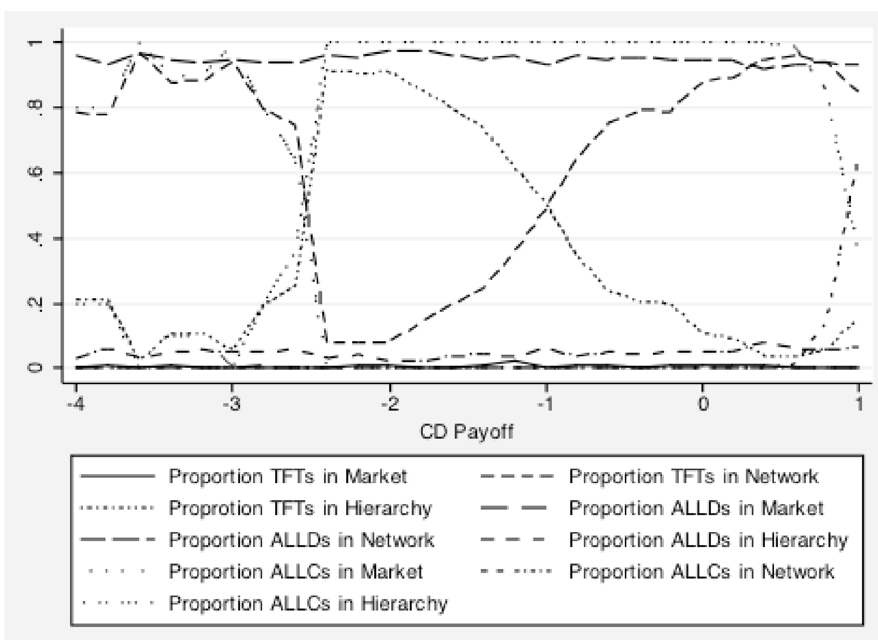

Figure 3.11: Seed: 83359

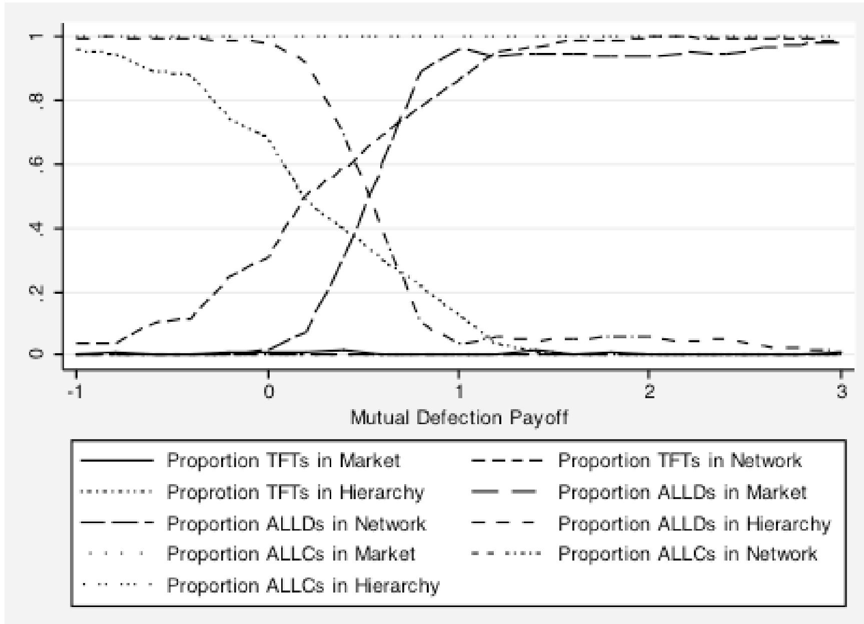

Figure 3.12: Seed: 720862

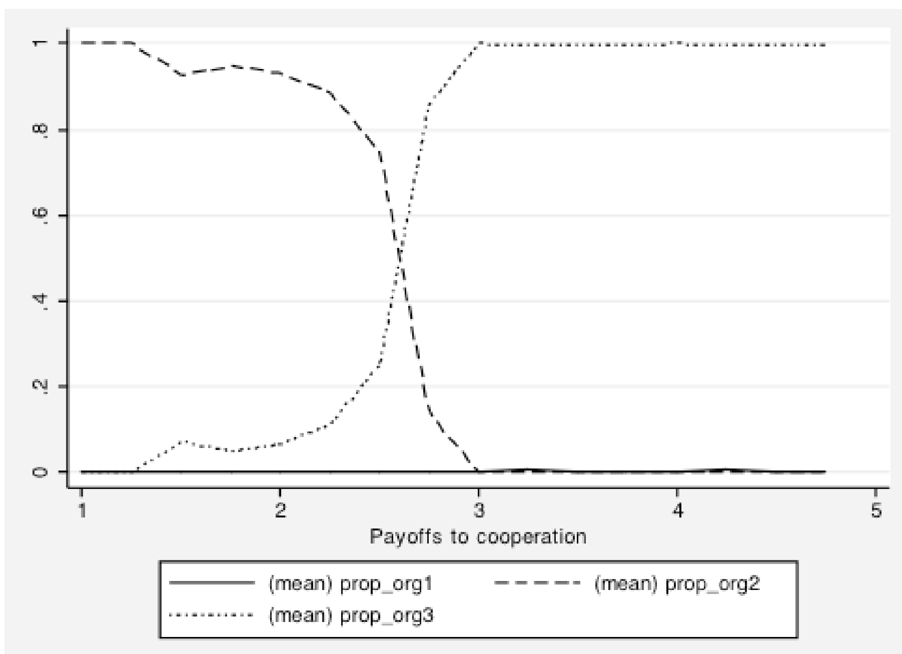

Figure 3.13: Organizational choice as the Payoffs to cooperation vary. This population is fairly nasty, composed of 85 ALLD agents and 15 TFTs. As payoff for mutual cooperation increases, even with an extreme hierarchy in a nasty population (where agents are unlikely to cooperate otherwise) can see lots of cooperation. [900979. Hierarchy ideal at 0.2]

Chapter 4

The Organizational Ecology of Rebels

4.1 Introduction

There is great variety in the organizational structure of rebel groups. Timothy McVeigh and militia movements work in an a-organizational market. Al-Qaeda is the canonical networked terrorist organization. Hamas is hierarchical and state-like in its organization.

In addition to variation across rebel groups, the structure of these groups often changes over the course of their lifespan. Much has been made of al-Qaeda's network structure, but even this organization has varied from hierarchy to network over its lifetime. Some rebellions, like the Eritrean movement during its secessionist war, varied significantly over the course of the conflict, passing through all three organizational forms: from market, to network, to hierarchy.

Variation in rebel structure affects many aspects of conflict. Coordination (or consolidation) enables disputes to be settled more quickly (Cunningham 2006), gain concessions (Cunningham 2011), and conduct deadly attacks (Heger, Jung and Wong forthcoming). Despite these major implications for the character of conflict, no one has answered the question of why rebels structure themselves differently both across and within conflicts. In this chapter, I argue that the organizational ecology and population dynamics of the rebel situation determine the organizational structure of rebel groups.

Rebels use violence to extract concessions from the state. In using violence, individual rebels face a prisoner's dilemma in which all are best off cooperating on violence to gain significant concessions and increase welfare. However, any individual's participation in violence has little effect, and assuming everyone else cooperates, their best outcome would be free riding on the efforts of others: gaining concessions from the government without personally bearing the costs of fighting.

To produce political pressure for concessions in the face of this dilemma, rebels can form as ad hoc "groups of guys" (markets), hierarchical militias with uniforms, ranks, and clear chains of command, or violent networks. Violent groups face the same cooperative and organizational dilemma as any other political actors: they would benefit from cooperation but they give up ideological control and potentially risk defection by either free riders or, worse, informers bought off by the state.

To preview, I find that organizational ecology and population dynamics explain rebel organizational structure. Specifically, the size and composition of the population, as well as the strategic space, affect the organizational ecology of rebels. Networks are most useful in small rebel populations composed of more "hardline" members—larger, more ideologically diverse populations are likely to use hierarchies to coordinate and cooperate. I test these propositions empirically, finding that size and population composition do affect the probability of rebel centralization of command and control. Additionally, when examining the organizational ecology and population dynamics, the theory produces interesting propositions for policy. Some counter-insurgency efforts that alter the strategic environment (the benefits to cooperation and the risks of defection) may facilitate the ability alter the population dynamics for reconcilable actors. This shift can potentially separate reconcilables and irreconcilables into different organizations.

In this chapter, I apply the general theory and agent based model (ABM) developed in Chapters 2 and 3 to rebels groups. I study the factors that lead markets, networks or hierarchy to be the dominant form of organization under different circumstances, and how individual rebels are likely to make decisions to join different organizations. I also present large-n analysis on the organizational structure of rebel groups.[1]

This chapter proceeds in five parts. In Section 2, I describe the cooperation and credible commitment problem confronted by rebel groups as well as the organizational

[1] To reemphasize, the model is not designed solely to study rebel groups, or any one set of actors, but rather to explain broad trends in cooperation and organization, including those of violent political groups.

solutions. Section 3 outlines the modifications made to the core-ABM's default parameters, and its organizational assumptions to capture this problem. In section 4, I show some of the emergent trends in organization generated by the model to formulate hypotheses. Section 5 reports preliminary statistical analysis using the extended Armed Conflict Dataset (ACD) on civil wars to focus in on centralization. The final section concludes.

4.2 Rebel Cooperation Problems and Organizational Solutions

4.2.1 Prior Work on Rebel Organization

We know from previous literature that rebels who are able to coordinate gain significant advantages, both strategically and operationally. Unified groups are more likely to gain self-determination concessions. Logistically, hierarchical groups are better able to conduct deadly attacks (**?**, Piazza 2009 and Asal & Rethemeyer 2008). Groups that coordinate (or consolidate at the extreme) are able to settle disputes more quickly (Cunningham 2006) because of advantages at the negotiation table.

Despite these outcomes, very little is known about the pressures that cause rebels to organize differently. Bond and Bapat (2011) look alliances *between* groups, and between groups and states. They find asymmetric alliances with state sponsors are likely when the group feels vulnerable, while groups that do not feel pressured will form alliances with other groups. Shapiro (2008) looks within hierarchies to show how bureaucracy and mechanisms of control are surprisingly common. He argues that these measures are beneficial in maintaining operational control (and therefore a clean Principal-Agent relationship) even in the face of the need for secrecy. Weinstein (2007) looks at the need for support amongst the population and shows that in rebellions that require popular support, the organization is more likely to provide public goods (a mark of hierarchy). I argue that the organizational ecology is determined by the strategic environment, which is dictated by the state, as well as the rebel population's size and composition.

4.2.2 The Rebel's Dilemma

Rebels are political organizations like any other: they attempt to gain political concessions from a state.[2] Rebels emerge from populations composed of actors with more or less 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.

Individuals within the rebel population often would like to share in the burden (and distribute the risk) of rebellion. Additionally, they see a benefit 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 difficult. Many rebel movements begin as many small groups, with non-identical goals. Both the Liberation Tigers of Tamil Eelam (LTTE or Tamil Tigers) in Sri Lanka and Euskadi Ta Askatasuna (ETA) began as numerous small groups that slowly coalesced into a single larger group.

Rebels, and rebel organizations are constrained to solve this dilemma within a context where free-riding is likely and the state can provide inducements to non-committed members to leave the organization. The relative utility of the value of cooperation, and the potential value of being bought off by the government, alter the strategic space and can affect the organizational ecology.

They essentially decide if they should go it alone (or in small "groups of guys") or cooperate operationally in some type of organization. Cooperation in networks or hierarchies comes with advantages, but also tradeoffs. Organizations like 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 likely to be met with reciprocal cooperation. Ideologically, individuals have to modify their goals and concession

[2] A note on terminology and scope: rebel groups are 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. This chapter will test the theory using data on rebel groups, but theoretically it extends to terrorist groups as well.

demands if they wish to cooperate with others with non-identical preferences. They 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—either through monetary or political concessions (Berman 2009).

The Rebel's Dilemma as a Prisoner's Dilemma

The problem of cooperation faced by rebel members is analogous to a repeated Prisoner's Dilemma (RPD) game (see Figure 4.1). The intuition of the RPD captures the strategic problem of coordinating attacks. Rebels would benefit if they work 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 cooperative partners 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 not attacking or a much smaller attack.

There is a strong temptation to defect. An individual's belief that others in the population can be trusted to cooperate, becomes a critical factor in determining behavior in a world without organizations. When there are uncooperative actors in the population, people still want to insulate themselves from the risk of being left "high and dry" in conducting an attack—they want to improve the likelihood of ending up in the mutual cooperation outcome.

A necessary complication to the setup is allowing actors to have individual preferences defined by ideal points along a finite continuum: here, (0,1). As above, the motivation for this is that mutual cooperation does not mean the same thing or carry the same value for all actors. Basque groups went through several iterations of ideological clashes: some wanted economic concessions, others language concessions, and still others an independent state. Cooperation with another who shares one's preferences and goals is different from cooperation with an actor with preferences distant from oneÕs own. If cooperation means working together to promote a particular concession from the government (e.g., secession, autonomy), two actors with similar preferences will coordinate at more a ideologically palatable place than two ideologically disparate actors. As in the main model, when actors both cooperate, I subtract the weighted spatial distance between their ideal points $(k_{ij} = w(|p_i\text{-}p_j|/2))$ from the payoffs from mutual cooperation.

		Agent $_j$ C	Agent $_j$ D
Agent $_i$	C	R-*k*, R-*k*	S, T
	D	T, S	P, P

Figure 4.1: **The modified PD game.** Where the payoffs are ordered T>R>P>S (Axelrod 1984). See also Skyrms (2004).

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

- **Mutual Defection** (P, P): Actors pursue their goals independently. Working independently, individuals and very small groups are likely to survive, and importantly, are able to maintain their personal ideal points. However, they face a lower probability of gaining concessions from the state (P). In populations with large latent, but not particularly active rebel populations, this is the dominant outcome. This is likely 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 essentially unilateral campaigns. They both bore most of the costs themselves, made no ideological compromises, but also lacked manpower and formal organization, having never been able to overcome an iterated trust game.

- **Mutual Cooperation** (R-k, R-k): If actors work in concert, they have a greater probability of gaining concessions, but will have to sacrifice their individual ideal points for a common one. Cooperative outcomes are likely in populations where large proportions are hardliners—determined to coordinate, even at the risk of being abandoned. Perhaps perversely, 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 shifts considerably. I will highlight the organizational mechanisms that lead to this outcome below.

- **Suckered or Tempted** (S,T) or (T,S): This is the outcome of the PD that drives many into the mutual defection equilibrium, and one that will make organizations even more valuable. If one actor cooperates and the other does not, those that stay home make no ideological concessions, and bear no costs for actually attacking, but observe only single, smaller scale attacks, so will see more concessions than in the mutual defection outcome, but not as many as in the mutual cooperation outcome. If they have been sold out to the state, this agent may not survive. Those who try to cooperate, but are suckered, are left more exposed to the state (potentially at the cost of their own survival) and have lost the opportunity to advance their own ideal points in that period. This may be analogous to two situations: an operative fails to complete their assigned task, or an operative informs on the rest of the rebel organization members to the state. Both of these are tremendous blows to the rebel population as a whole, both change 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.

4.2.3 Organizational Solutions: Markets, Networks and Hierarchies

The cooperative dilemma outlined above captures the intuition of the coordination dilemma that participants in rebellions face. These actors can solve this problem organizationally. Although there are many hybrid organizational forms, to keep the theory and analysis simple, I focus on the three ideal types of organization: markets, hierarchies and networks. The basic theoretical underpinnings of these forms have been outlined in Chapters 2 and 3 Here, I draw the analogy of these ideal types out to rebel organization structures.

An underlying assumption in this analogy is that more cooperation amongst members of the rebel population leads to more rebellion, which in turn leads to increased pressure on the state to provide concessions.

The rebel population is a difficult concept to conceptualize precisely. It is the set of actors that is geographically or ideologically proximate to the rebel organization. This includes both the supporters of the rebel organization as well non-supporters or those who are antagonistic to the rebel's purpose, goals, tactics, or existence. Some rebel organizations emerge in environments that are quite hostile to them, for example Timothy McVeigh or the ecoterrorists 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. Some rebels emerge amongst populations of entirely sympathetic or active populations. At its height the Eritrean Liberation Front engaged 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. This is captured by k, and extremists are closer to 0 or 1, relative to the median in the population (default 0.5).

Rebel Markets

As above, markets are characterized by unconstrained interaction. Cooperation is possible, but only amongst those predisposed to cooperate initially. In the world of rebels, "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).

Militia movements or local rebellions are examples of this basic organizational form. Likewise Timothy McVeigh, who used one-time accomplices and immediately available materials captures the intuition behind this organization. Attacks 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 this way as well. Common early on, individuals may coalesce into small, temporary groups. This may lead to one off protests against the state, or events that may be lower personal risk.[3] These "local" groups sometimes consolidate and formalize into other organizational forms, but often do not (in the case of militia movements). In Sri Lanka, several dozen small Tamil groups existed, independent of one another, but make very little impact on the Sri Lankan government.[4] This conception of unconstrained interactions parallels those in the earlier chapters.

Without taking ideology into account, cooperation will be common amongst actors who are cooperative by nature. With ideology taken into account, cooperation will be common between cooperative 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 cooperation or defection), be a critical determinant in whether or not a grassroots, mass rebellion can be coordinated.

Rebel Networks

A core theoretical feature of networks in the ABM is their role in transmitting information about who is likely to be a "good" member of the group. Rebels that are not in tight, formal hierarchies are often able to cooperate and coordinate, but do so by passing information to each other about another's "reliability." This allows for a person's 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, and who therefore is unlikely to hold up their end of a coordinated campaign in the future. Who is more extreme or moderate, who is 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

[3] Arab Spring

[4] These groups would later consolidate into the LTTE after overcoming the trust problem and settling on a common ideology.

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. Al Qaeda is based on kin groups, which allows them to shortcut this problem (Kahler 2009).

Rebel Hierarchies

Hierarchies are often some of the most visible and successful rebel organizations. Centralized enforcement allows hierarchical rebel organizations to specialize their operations in a way that rebels 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 hierarchic organizations—and this specialization happens over time as confidence in hierarchies, and their ability to enforce cooperation, increases. The IRA's units were given highly specialized tasks, but punishments for defection were also severe— indeed a specialized units of enforcers were created to ensure cooperation. Similarly ETA consolidated under a single ideal point after rounds of negotiation between Basque groups.

Hierarchy is beneficial to the group and the individual. The increased returns to scale in the form of pressure on the state is good for the organization, but also for the individuals who are more likely to see returns to their effort. At a lower, operational level, hierarchy helps to solve the trust game that is at the core of this chapter. Hierarchy allows for centralized punishment of behavior that hurts other member of the hierarchy. In essence, this alters the behavior of someone who might not have shown up at the bridge, or pre-empts someone who might be tempted to inform the state of plans. It makes "good" behavior more likely, and reassures actors who face the dilemma that the other party is more likely to cooperate.

4.3 Modifications to the General Model

An ABM is the best theoretical tool to capture organizational ecology and population dynamics. Thus, unlike closed-form formal models that focus on a small number (usually two to three) of actors in a well-defined strategic setting, this ABM shifts attention to the attributes of the *population* of interacting agents. The most important and interesting implications here come from variation in the size and composition of the rebel population as well as the role and response of the state to the rebels as proxied by several variables in the model: starting population size and composition, as well as payoff structure.

While this model does not perfectly capture the minutia of rebel organizations, particularly the many hybrid forms we often observe, the core characteristics of these organizations are present. Nonetheless, given the basic character of markets, hierarchies, and networks, their ubiquitous presence in the real world, and their similar treatment across very different academic literatures, I believe the model has broad applicability.

This section briefly describes the alterations to the model outlined in Chapter 3 and the Appendix to more accurately model rebel organization. The core model still has three stages.[5] The primary changes to the model are captured in the initialization phase.

Payoffs for the four outcomes are set in the initialization phase: T, R, P, and S. I focus on three basic strategies: always cooperate (ALLC), always defect (ALLD), and tit-for-tat (TFT). ALLC and TFT are nice strategies that begin by cooperating with new agents, while ALLD is a nasty strategy. Below, I refer to nice and nasty populations as defined by the relative proportions of these two sets of agents. Nice populations are highly cooperative toward rebel goals.

Perhaps counter-intuitively, nice means likely to cooperate within the rebel movement. Within the context of these groups, ALLCs are the ideologues who will always be willing to cooperate in pursuit of an attack. These are the hardcore, committed members of the rebel organization who are *so committed* they are willing to pay high personal costs to increase the probability of cooperation. TFT agents are members of the rebel population who are 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

[5]This is run with no selective affinity, and without evolution.

reliable in that sense, but if the rest of the rebel fighters are *not* fighting, they will stay home. These actors are some of the "reconcilables," those who are most likely to be "bought off" by the state, to be integrated into mainstream politics.

The ALLDs are the members of the rebel population who are reluctant to fight. If given any choice they would not cooperate, not join a larger rebel movement. 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. In an evolutionary world, exercising their true preferences not to participate would likely eliminate them from the population quickly. They are also those willing to leave the rebel organization if given a credible alternative.

Networks are specified as described in Chapter 2, but with a higher default fee (ϕ), in order to account for the high risk associated with passing information about illegal activities, the network cost is relatively high compared to that in other simulations in other chapters.

4.4 Illustrations of Rebel Organizations

The organizational ecology of rebels has often been characterized as networks or hierarchies.[6] The literature divides rebel groups primarily into either networked or flatter, organizations, or hierarchies of one stripe 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 modified ABM to the organizational ecology of rebel organizations. In many cases, but particularly that of rebels composed of many individuals and potentially many organizations, the interactions are rarely re-

[6] For example Sageman (2004).

ducible to two unitary actors. In order to study behavior in and adoption of different forms social organizations—namely markets, networks and hierarchies— population models are particularly valuable. These models are able to show the value of explaining phase 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.

4.4.1 The potential frailty of networks

In contrast to much of the conventional wisdom on the great utility of networks for rebels (Sageman 2006, 2008; Kahler 2009), the ABM shows that—under certain circumstances—networks can be quite fragile. The larger the rebel population, the less likely networks are to be selected by agents (see Figure 4.2). It might seem that larger populations favor networks as it takes more iterations of the game for agents to acquire direct knowledge of other agents and, therefore, networks are more valuable. Yet, 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. As the number of actors in the population increases, the probability of receiving useful information falls.[7] In very large rebel populations, "small" networks are of little value and, therefore, will not be chosen by agents. 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 is larger, the cost of passing information in a clandestine environment quickly overwhelms the benefit if markets or hierarchies are viable options. Ultimately, when the set of agents with whom an agent may interact is large, the preferred organizational form quickly becomes either markets or hierarchy.

This pattern indicates that networks are most valuable in smaller populations. It may also suggest some natural limits on the size of "networked" violent organizations, and their size relative to their environment. While the media portrayal of "terror net-

[7] 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.

works" 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 that ALLCs do not use the network. They are either in the market 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 ("highly secret cells and lack of clear and quick communication" [Iyob 1995:104]) 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—its population outstripped its organizational capacity, given the risks. It solved this problem organizationally with the more hierarchic ELF (Eritrean Liberation Front), superseding the ELM, particularly as the costs of an underground organization in an era of increasing state surveillance quickly began to outpace the benefits (Iyob 1995). 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.[8]

Figure 4.2 about here.

Hypothesis 1. More agents will join the hierarchy as the rebel population increases.

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

4.4.2 When are hierarchies dominant?

Asal and Rethemeyer (2009) and Heger, Jung and Wong (2008) both 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, theorizing counter-terrorism strategies 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.

The ABM explains hierarchy as an equilibrium of many egoistic actors. Given a rebel population that is sufficiently uncooperative toward goals, but where there is a higher payoff if cooperation against the state is achieved, agents join a hierarchy and submit to its possible punishments in order to secure the benefits of cooperation 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, the model has several important implications.

Figure 4.4 shows when agents of different types enter the hierarchy, as the population becomes increasingly nasty. Hardliners (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. (See also Figure 4.3). 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. TFTs 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 they will enjoy (with near certainty) the benefits of cooperation in the hierarchy. The vulnerability that drives the rest of the agents into the hierarchy first now creates a herd effect. These agents will be eager to leave if there is a viable alternative organization (likely another hierarchy).

Figures 4.3 and 4.4 about here.

Hypothesis 2: Given benefits to cooperating against the state, more agents will join the hierarchy as the population becomes increasingly "nasty" and prone to defection.

4.4.3 Why do extreme organizations survive and sometimes thrive?

The ABM also provides insights into why hierarchies can be stable over long periods. By design in the ABM and by analogy to the real world, within a hierarchy agents do not learn anything about the strategy types or ideal points of other agents in the hierarchy. If both are in the hierarchy and agent j cooperates with agent i, i cannot learn whether j cooperated because it "wanted to" or did so only under threat of punishment. Having joined the hierarchy because it believed the population was sufficiently nasty, i then has fewer opportunities to revise its beliefs. Given these fewer opportunities, agent i will actually develop more skewed beliefs that lead it, over subsequent rounds, to believe the population is nastier than it really is. While the nasty types run to the hierarchy, that organization becomes increasingly attractive as the proportion of agents in the hierarchy is large and growing. This serves to entice nice types to join, who can avoid interacting with ALLDs in the market. Additionally, those already in the hierarchy see their decision reinforced as they have to interact in the market with decreasing frequency, and the probability of cooperative payoffs increase.

These results hold, at varying parameter values, for all hierarchies. Yet, the equilibrium nature of hierarchy may be most counter-intuitive when the hierarchy is coercive, or when the hierarch has an ideal point that is "extreme" within the population and, by analogy, cannot stay in power simply because he reflects broadly shared preferences. It is on this point that the modification to the standard PD game (see Figure 4.1 and accompanying discussion above) becomes perhaps most important.

In looking at the variation of hierarchic ideal points that the rebel population will support, we see some surprising implications. Examination of the hierarchy membership patterns as the hierarchy's policy preferences vary reveals a variation on the insights shown above in Figure 4.5 (and Figure 4.7). Figure 4.5 shows that ALLC agents will, under certain conditions, enter into a hierarchy en masse and remain there, without regard to the policy preferences. Because the gains to be had from cooperation are so significant, they are willing to (within certain weights of *w*) sustain a fairly significant ideological penalty for cooperation within a hierarchy. TFTs are least willing to tolerate large ideological penalties, only entering a hierarchy when it is approximately near their own preferences. (ALLDs are in between these two trends.) ALLCs are the least able to be "picky" about when and with whom they are willing to integrate.

Figure 4.5 about here.

Hypothesis 3: Hierarchies gain the most members as their preferences are closer to those of the population (vis-à-vis the population).

4.4.4 Changing Incentives to Cooperate

One of the key determinants of an individual rebel's organizational choice and behavior is the fear 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 policy concessions (Cunningham, K 2011) or bribing them for information (Berman 2009).

The effect of this shift is quite stark. Figures 4.6 and 4.7 below show this dynamic, which has very interesting counter-insurgency implications for states. When the incentive to defect is low, agents of all types are in 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 **??** indicate that there is a narrow range of payoffs or policy concessions that a state can make that will hollow out the hierarchy, leaving only the hardline ALLC agents. ALLD agents need only a small inducement to leave the hierarchy are happy to do so if the state can change the incentive structure, and the 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 finding indicates that there are two levels of payoffs that 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.

Figures 4.6 and 4.7 about here.

Hypothesis 4: Fewer agents join the hierarchy as the incentive to defect increases.

4.4.5 Why are Hierarchies Dominant?

The analogy to the PD is premised on the idea that mutual cooperation amongst 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 CC payoff (R). Figure **??** 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.[9]

Figure 4.8 shows that when the gains to cooperation are minimal, the incentive to cooperate in hierarchy is fairly low. Only as the potential gains to cooperation jump (significantly) do TFT agents see the utility of either the network or the hierarchy. Essentially, the costs associated with either of the two "formal" organizations are only worth it when the gains will offset them. It also shows that there are fairly sharp cutpoints 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 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 avenue through which this can be done;

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

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 representative of the policy preferences of society, or even the subset of that group.

Figure 4.8 about here.

Hypothesis 5: More agents join the hierarchy as the benefits to cooperation increase.

4.5 Data and Analysis

In this section, I link the propositions generated by the model, to testable indicators, and present the results. Calibrated to the dilemma faced by rebels, the ABM produced five propositions:

Hypothesis 1. More agents will join the hierarchy as the rebel population increases.
Hypothesis 2: Given benefits to cooperating against the state, more agents will join the

hierarchy as the population becomes increasingly "nasty" and prone to defection.
Hypothesis 3: Hierarchies gain the most members as their preferences are closer to those of the population (vis-à-vis the population).
Hypothesis 4: Fewer agents join the hierarchy as the incentive to defect increases.
Hypothesis 5: More agents join the hierarchy as the benefits to cooperation increase.

These propositions indicate that rebel organizational structure is driven by two factors: the population in which rebels interact, and the strategic setting. Changes in the organizational ecology and population dynamics are rooted in the population in which the rebels interact, specifically the size of the rebel population and ratio of rebels to non-rebels in a population and the mobilization capacity. Changes in the strategic setting are linked to policy concessions from the state, including legalization of a political wing.

4.5.1 Data

I use the Cunningham et al. (2009) (CGS) extension to the Armed Conflict Database for coding of non-state actors. While the trends identified above should apply to actors beyond just those involved in a civil war, this subset provides a good cut in looking at the broad trends at work in rebel organizations. The unit of analysis is the conflict dyad. The dataset contains 471 cases and 1085 observations between 1946-2003.

Dependent Variable

The theoretical dependent variable of interest is a measure of rebel organizational structure. Ideally a measure would exist that differentiates between rebel markets, networks and hierarchies. Rebel hierarchies are the most clearly distinguished. CGS code organizations as having centralized command and control or not. In using this variable, market and network forms of organization into an "other" or "not hierarchy" category. This allows for movements toward or away from hierarchy to be particularly highlighted, as they are in the propositions.

The primary dependent variable of interest is whether a group has a clear central command (1) or not (0). I assume groups with a clear central command are hierarchical.[10] This assumption allows me to translate the hypotheses' predictions for hierarchy into predictions for centralized command and control. CGS code for centralized leadership, as well as for degree of centralization. I recode their coding for strength of central command to an ordinal scale 0-2, where 2 is strong, and 0 is weak.

Independent Variables

Righthand side measures are related to either shifts in the population size and composition, or with some evidence of state concession. I use CGS measures of rebel size, strength and support, as well as state and conflict-specific characteristics come from Fearon and Laitin's (2003) data (FL).

Variables affecting organizational ecology and population dynamics

- Population size: The construct within the ABM to be captured is the size of the population or number of agents. Empirically, this is captured by an estimate of the total population within which the rebel organization operates. To measure this, I use the logged population size from FL as a measure of the state's population.

- Rebel estimate: This measure is designed to capture the number of "nice" or ALLC strategy types in the population. This is proxied by the size of the rebel force, estimated to be the number of rebel combatants from CGS.

- Relative proportion of rebels: This variable is constructed to capture the population composition (proportion of nice/nasty types) from the model. Although a rough indication of how "nasty" the population is for the (nice) rebels, I use the estimated number of rebels divided by the population size of the state. This measure is constructed from CGS and FL.

- Mobilization Capacity: Within the model, the hope is to capture the number of TFT agents, who would join if pressed, but would rather not. Empirically, this is indicative of an organization's ability to mobilize support, for example potential

[10] A clear central command is a sufficient condition of hierarchy, although it may not be the only indication. In using this coding, I believe I am biasing against finding results.

troops in reserve that can be called up. Using CGS, this is coded as low, moderate or high relative to the government.

Variables affecting the strategic setting

- Legal Political Wing: Within the model, the concept to be captured is an increasing payoff for defection. Empirically, I look for evidence of state concession. This variable is designed to capture whether there is a viable political avenue within the state for integration or a non-violent path to concessions and/or representation within the state. This is measured as 1 if there is a legal political wing, 0 if not, from CGS.

- Rebel Strength: Within the model, increases in the payoff for cooperation are an important shift. Empirically, this variable captures the ability of the rebels to effectively engage the army militarily and win major battles, posing a credible challenge to the state, and therefore greater likelihood of concessions. From CGS, I code rebel strength such that parity with the state is 0, stronger rebels are positive, and stronger states are negative values.

Control Variables

Both the number ongoing self-determination wars as well as territorial control can affect either the population dynamics or the strategic setting.

- Number of ongoing self-determination wars (SD wars): Number of SD wars is included as a control variable because it will affect both the population that the rebels operate within (meaning that the population is actually smaller) as well as the payoffs associated with cooperation because the same government will be engaged in conflict with other movements. This is a count variable for the number of ongoing self-determination conflicts from CGS.

- Territorial control: Like rebels strength, groups that have some measure of control over the territory have an advantage strategically. This also indicates a shift in power (and therefore payoffs) between the government and rebels. This measure is taken from CGS, where 1 indicates territorial control, 0 not.

Table 4.1: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Centralized	1028	.931	.254	0	1
Degree of Centralization	915	1.207	.623	0	2
Political Wing	377	.416	.494	0	1
Rebels	740	12560.57	41074.84	60	1000000
SD Wars	887	.629	.659	0	3
Territorial Control	348	.807	.640	0	2
Proportion Rebels	594	1.077	2.484	.000453	25.0
Mobilization Capacity	1059 0	.448	6193488	0	2

4.5.2 Analysis

The results presented below provide initial validation for the core ideas that emerge from the ABM: population size and composition, as well as the strategic environment created by the state affect the organizational ecology of rebellion.

Population Size

Hypothesis 1 predicts that centralization of command and control is more likely as the rebel population increases. To test this, I estimate the log odds of centralization of command and control using rare events logit (given the dichotomous dependent variable—centralized command and control or not).[11]The standard errors are clustered by conflict, to control for conflict specific effects. The results are presented in Table 4.2 below.

Though an extremely coarse measure, the overall population size, presumably the complete population "available" to the rebels, is positively related to the likelihood of centralization without any controls. This suggests that as the total population increases, so does the likelihood of centralized command and control. However, Models 1-3 in Table suggest these results are fairly weak. Controlling for the size of the rebel population, and mobilization capacity of the rebels, the number of ongoing self-determination wars(these are likely cooperators, but ideologically very different), and

[11]I replicate the primary tests using degree of centralization as a robustness check. These results are presented in the Chapter Appendix.

territorial control weaken the result. The data offer weak but preliminary support for this relationship. Weak support is not entirely unexpected given the very blunt measure of population.[12]

Table 4.2: Rebel Population's Effect on Centralized Command and Control

	Rare Events Logit Model 1	Rare Events Logit Model 2	Rare Events Logit Model 3
Population	.40	.61	.28
	(.28)	(.39)	(0.87)
Rebels		-6.98e-06	-8.86e-06
		(5.34e-06)	(1.41e-5)
Mobilization Capacity			-1.49**
			(0.74)
SD Wars			-0.77
			(0.98)
Territorial Control			0.70
			(1.05)
N	852	578	217

Notes: Rare events logit. Robust standard errors clustered by conflict are in parentheses. *Level of significance*: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Population Composition

Hypothesis 2 predicts that the probability of centralized command and control will increase as cooperation becomes less likely in the rebel population. The ABM shows that the environment in which individual rebels are interacting is important in determining their organizational choice. The ABM indicates that the more prone a population is to defection, the greater the impetus to organize hierarchically.

To estimate this empirically requires a measure of population composition. The proportion of cooperative actors in the population is captured by looking at the proportion of rebels over the total population of the state in which the conflict is taking place. This means that as the proportion of rebels decreases, the rebels should be more likely

[12] A better measure would be to restrict the population to the areas where the rebels are active.

to be organized in a hierarchy (a negative predicted coefficient). While this measure is very rough, it provides a sense of how many rebel or "ALLCs" types there are that an actor is likely to encounter. Additionally, the mobilization capacity indicates a measure of accessibility to the rebels in the population. As both of these measures increase, the defection rate should decrease. Models 1-3 in Table 4.3 provide strong support for this hypothesis. The direction of the relationship with both mobilization capacity as well as rebel proportion are consistently negative and significant.

Model 3 controls for territorial control as well as the number of other self-determination wars. The degree of effective territorial control (by the rebels) as well as ongoing self-determination wars in the state should both control for the government's potential level of engagement. As either of these measures increase, we would expect the environment to become less "nasty" for the rebels. Both indicators and all models give support to Hypothesis 2 (Table 4.3). With controls included in particular, both measures come up consistently negative and significant, as Hypothesis 2 predicts.

Table 4.3: Rebel Proportion of Population's Effect on Centralized Command and Control

	RE Logit Model 1	RE Logit Model 2	RE Logit Model 3
Rebel Population Proportion	-.15***	-.13***	-.23***
	(.054)	(.054)	(.093)
Mobilization Capacity		-0.20***	-1.30***
		(.21)	(.33)
Territorial control			1.09**
			(.48)
SD wars			-1.03***
			(.48)
N	578	578	217

Notes: Rare events logit on centralized command and control. Robust standard errors clustered by conflict are in parentheses. *Level of significance*: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

The Role of the state: Buying off the Moderates

Hypothesis 4 suggests that concessions granted to buy off the moderate or irresolute members of the population who may be part of the rebellion out of desperation, will have a bearing on the organizational form adopted by organizations. Specifically, political concession, such as the legalization of political wings representing the rebels, will provide enough of a payoff to mollify the more moderate members, leaving only the hardliners in the organization. This suggests that the probability of concessions from the state has some bearing on what deal the state is willing to accept versus not.

In looking at conflicts with legalized political wings for rebels, the likelihood of a centralized command and control mechanism is dramatically decreased (Models 1-3 in Table 4.4). Policy implications suggest that legalizing parties is a way to integrate rebels into politics. The results in table 4.4 suggest confirmation of Hypothesis 4, that increasing incentives to defect decreases centralization.

Table 4.4: Political Wing's Effect on Centralized Command and Control

	RE Logit Model 1	RE Logit Model 2	RE Logit Model 3
Political Wing	-1.462325	-2.454803**	-1.05961
	(.9995797)	1.039155)	(.9819063)
Rebel Strength			-1.250466
			(1.313119)
SD wars	-.6699933**		-.4872575
	(.2924708)		(0.4148332)
N	304	358	303

Notes: Rare events logit on centralized command and control. Standard errors (robust) are in parentheses. *Level of significance*: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Taken together, these results provide support for Hypotheses 1, 2, and 4. Both the population dynamics as well as the strategic setting of the interaction affect the organizational ecology of rebel movements.

4.6 Counter-Insurgency implications: separating out irreconcilables

These results suggest that looking to organizational ecology and population dynamics offer significant promise in explaining rebel organizational structure. In closely examining hierarchy in the model, as factors that cause more rebels to join the hierarchy increase (e.g., defection rate in the population, extreme preferences), the nicest strategy types enter into the hierarchy—first ALLCs, then TFTs, then ALLDs. What this emergent property suggests, and Kilcullen's (2009) study, is that strategy and type matter. There are indeed different types of actors in the population. There may in fact be large groups of what Kilcullen calls "accidental guerrillas" that are embedded in the population. While these actors are likely to be reluctant overall to join a hierarchy, population dynamics may push them to the point where joining is the "least bad" outcome. These actors are unable to prevent being suckered and exploited in any non-hierarchic interaction, and the only way to maintain stable, cooperative interactions is to join the hierarchy. Additionally, because actors within hierarchies, as modeled, do not update their beliefs, they become increasingly pessimistic about the world in general, perpetuating their incentives to remain in the hierarchy.

The long-term stability of hierarchies can be difficult to break into but the model also offers support for some counter-insurgency efforts. The strategy pursued in Iraq during the Surge was one of attempting to change the payoffs to these actors. While actual benefits to cooperation (S) can likely be quite low, raising the payoffs to defection—through the form of side payments, or internal defection. Additionally, if the weight on the ideal is increased, while extreme hierarchies will still gain very unlikely members, they may have to moderate policies or provide public goods in exchange to balance the ideological penalties imposed for "supporting" or joining that organization. All suggest further exploration within the model and tests of these implications.

Additionally, the role of networks in studying rebels is still emerging. Although clearly a useful, and used organizational choice by insurgents, the ABM presented here indicates that while there may be a great deal of theoretical overlap with previous transnational network scholars, rebels may face higher costs to adopting this structure than other transnational groups, constraining their choices. The very preliminary results above offer support to continued refinement and application of this model to rebels.

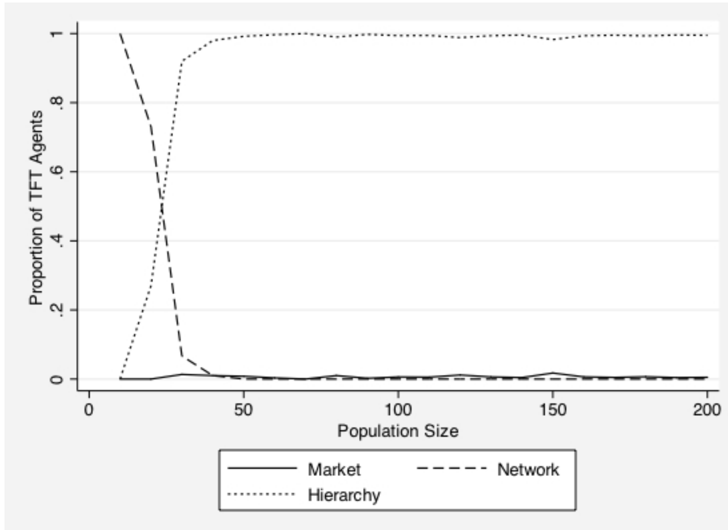

Figure 4.2: Population size and TFT organizational choice. As population size increases, TFTs leave the network for the hierarchy. This population is 70 percent cooperative types (60 percent TFTs, 10percent ALLCs) and 30 percent ALLDs. Hierarchy is very sensitive to the number of members in small populations. In nicer populations, TFTs generally leave the network at similar rates but interact only in the market. Seed: 386568, population size increases by 6 TFTs, 1 ALLC, and 3 ALLDs with each increment.

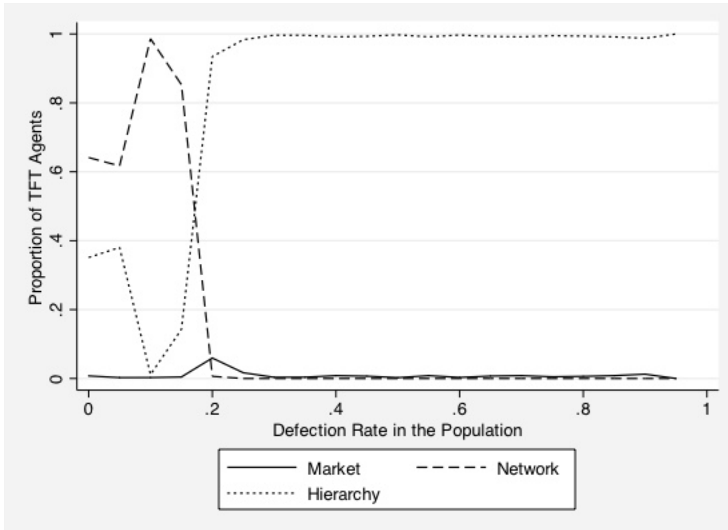

Figure 4.3: TFTs move from the network to the hierarchy as the population becomes increasingly uncooperative.[Seed 515243, incremented 21 times]

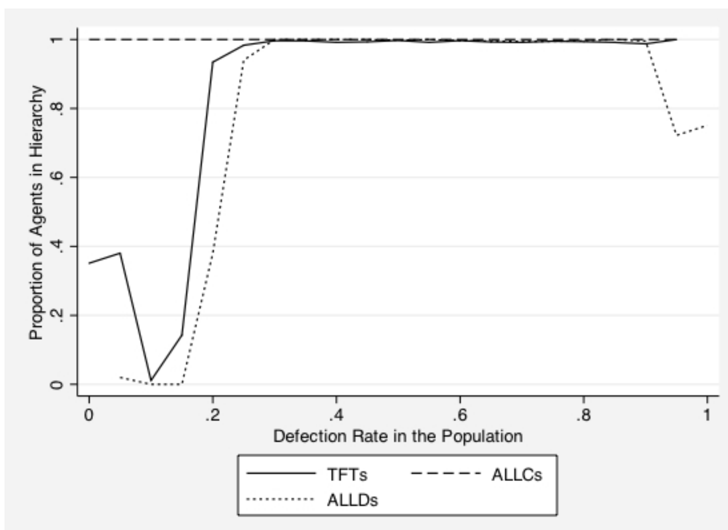

Figure 4.4: Proportion of different strategy types joining hierarchy as the population becomes increasingly uncooperative. ALLCs join the hierarchy universally as the proportion of uncooperative strategy types increases in the population, followed by TFTs and then the ALLDs. In populations where the defection rate is quite high, the TFTs leave the hierarchy, able to discriminate between nice and nasty types in the market, while pure strategy types prefer to stay in the hierarchy. This population begins with 100 ALLDs, 0TFTs, and 0 ALLDs. At each increment, the number of ALLDs decreases by 10 and the number of ALLCs and TFTs increases by 5 each. [Seed 515243, incremented 21 times]

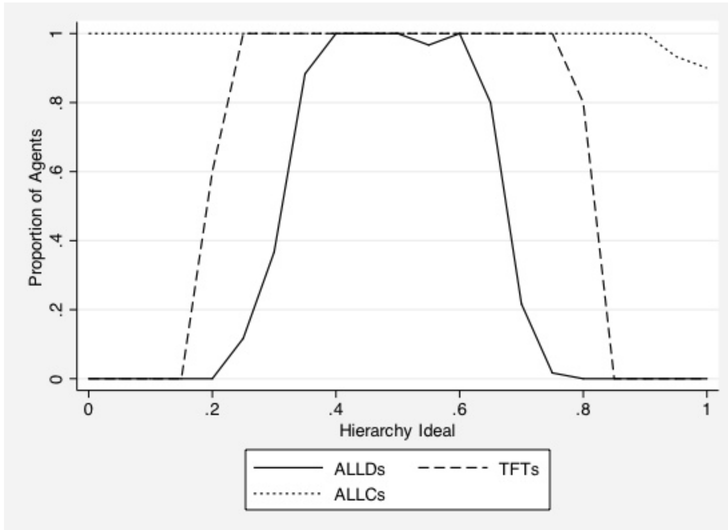

Figure 4.5: Hierarchy membership by Strategy. ALLC agents are universally members of the hierarchy, even extreme hierarchies. TFT agents are willing to make large ideological sacrifices, but only to a point, ALLDs are the most ideologically "picky"—only joining hierarchies that are very close to their own ideal point. [Seed: 503237, population composed of 60TFTs, 10 ALLCs and 30 ALLDs, the hierarchy's ideal point is incremented from 0.0 by cuts of 0.05]

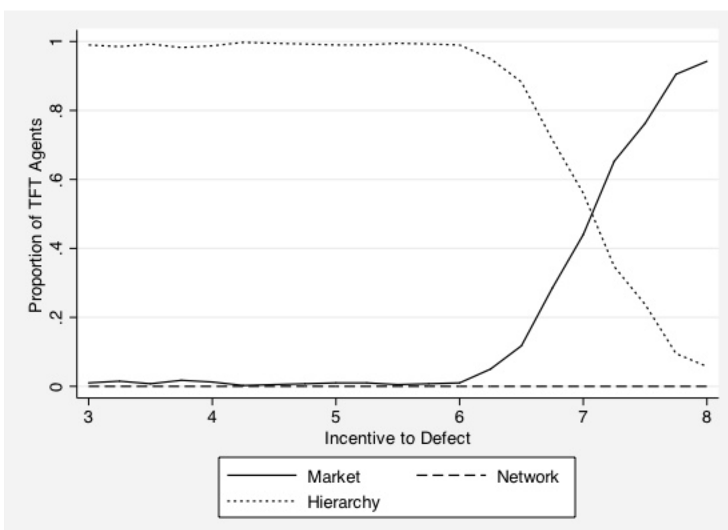

Figure 4.6: TFTs are reported here. As the incentive to defect is low, agents are in the hierarchy, including the TFTS. ALLCs (not shown) remain in the hierarchy, no matter the incentive to defect. They are true ideologues, there is no incentive that can get them to leave. TFTs and ALLDs leave as the incentives to defect increase. [977308]

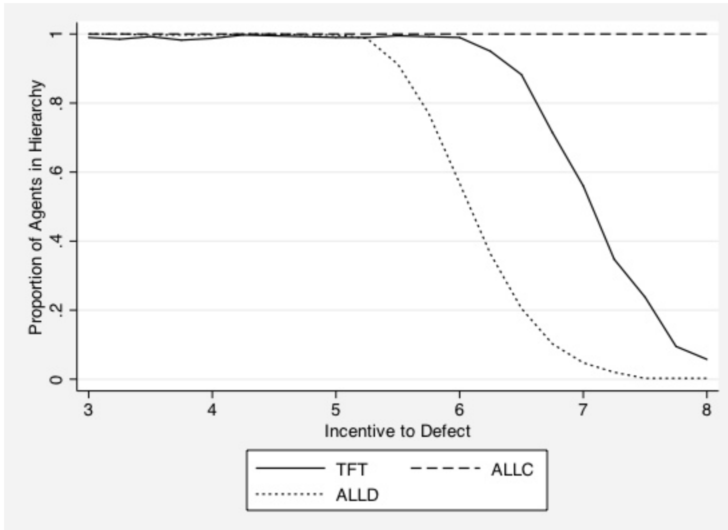

Figure 4.7: Exit from hierarchy by strategy as Incentive to defect increases. Showing the exit from the hierarchy given increasingly large incentives to defect shows that there are waves of "prices" for defection. The TFTs exit first, followed by ALLDs. ALLCs can never be induced to leave, but this leaves the hierarchy fairly hollowed out.

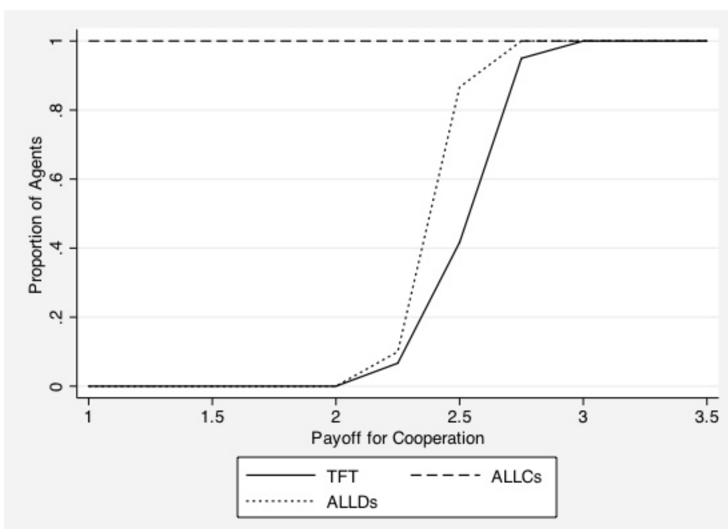

Figure 4.8: Benefits to Cooperation. Hierarchy membership by strategy type. ALLC strategy types enter into the hierarchy first, followed by ALLD agents. TFT agents need the highest payoff to cooperation to join. Seed 389147

Chapter 5

Population Dynamics and Organizational Ecology in Security Relationships

5.1 Introduction

The provision of security is one of the core functions—if not *the*— core function of the state. States are self-interested social actors like the others in this dissertation; they form organizations to enhance both cooperation and welfare, particularly in situations where cooperation is difficult.

States use the same three recurrent forms of social organization: markets, networks, and hierarchies. They may provide security in markets in a go-it-alone, self-help manner, through networks of reciprocity, or through more formal organizations. While states adopt different organizations to provide security individually, these decisions are influenced by the population of states and the prevailing organizations at the time. The organizational landscape of the international system varies over time as a result of the population dynamics. In this chapter I find that states react to the population of states and their potential vulnerabilities. This reaction can lead them to formalize their security relationships.

This chapter focuses with the way states use organizations to solve the problem of security provision and how population dynamics and organizational ecology help unpack these decisions. Countries cooperate with one another under anarchy, in supranational organizations, and in small groups of deeply interdependent or “networked” states (Kahler 2009). The persistence of NATO, in the post-Cold War era has been explained by those who point to the value of institutions. This is contrasted with some of the newer portraits of international order that point to more fluid, reciprocal (flatter), networked structures. The model presented in Chapter 3 shows there is a selection effect in who joins alliances and their composition over time.

In this chapter I apply the principles of organizational ecology and population dynamics to states, particularly alliance formation. The chapter proceeds in five parts. In section two, I briefly summarize the problem faced by states in alliance formation. In section three, I describe the modifications to the general Agent-Based Model (ABM) of organizational ecology to look at how states use organizations. In section four, I generate and describe propositions for alliance formation and state behavior from the model. In section five, I present data and analysis in support of the generated propositions. Section six concludes.

5.2 State cooperation problems and organizational solutions

Alliance obligations are pledges “of future coordination" (Morrow 1991). These security agreements are contracts, enumerating very specific obligations for all parties, with the critical distinction that they are made in an anarchic environment. Those agreements that are that are self-enforcing will be upheld, but there is no legal enforcement for jilted states to argue their case.

The international system is as close to the anarchic “market” as we are likely to observe. The Hobbesian system of states lacks true third party enforcement. Critics of the conception of market I use in the dissertation generally highlight that interactions of whatever variety take place within the auspices of a state or some arbiter. This may be true in some situations, but certainly not all. Moreover, of the applications presented in the dissertation, relations between states are the least likely to have an arbiter.

Prior work on state organization explains alliance formation as a result of security imperatives (Balance of Power, Balance of Threat, Bandwagoning),[1] from perceived efficiency in aggregating capabilities or building complimentary defense portfolios,[2] or shared identify.[3]

Morrow's more contractual explanation for alliance formation argues each state's balance of autonomy with security is the source of decisions to form alliances. I depart from Morrow, but emphasize two characteristics that are incorporated into the decision: an individual state's characteristics and the decisions of other states, which is to say population dynamics and organizational ecology.

5.2.1 State's dilemma

The key question of interest in this chapter is who joins alliances. I do not aim to overturn conventional wisdom on alliances. Rather, the primary goal is to understand alliances as observable evidence of actors using social organizations to overcome cooperative dilemmas. Looking at this question through the lens of organizational ecology adds to our understanding of when alliances as organizations are most likely to gain hold within a population. Specifically, I find more vulnerable states should be the first to enter into alliances and be willing to pay higher costs (ideologically and in terms of provisions) than their less vulnerable counterparts.

5.2.2 States' Dilemma as a Prisoner's Dilemma

I am far from the first to liken the decision set faced by states when providing security to a prisoner's dilemma (for example see Posen 1993, Jervis 1978, and Snyder 1984). The set of interactions between states in providing security is set up very much as a prisoner's dilemma. The ordering of preferences is identical. In this situation, mutual cooperation results in states working together to produce security. This solution allows both to specialize, able to redirect resources to other ends in the same way that those who look at security allocation decisions as portfolio decisions (like Conybeare 1992).

[1] See: Waltz 1979, Walt 1987
[2] Conybeare & Sandler 1990, Boyer 1989
[3] Risse-Kappen (1997)

In the face of these many benefits, and observationally fewer than universal participation in security organizations (and fulfillment of security obligations).

The problem, of course, is that the potential for collective gains alone is not sufficient to create and sustain cooperation in all situations. These enticements to cooperate in security provision, and the reward of collective gains and burden-sharing can *only* be sustained if mutual cooperation is. Incentives to exploit, or not return the favor, of a congenial ally, who comes to your defense are omnipresent. Actors would be better off providing their own security, even at significantly greater cost (and diverting from other welfare producing efforts), if they believe that in expectation their security partners are likely to shirk their duties. This fear of paying into a security regime and being exploited or suckered is what makes security production so very tricky. Conversely, the best of all worlds is to have a sure partner who will come to your aid while never devoting resources to security oneself. This dynamic is summarized in Table 5.1.

This basic intuition is captured by the structure of the repeated PD (RPD) used in other chapters, played between actors in a large population.[4] Actors can be understood to be interacting with the entire population of actors. While this may not be strictly true, it is a good working assumption.[5] Further refinements of the model will be able to capture "affinity" in these relationships—essentially a way to "shrink" the population in which one interacts to a set of familiar actors. Given these interactions, they may either bilaterally, or multi-laterally, enter into agreements that provide a guarantee of cooperation, or as near to a guarantee as possible in an anarchic environment. The basic ABM works from this basic assumption that there is a set population of actors that all simultaneously face this dilemma. The chapter studies ways that their decisions about what set of organizations to use to overcome this dilemma may vary, individually and as a population.

[4]Though Table 5.1 depicts an interaction between two actors, the intuition here is one faced each time a state considers a potential partner for cooperation.

[5]States may interact more frequently with a fairly small subset of other states— their regional neighbors, or some functional group like OPEC, or states may have differently sized numbers of states of interaction. Some of these factors will be captured by states that use networks, but at this stage I table thse issues.

Table 5.1: Security cooperation prisoner's dilemma

	Cooperate	**Defect**
Cooperate	Both states benefit from working together to produce security jointly	Actors would be better off providing their own security in equilibrium if the believe their security partners are likely to shirk their responsibilities, unrealized gains to cooperation.
Defect	Best outcome would be another state to come to their assistance in time of conflict, but not to have to return the favor, this is off the equilibrium path.	There are unrealized gains to cooperation, but cooperation is not upheld.

5.2.3 Organizational Solutions

Like all social actors, states confronting this dilemma have three basic organizational choices in their security provision—markets (go it alone), networks (reciprocal, interdependent relationships between states), or hierarchies (formalized organizations with other states– in this case operationalized as alliances). Each of these modes of organization exist in the international sphere, so I take time to explicate the theoretical range of relationships here for completeness. Due to limitations in data, in subsequent sections, I will be forced to limit the range of observable organizations.

Going it alone: Market

Within the RPD set-up, this is the default organization when states do not choose another organization. In markets, states choose to provide their own security, or cooperate in an ad hoc manner (alliances of convenience that emerge on the battlefield). Market relationships are not institutionalized relationships. States interact in the state of nature, with nothing, save the consequences of their behavior to guide their actions. In the model this is represented as spot-market like organization, or the lack of a basic organization. Two states may cooperate, turning up at a battle field together without some prior coordination or formal collaboration, but that cooperation is ad hoc and not necessarily repeated after that interaction. Finland and Germany fought the USSR, but in an ad hoc, non-institutionalized way. Cooperation is possible, but there are no organizational structures in place to enforce these relationships, or provide external punishment for those who defect.

Networks of Cooperation

The emergence of networked forms of organization amongst states has become a focus of the literature recently (for example Kahler 2009; Slaughter; Keck and Sikkink 1997). These networks of interdependent states allow for cooperative "cliques" to emerge, without a formal organization to bind them. In these subsets, norms of reciprocal behavior are enforced allowing for cooperation to emerge and flourish, but amongst tight subsets of states where behavior can be monitored and cooperation sustained. The heads of state and the military might meet frequently to exchange information and coordinate, but formal accords detailing the commitments made have not been signed.[6]

In the model, these networks of cooperation are represented by two mechanisms: an information polling mechanism, and selective affinity. The information mechanism allows for actors to gather information about the actor with whom they are paired in the current round from other actors with whom they have had a recent, cooperative relationship. Selective Affinity, the second mechanism, allows actors to be matched with a higher probability with the actor with whom they have had the "best" interaction in recent memory (the highest expected utility). Networks of cooperation in international relations would be conceptualized ideally by reciprocal security cooperation, without a formal institutionalized commitment.

[6]Although they have several formal agreements, the "special relationship" between the United States and the United Kingdom is of the type I would expect to observe in this category.

Formalized Relationships: Hierarchy

A large literature exists on how states formalize their security relationships. I will argue that these relationships are hierarchical, admittedly a very strong assumption. Many conceive of alliance organizations as anarchic organizations. While I agree the lack of an international arbiter means these are not hierarchies in the strictest sense, any security agreement imposes costs on its members and the number of obligations mirror increasing costs to become a member. Additionally, these costs are not born symmetrically in many cases. Using alliance data to unpack these asymmetries is useful. For example, the United States and South Korea have security agreement, but one in which the United States is obligated to defend South Korea if attacked, but not the inverse. Short of data on empire and formal and informal protectorates, I believe these asymmetric formalized agreements are indicators of some degree of hierarchy.[7]

As in the general ABM, internal compliance is not perfect, but those who shirk their obligations *do* bear costs for this defection, though they are probably fairly light.[8] This said, Lake (1999, 2009) points to the great variation in the levels of authority in the international system. This indicates that agreements may be enforced with greater or lesser skill. Some of the elements of this enforcement can be captured in the specification of the hierarchy in the model. Likewise the costs, both ideologically as well as in terms of upfront transactions costs can be captured in the model terms.

While alliances are in no way a perfect analogy to hierarchy, they provide some measurable indication of obligation or commitment that I am able to leverage to identify when states will bind themselves to cooperate. Having outlined the theoretical organizational choices states may make above, in the next section I modify the model to this problem.

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[7]Empires and formal protectorates are more hierarchic forms of security organizations, but we lack systematic data to test those relationships at present.

[8]I should reiterate that this chapter is not concerned with the likelihood of compliance, or obligation fulfillment— though the model would be useful in theorizing this dependent variable. Instead, I focus here on the organizational ecology question: when are states likely to choose alliances or formal obligations over go-it-alone relationships, or netowrked relationships where relationships are not formalized.

5.3 Modifications to the general model

As a first step in capturing the dynamics of alliance formation, I have conducted simulations using the general ABM described in Chapter 3. The core architecture remains the same. In line with the dilemma faced by states, I model this using Prisoner's Dilemma payoffs.

Table 5.2 shows the default values for the parameters in the model. As with all agent based models, much depends on the initial conditions—it is possible to stack the deck for one of the organizations. The default starting conditions here are particularly good here because they allow all three organizations to be viable over a wide range of the parameters of interest.

Table 5.2: 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 actorsÕ 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	

Table 5.2 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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	5
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 Co-operation	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

The goal in the remainder of the chapter is to present several comparative static results from the model. Below I report the results as I increment (or scan) one variable at a time to look at the proportion of different types of actors in different organizations.

Due to measurement constraints in the data, I pay particular attention to actors who join the hierarchy: the closest analogous organization to a formal alliance. What we see is that there is a marked difference in who joins hierarchies and when, leading to testable implications.

There are several actor types of interest. I argue that states can be arrayed according to their vulnerability in the international system. This vulnerability has analogues in the strategy types of agents in the model. There are three basic strategies I will use to illustrate the range of vulnerability.

- **Always Cooperate (ALLC):** ALLCs are eager (indeed hardwired in the model) to cooperate with others, but if they are in a population that is disproportionately composed of uncooperative types, they are likely to be "suckered" and the lowest payoffs (welfare) in the system. It is because of this that in an evolutionary model (Jung and Lake 2012), these are the actors who will be eliminated without organizations. They are the "nice" actors in the system, and the most vulnerable to exploitation.

- **Tit-for-Tat (TFT):** Contingent players in the model, taken to be the simplest tit-for-tat strategy begin by cooperating with an unknown player. If they have "met" the actor before, they will behave as that actor did in the past interaction. In a population full of ALLCs and other TFTs, cooperation is likely to be sustained without external enforcement. In populations that are "nastier" (i.e., less cooperative and more heavily populated by ALLD actors) TFTs will be able to survive, and are only likely to be suckered initially absent organizations.

- **Always Defect (ALLD):** These actors are hardwired to defect, they are the "nasty" actors in the population. They will exploit both ALLCs and TFTs (though only in the first interaction). They are happy to take advantage of security investments made by others, and will shirk in any cooperative situation.

The core parameters of interest here are to look at the actor level, and then theoretically at the alliance level. This leads to a focus on population dynamics, focusing particularly on the variation in which states are more likely to join alliances, and alliances with more obligations attached. A second theoretical (but not tested) implication is how the population dynamics affect the composition of these organizations.I look at these two theoretical issues in turn.

5.4 Illustrations of the Model

5.4.1 Variation in states who join

In this section, I examine how variation in the population, population decisions, and particularly agent characteristics will affect organizational decisions. While the previous chapter focuses more prominently on the organizational ecology and the dominant organizational form adopted, in this chapter I focus on an earlier stage. The key question here is what types of actors are more likely to "join" organizations? The largest variation in the population is between actors who are more cooperative by nature (the ALLCs described above), those who play a contingent strategy (the TFTs), or those who are natural defectors (the ALLDs). Figure 5.1 below tracks the proportion of different strategy types that join the hierarchy over networks or markets depending on the composition of the starting population in which they find themselves. Actors move from markets and networks into hierarchic organizations according to their strategy type, and as a result of the organizational choices of others in the population.

I sweep the initial starting population from a very nice population composed exclusively of ALLC and TFT strategy types to one that is composed of exclusively ALLD strategy types. The composition of the population has a tremendous effect on the likelihood that actors will join the hierarchy. This conforms with the general intuition that as cooperation becomes more difficult, or more valuable, actors of all types will seek out more costly organizations to facilitate it. In this case it is the states who feel vulnerable in a very— and increasingly— uncooperative world who quickly leave a world of ad hoc relationships.

This simulation also shows that the population dynamics drives organizational choices. An ALLD in a "nicer" population (below about 0.5) will make very different organizational choices, and behave very differently as a result. The identical ALLD in the world with a defection rate of 0.3, remains in the market, exploiting the ALLCs (and some TFTs). This is a state that might rely on others to come to its aid in a security incident, but does not reciprocate when that neighbor needs help.

What is particularly striking about Figure 5.1 is the differential rates at which players join the hierarchy. ALLC agents are the first to pay very high costs to prevent a situation where they must "go it alone" in the market, without any form of organizational support. These appear to be the agents most likely to be exploited in the market, again prompting them to seek cooperative partners (alliance partners) in the hierarchy. These two trends lead to Propositions 1 and 2 about which states are most likely to join alliances and when.

Proposition 1: More vulnerable (more cooperative) agents will join hierarchies in greater proportions than their less vulnerable counterparts.

The basic intuition behind Proposition 1 is that those for whom a self-help strategy is unlikely, or who will be more prone to exploitation in the international system, are the most likely to seek the protection of some sort of organization, even if joining involves significant costs.

Proposition 2: More agents join the hierarchy as the population becomes less cooperative.

The intuition here follows a similar logic as Proposition 1, but changes in the organizational ecology drive hierarchic organizations to be increasingly popular. Because the utility of being in the hierarchy increases with their membership size, as they gain members the hierarchy becomes an increasingly popular choice in the population.[9] The system as a whole is likely to move toward coalescing on formalized institutions once

[9] Many of the initial ones due to heavy initial membership from those most vulnerable agents.

the number of members reaches a critical mass. Though the ALLD agents are the last to join (from Proposition 1), they do so because there is no one left in the system to sucker in the market. Essentially, once all other states in the system are entrenched in the enforcement of the hierarchy.

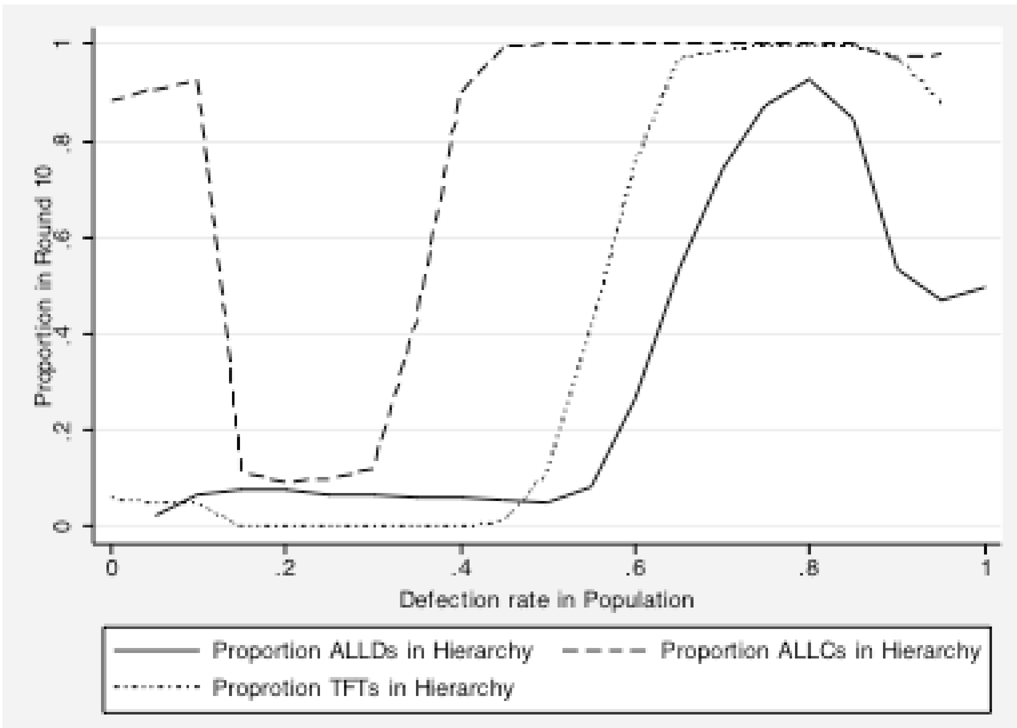


Figure 5.1: Proportion of different strategy types joining hierarchy as the population becomes increasingly nasty.

A second major source of variation is in the composition of alliances. As Figure 5.1 indicates, those actors who are most exposed to the effects of uncooperative behavior in the market will be the most likely to join a hierarchy, and a more costly hierarchy at that. For example, the ALLC in a moderate or nasty world, will expect very low payoffs in the market as they are increasingly likely to meet with an ALLD and be "suckered." The added benefit of enforced cooperation is greater for these actors. As the defection rate increases, the composition of actors within the hierarchy approaches the population composition. In all other situations, the hierarchy is composed of agents that are significantly "nicer" than the population in general.

Figure 5.2 below shows the proportion of each of the three strategy types joining the hierarchy as the hierarchy's ideal point varies. In a similar trend to those in Figure 5.1, we see that ALLDs are the least likely to make costly tradeoffs when joining an alliance. These actors will only join when it is ideologically very similar, whereas TFTs, and particularly ALLC agents are wiling to suffer fairly significant penalties for joining ideologically extreme hierarchies, leading to Proposition 3:

Proposition 3: Hierarchies that are ideologically distant from the population mean are more popular with more vulnerable (cooperative) agents.

This proposition is fairly intuitive: the more vulnerable an actor feels in the population, the more it is willing to pay to have a cooperative partner. An implication of this proposition is that these actors will be willing to pay costs of all types, not just ideological costs, to join organizations that increase the probability of cooperation.

5.5 Data and Analysis

In this section I use the Alliance and Treaties Obligations and Provisions (ATOP) data set (Leeds & Anac 2005; Leeds et al. 2000) to test initial propositions. An important limitation to tests of the theory that I acknowledge up front is that these data are able to address only the most extreme behaviors, but behavior that still falls short of true international hierarchy. What the data do indicate is a movement away from the market.

Looking at more nuanced measurement movement from markets to networks to hierarchies will be a critical next step to examine the organizational ecology of interstate relationships, but one I am not able to address completely here. I focus on state level characteristics, rather than alliance and population level factors that might affect organizational choices, reserving those for subsequent work. I test propositions 1 and 3 to see if the intuition provided by the model finds support empirically.

The core intuition from the model is that nicer states will enter into hierarchic arrangements in greater numbers, and in a wider array of circumstances (including more

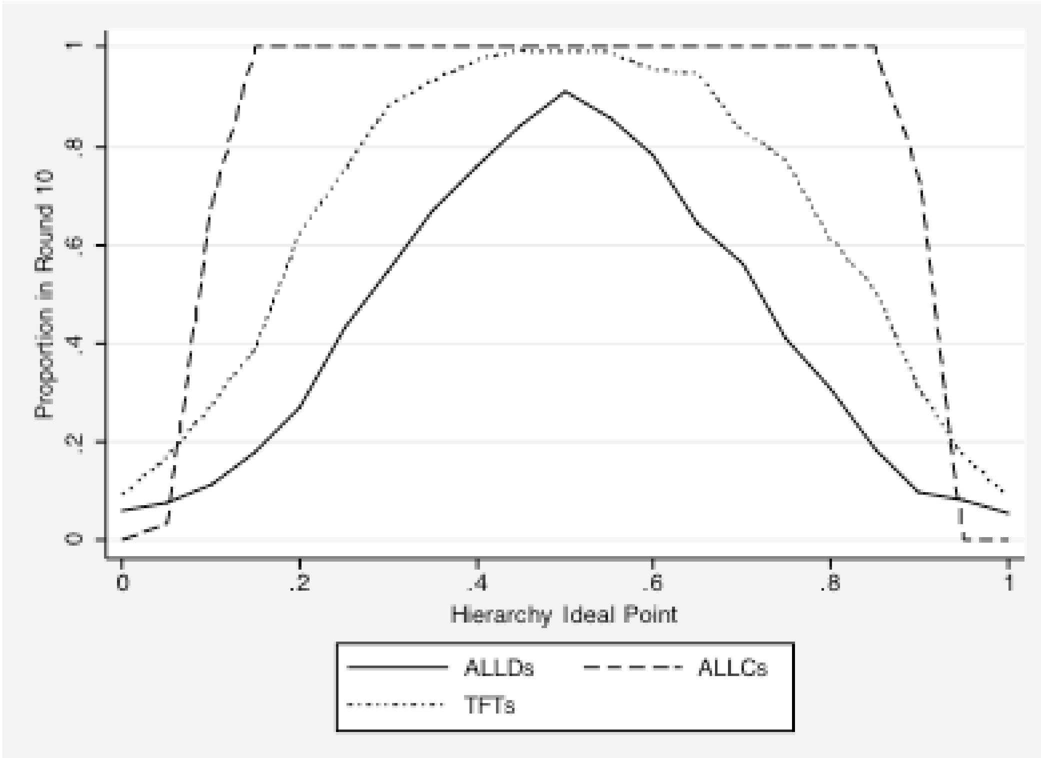


Figure 5.2: This is a relatively nasty population of 70 ALLDs, 10 ALLCs, and 20 TFTs. Ideal points of agents are normally distributed with a mean of 0.5. As the hierarch's ideal point moves toward either extreme (closer to zero or closer to one), fewer agents joint the hierarchy. Importantly, however, except for very extreme values, agents still join the hierarchy for the cooperation it facilitates. As seen above, the nice agents, TFTs and ALLCs, enter the hierarchy first and at high rates; nasty agents enter later, and enter in the largest proportions when the hierarchy's ideal point is very close to the population mean. [Seed 936725, Hierarchy's ideal point incremented from 0 by 0.05 over 11 iterations.]

costly circumstances) than their nastier counterparts. If alliances are used as a way for these "nice" states to guard against being suckered and taken advantage of in the international system, we would expect to observe different membership patterns across state types. The propositions generated in section 4 point to the need to separate out "types" of states, most particularly nice and nasty types. I try to tease out the most vulnerable types of states, to track them through the various predictions. Specifically the predictions are that nice or vulnerable states will be join in higher rates and that they will be willing to bear more costs to join.

5.5.1 Data

Following from Propositions 1 and 3 there are two dependent variables of interest: alliance membership, and the symmetry of the constraints accepted by the state. The data I use cover the time period from 1815-2007. The unit of analysis for Proposition 1 is the state-year, testing if "nicer" states join more alliances. To test Proposition 3, I look at the directed dyad year, to see if dyads with a greater ideological spread are more likely to have asymmetric obligations.

Dependent Variable: Number of Alliances

To test the intuition behind Proposition 1—that nicer or more vulnerable states join more alliances— the primary dependent variable is a measure of alliance membership. To test alliance membership I look at the number of alliances a state is a member of in a given state-year. This provides a measure of how constrained to assist states are willing to make themselves. The model suggests vulnerable states will be quick to be bind themselves through agreements, because the likelihood of being suckered is very high for these actors. This measure of alliance membership is taken from Leeds et al. 2000, who define an alliance as "a formal agreement among independent states to cooperate militarily in the face of potential or realized military conflict."

Dependent Variable: Asymmetric Alliances

A second dependent variable, used to test Proposition 3—that nicer or more vulnerable states are more willing to pay ideological costs to join alliances— is the degree of symmetry (or more particularly asymmetry) of constraints faced by a state. In the equations shown in the Appendix, "cost" can be calculated into the model in several ways, in Figure 5.2, we see this in terms of the ideological penalty. The effect is identical when considering taxes or any other feature of the hierarchy that imposes costs on its members. The intuition remains constant: nice states will "pay" more than nasty states to belong to an alliance.

Independent Variable: Operationalizing Nasty and Nice

The key independent variable is whether the state is a "nice" state or a "nasty" state. The underlying concept here is to capture whether the state is likely to be cooperative or uncooperative in its interactions.

I measure "niceness" or propensity to cooperate with other states in the system as willingness to join international organizations (IOs). This is perhaps a strong assumption, but the measure has two particular advantages. First, states with high rates of IO membership are cooperative states will have established positive, meaning mutually cooperative, interactions with other states in the system. The second advantage of the measure is that it is unlikely that all of the IO memberships are in response to security threats. While there may be IOs that are tangentially related to security, most are of the mold of the International Meteorological Organization or the International Railway Union, which I expect to be unrelated to threat or security issues faced by states

I measure IO membership using the Correlates of War IGO data (Pevehouse et al. 2004). For each country year, I use Pevehouse et al. to construct the number of International Organization memberships a state has.

This measure departs in two ways from the model. The first aspect of the measure not captured in the model, is that a single actor (state's) "niceness" or strategy type can change over the course of study. In this sense a state could increase its IO membership count one year (becoming "nicer") and decrease it dramatically later. This is not captured in this non-evolutionary version of the model. The second point of departure is that IO membership is a continuous variable (and in the Appendix, one that's normalized [0,1] to capture the proportion of IOs joined in that year out of the total possible), where I look at three distinct strategy types: ALLC, TFT and ALLD. Using the continuous measure I cannot distinguish between ALLC and TFT, however, the ordering predicted by the model gives a clear prediction that translates to "niceness" that can be captured in the measure.[10]

[10]For robustness, I also calculate IO membership for a state year as a proportion of the maximum number of IOs in that year. The results are reported in the Chapter Appendix.

Independent Variable: Operationalizing Cost

The independent variable of interest in Proposition 3 is a measure of ideological cost. I use the Gartzke et al. 2000; 2010pairwise affinity scores. Negative scores indicate less similar voting patterns in the UN General Assembly, while positive scores indicate greater affinity. I expect that greater ideological distance will result in an asymmetric relationship.

5.5.2 Control Variables

I control for several factors that may influence both the state's likelihood of joining a security alliance, or their propensity to cooperate in the international system.

- The state's total population: The population of a state in millions. This measure is taken from Correlates of War (COW).
- Alliance type– I control for the different types of alliance commitments as defined in Leeds et al. (2005)
  - Defensive Alliance: coded as a commitment to aid a state if sovereignty or territorial integrity is attacked.
  - Offensive Alliance: promise of active military support that are not included in the defensive alliance conditions.
  - Neutrality: promise to refrain from military action assisting an ally's adversary.
  - Non-aggression: promise to refrain from military action.
  - Consultation: obligation to communicate with allies in crises that may result in military conflict.
- CINC score: The composite index of national capabilities, taken from COW's National Materials Capabilities (NMC) dataset (Singer 1988: version 4).
- Military Expenditure: Millions spent by the state on military in that year taken from COW NMC.

Table 5.3 below shows the descriptive statistics of the variables used in this chapter.

Table 5.3: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Year	1945	52.29625	1815	2007
Defense	.7630316	.4252471	0	1
Offense	.1075674	.309851	0	1
Neutral	.1568358	.3636667	0	1
Non-aggression	.8187014	.3852874	0	1
Consultation	.7552583	.4299585	0	1
Military expenditure (in millions)	2.59	18.47	0	5.52
Total Population	25965.09	89435.79	9	1324655
CINC score	-.0019862	.3798142	2.43e-7	.3838635
Number of Alliances	3.081847	3.586737	1	42
IO memberships	43.13594	24.7153	0	129
Affinity	0.7524	0.3462	-1	1

5.5.3 Analysis

I turn to running preliminary tests of Propositions 1 and Proposition 3.

Proposition 1: Type

Here I test the intuition from Proposition 1: whether "nice" states adopt different alliance strategies than "nasty" types. The dependent variable is the number of alliances joined (a count variable). The key independent variable of interest is the number of IO memberships. The higher the memberships, the "nicer" the state. Theoretically, I predict a positive coefficient, indicating states with large numbers of IO memberships will be more likely to join a large number of alliances. Likewise, a high reading on both, should drive down the number of alliances joined. I estimate the relationship between IO membership (niceness) and alliance membership using a negative binomial regression and cluster the standard errors by state.

I include both Military expenditures (in millions), CINC score, and Population as control variables. Both are positive (and often significant) across the three models. All models show a positive coefficient, meaning states with higher IO memberships

Table 5.4: Negative Binomial Estimation results: Number of Alliances

	(1) Number of Alliances	(2) Number of Alliances	(3) Number of Alliances
IO Memberships	0.0115***	0.0113***	0.00820**
	(0.00218)	(0.00220)	(0.00270)
CINC	7.185***	6.620***	3.543*
	(1.348)	(1.644)	(1.509)
Mil Expenditures	3.02e-09	3.19e-09	2.50e-09*
	(2.42e-09)	(2.44e-09)	(1.19e-09)
Population		0.000000197	0.000000704
		(0.000000264)	(0.000000361)
Constant	0.582***	0.586***	-0.794***
	(0.108)	(0.108)	(0.104)
Alliance Type Control	No	No	Yes
Constant	-1.038***	-1.040***	-1.746***
	(0.179)	(0.180)	(0.188)
Observations	6686	6685	6685

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

are also more likely to join security organizations. The results presented in Table 5.4 provide support for Proposition 1.

For robustness, I test this same proposition using the directed dyad ATOP data. I test the effect of IO membership proportion on the likelihood of joining an asymmetric alliance. Following the same logic as above, I report the results in Table C.2. The expectation from the model is that greater "niceness" should result in a higher likelihood of joining an asymmetric alliance (a hierarchical organization). The positive coefficients on IO membership provides additional support for this finding. Taken together, there is evidence confirming the differential patterns of organizational choice by different "types" of states in the system.

Table 5.5: Rare Events Logit: IO membership on Asymmetric Alliance

	(1) Asymmetric Alliance	(2) Asymmetric Alliance	(3) Asymmetric Alliance	(4) Asymmetric Alliance
IOprop	3.567***	3.568***	2.758***	1.303***
	(0.171)	(0.171)	(0.185)	(0.137)
Number of Alliances		0.000500	0.0325	0.811***
		(0.0418)	(0.0438)	(0.0550)
Mil Expenditures			2.13e-09***	3.04e-09***
			(2.75e-10)	(6.49e-10)
Population			-0.000000519***	-0.00000166**
			(6.48e-08)	(0.000000592)
CINC			6.902***	8.479***
Constant	-6.611***	-6.612***	-6.325***	-2.995***
	(0.117)	(0.127)	(0.132)	(0.134)
Observations	186411	186411	186290	186290
Alliance Type Control	No	No	No	Yes
Observations	186411	186411	186290	186290

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Proposition 3: Costs

The intuition in Proposition 3 is that ideologically distant hierarchies are most likely to be adopted by vulnerable agents. Testable implications from this proposition rest on the assumption that asymmetric alliances—in which one state's obligations are greater than the another's— are more hierarchical than symmetric alliances. The intuition following proposition 2 would predict that asymmetric alliances are most likely to be observed in ideologically distant pairs. One pair would pay significant ideological costs, while the other would bear more security constraints.

To test this I use the ATOP directed dyad data to measure the symmetry of alliance obligations. Specifically I look at whether the terms bind the states asymmetrically, which I take to be an indication of greater "hierarchy" in the agreement than symmetric obligations. Asymmetric alliances are the dependent variable of interest in these models.

The independent variable of interest here is some measure of ideological cost. I use the Gartzke et al. pairwise affinity scores. Negative scores indicate less similar voting patterns in the UN General Assembly, while positive scores indicate greater affinity.[11]

Proposition two would predict that alliances between dyads with lower affinity scores are more likely to be asymmetric. I expect a negative sign on the key independent variable— affinity. I use a rare event logit model (King and Zeng 2001) to estimate the effect of affinity on symmetry of alliances. I cluster these models by dyad. The results are reported in Table 5.6.

The negative relationship between the degree of affinity in the dyad and likelihood of an asymmetric alliance across all models indicates support for the hypothesis. Uneven, formalized obligations are more likely when one member of the dyad pays a greater ideological cost. In model 4 I exclude dyads where there is no obligation, either symmetric or asymmetric, between the members of the dyad. The results hold in here as well.

[11] All of the tests below were replicated with the three way measure as well as the interpolated measures, no substantive differences resulted.

Table 5.6: Rare Events Logit Estimation results: Affinity on Asymmetric Alliances

	(1) Asymmetric Alliance	(2) Asymmetric Alliance	(3) Asymmetric Alliance	(4) Asymmetric Alliance
Affinity	-1.293***	-1.315***	-1.070***	-1.340***
	(0.142)	(0.154)	(0.245)	(0.115)
Number of Alliances		0.127	0.862*	0.146
		(0.273)	(0.369)	(0.121)
Constant	-3.418***	-3.573***	-2.103***	-3.606***
	(0.169)	(0.387)	(0.458)	(0.429)
Observations	131294	131294	131294	131259
Alliance Type Controls	no	no	yes	no
Exclude no obligation	no	no	no	yes

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.6 Conclusion

This chapter has presented an application of the ABM to another set of actors and organizational behavior; states and formal security relationships. The model's general propositions are validated, particularly the ability to separate "types" of actors out and observe differential behavioral patterns. This trend is not unique to the alliance specification, but the available data allow for this implication to be tested at the actor (state) level, which many other data sources do not. The tests above serve to validate the underlying intuition that there are different "waves" of actors in the international system, whose organizational behavior differs significantly.

Data constraints limit fully testing the implications of the model with respect to security organizations. This chapter has so far focused only on the hierarchy, the most clearly observable organization because agreements are formalized. However, recent work on networks has pointed to the growing importance of networks as alternative organizational forms to both anarchy as well as hierarchy. Future work on this topic will refine the measures of organization and actor type type. Proposition 3 is tested using broad measures of asymmetry, this can be expanded with variation within the alliance and across dyads to better assess the degree of the relationship and the composition of the alliance. In addition to adding variation to the formal relationship, measures of networks that track reciprocity outside of formal alliance organizations to capture network trends across different types of actors. I also hope that refining these measures will lead to testable implications at the alliance level that will allow for alliance composition (Proposition 2) to be appropriately tested.

Chapter 6

Organizational Ecology in Voter Mobilization, Sanctioning, and Turnout

Rational choice theorists have long puzzled over why citizens vote, given that voting is costly and the likelihood any one person's vote is pivotal proves to be small (Downs 1957, Riker & Ordeshook 1968, Blaise 2000). Yet citizens consistently vote in large numbers, particularly in transitioning democracies such as those in Africa that have introduced multiparty elections only recently. In these countries, the level of voting is even more peculiar given the high costs of doing so: many impoverished African voters lose a productive day of labor, must stand in long lines (amidst potentially unfavorable weather conditions such as heat or rain), and may face other adverse conditions such as electoral violence. And yet roughly 70 percent of Ghanaians turned out for their 2008 presidential elections, mirroring similar patterns across the continent (Electoral Commission of Ghana 2008).

Why do Africans vote? To explain the perceived "anomaly" of turnout, scholars have amended the classic rational choice approach by focusing on three sets of additional factors that may drive voter mobilization. The first is selective incentives that parties or candidates promise to voters, particularly in the form of vote-buying or patronage (Chabal and Daloz 1999, Posner 2005, Chandra 2007, Watchekon 2003). This typically includes a one-time pay-off to the individual simply for showing up the polls and casting a ballot for the designated party. The second is that a voter's sense of duty from affective ties of belonging to a group, including a political party or ethnic group, will drive them to vote in order to affirm their social membership(Horowitz 1985, Dickson & Scheve 2006, Ulander 1986). This approach examines the duty or "D" term in predictions of turnout, and focuses on non-material gains that accrue to voters.[1] The third suggests that individuals vote to avoid costly sanctioning from members of their community (Niemi 1976), defined possibly as their family, neighbors, ethnic group, or political party given a general understanding that for the group's interests to be pursued, they must field electoral winners which requires cooperation and turnout, usually through dense social networks (Rosenstone & Hansen 1993).

However none of these explanations on its own correctly predicts observed levels of turnout, and face a number of other challenges as they apply to explaining voting in Africa's emerging democracies. Selective incentive approaches assume that small personalistic goods are enough to drive turnout, without measuring these against the opportunity costs of voting or how parties are able to mobilize voters in such large numbers as well as afford pay-offs. With turnout nearly 70 percent (equivalent to 12,472,758 voters) in Ghana (see Table 6.1), it is unlikely that every person voting has been given money, public sector employment, or gifts for doing so. The duty one feels to a group may be an important factor in explaining political behavior, but scholars frequently assume that group attachments are consistent across individuals and groups in which case elections should always produce near universal turnout. However, as Table 6.1 demonstrates, not everyone votes. In fact, as we will show, expressed levels of partisanship and ethnic attachment fall significantly below the level of observed turnout in Ghana, suggesting that people without a strong "duty" still vote. Last, sanctioning from others may contribute to voting behavior, but this does not explain why communities find it important to sanction, whether there is variation in sanctioning levels and if so what explains those patterns, or how they monitor outcomes of whether everyone has voted, a costly exercise in its own right.

This chapter solves these conundrums by synthesizing various explanations to explore Ghana's level of voter turnout. Like previous chapters in the dissertation, voting is understood to be a prisoner's dilemma in which individuals vote as personal investments in collective goods. Voters must therefore coordinate to cooperate and maintain a

[1] As formulated by Riker and Ordeshook

Table 6.1: 2008 Turnout in Ghana by Region

Region	Turnout
Western	67.31
Central	69.09
Greater Accra	67.10
Volta	67.12
Eastern	67.35
Ashanti	73.58
Brong Ahafo	68.48
Northern	74.90
Upper East	70.72
Upper West	68.89
Total National	69.52

level of turnout that helps support the community's interest. We use the ABM described in Chapter 3 to derive turnout predictions given certain parameters that we manipulate across a host of models with respect to selective incentives, duty, and social sanctioning. We test these predictions against data drawn from a novel nation-wide public opinion survey that we conducted a few weeks before Ghana's 2008 election and changes in actual turnout from 2004 to 2008. Ghana provides a robust setting in which to test these hypotheses. Because Ghana's level of political development and social diversity is similar to many cases in Africa, findings there ought to represent a larger pattern of what should be observed across Africa and therefore provide important insights into voter mobilization in emerging and multi-ethnic democracies with weak party systems but curiously large turnout.

To preview our results, we find that a certain number of citizens will turnout regardless of additional costs or benefits of doing so— these are the analogues to the ALLC strategy type. However, this only accounts for 30 percent turnout. Next, we find that some selective incentives will boost further turnout, but at a price that is unrealistic for parties to pay and is beyond their ability to provide. Therefore, patronage has negative effects on turnout because voters who believe it is important are less likely to vote in light of not receiving a pay-off. Third, we find that strong ethnic attachments only contribute partially to turnout, but become insignificant once controlling for urban/rural setting and education. Fourth, we find that the pay-offs associated with costly social sanctioning contribute significantly to predicting turnout. Cooperation, understood as individuals voting, is maintained by the avoidance of extreme negative sanctions on the part of other community members. Individuals are able to sanction each other given that voting is highly visible to small local communities both at the polling station but afterwards as voters have marked fingers with indelible ink. This avoidance of negative sanctioning from other individuals in the community drives cooperation at levels that match the actual turnout. Taken together, our findings suggest that there are a host of motivations that are important towards understanding why citizens vote in new democracies, but social sanctioning proves vital. In addition to speaking to primary outcome of interest, turnout, we also highlight the organizational story that produces that outcome.

This chapter makes contributions to the turnout literature as well as in advancing the theory of organizational ecology and population dynamics. First, in addressing the turnout literature, we argue that social sanctioning is *a* key mechanism by which high voter turnout is achieved. Second, we argue that part of the reason we see confusion in the turnout literature is that there may be multiple paths to high turnout. What motivates one voter to show up at her polling station may not be the same thing that motivates another voter. Because we look at populations of voters, the ABM is a particularly well equipped tool to study these dynamics.

This chapter also makes two major points in relation to the theory of organizational ecology and population dynamics advanced in earlier chapters. First, there may not be one monolithic path to high levels of turnout (cooperation); indeed it may (and likely does) involve multiple organizations simultaneously working within populations that promote high turnout. Previous chapters have focused primarily on the role of one organization becoming adopted to promote cooperation, here I argue populations may turn to more than one organization. Second, while earlier chapters have focused on changes in the population, this chapter manipulates the difference in payoff magnitude, while preserving the overall Prisoner's Dilemma payoff structure, to look at changes in cooperation.

6.1 Prior Approaches to Explaining Turnout

There are three prior approaches to explaining turnout that help explain why citizens vote in transitioning democracies. In divided societies, the strength of ethnic attachments may account for the "duty" that voters feel with respect to voting. Ethnic groups have histories of relationships before the transition to democracy, and in many countries such as Afghanistan, this may include conflict and civil war. Strong in-group attachments and out-group animosity may produce negative evaluations of ethnic others based on fear and prejudice and positive evaluations of association members that contribute to a sense of shared identity and belonging(Berkowitz & Lutterman 1968, Bell 1991, Kinder & Sears 1981, Huckfeldt & Kohfeld 1992, Bettelheim and Hanowitz 1964, Reeves 1997, Volkan, Snyder 1984). Citizens may therefore vote to express their group identity (Horowitz 1985, Rabushka & Shepsle 1972, Ulaner 1993).

The costs of voting could be partially or fully off-set by positive pay-offs through vote-buying, and so politicians may also use this strategy to mobilize supporters. The importance of clientelism and patronage has long been noted in developing democracies(Bates 1971, Obrien 1971, 2003, Bayert 1993; Kitschelt and Wilkinson 2007; Chabal and Daloz 1999), as well as its relationship to voting (Chandra 2006, 2009, Posner 2005,Keefer & Khemani 2005, Lynne 2007). Given levels of poverty and underdevelopment, voters in Afghanistan could be particularly susceptible to this form of influence(Biljert 200X).

6.2 Voter's Dilemma

Following Popkin et al. (1979) and Popkin (1991), we argue that the act of voting is analogous to an individual investment in collective goods. Regardless of the individual benefits that may accrue to a voter either from voting or selecting a winner, the motivations for selection are done with an eye towards how electoral outcomes affect the provision of goods to the environment in which individuals live. We are agnostic as to whether voters view these "collectives" in terms of parties, ethnic groups, regions, villages, etc. We also recognize that regardless of collective aims, voting may also confer private benefits to a voter, whether psychic or material. However, since democratic lawmakers legislate on the bases of groups or locales and not individuals solely, electoral outcomes affect collectives and voters face a constant problem of coordination in order to ensure that their group or area successfully fields electoral winners.

6.2.1 Voter's Dilemma as a Prisoner's Dilemma

Voter turnout is a problem of cooperation at its core, and secondarily a problem of coordination. This can be captured in the modified PD framework outlined in Chapter 3. Patterns of cooperation and coordination within a population playing a RPD can be seen as analogous to turnout, especially since individuals have incentives to free ride as they will enjoy the benefits of distribution regardless of whether or not they turnout. The ABM allows for the introduction of population dynamics and individuals' reputations within the population as key characteristics that increase or decrease cooperation through the use of the network and hierarchy. These characteristics may include payoffs to the game, individuals' beliefs about the population, and ideology.

Voters, as agents, play a PD in which they have an assigned strategy: all cooperate (ALLC), all defect (ALLD) or tit-for-tat (TFT). Agents also have an individual ideal point (0,1), that represents ideological or affective attachment. The model begins with user specification of the parameters. Payoffs are set. Each of the four outcomes of a PD (i.e., CC, CD, DC, and DD) is specified. See 6.2 below.

- Higher payoffs to the CC outcome are analogous to tangible benefits from voting, such as personalistic goods like patronage received through vote-buying. They may also be akin to the positive psychic benefits that an individual feels from voting to affirm their identity or otherwise support their "duty" to vote. We think of the CC outcome as occurring when an individual and the randomly selected member of her community both turn up at their polling station. The CC outcome should indicate investment in the collective goods.
- Worse payoffs for not voting, the DD outcome, are analogous to a social punishment from not voting, in which case sanctioning from community members drives cooperation. The DD outcome occurs when an individual actor defects against a

randomly chosen member of her community, who also defects. This community has minimal investment in collective goods.

- The CD and DC payoffs are the situation in which free-riding takes place: either the individual or its community fails to invest, producing a socially sub-optimal investment.

Table 6.2: Turnout as a Cooperation Problem

	P2 Turnout (C)	**P2 Stay Home (D)**
P1 Turnout (C)	*Community Outcome* Higher investment *Individual Outcomes* P1 and P2: Psychic benefits, potential social benefits, material benefits, lose 1 day of work.	*Community Outcome* Middling investment *Individual Outcomes* P1: Access to community benefits, psychic benefits, lose a day of work. P2: Access community benefits, keep day's wages, no psychic or material benefits, potential social sanctioning.
P1 Stay Home (D)	*Community Outcome* Middling investment *Individual Outcomes* P1: Access community benefits, keep day's wages, no psychic or material benefits, potential social sanctioning. P2: Access to community benefits, psychic benefits, lose a day of work.	*Community Outcome* Little or no investment *Individual Outcomes* P1 and P2: No lost work, no psychic or material benefits, potential social sanctioning.

Unlike in earlier chapters, the weight on ideology varies (though does not deviate from a normally distributed population centered at 0.5). The higher the weight, the less attractive cooperation with an agent who is ideologically distant becomes. The model allows for ideological affectation, but ultimately can model any kind of strong attachment. In this way the model's focus on "ideology" is analogous to the discussion of strong ethnic and/or partisan attachments found in the literature that may drive voting from a sense of duty to one's group or achieving psychic benefits from voting. Setting this dynamic allows us to incorporate psychic explanations for cooperation as a baseline for determining turnout given hardcore partisans.

To examine turnout, we look at the default rate of cooperation in the population. Some players will be predisposed to cooperate. Secondly, we will look at the observed turnout (cooperation) rate in this simulated world.

6.2.2 ABM generated hypotheses

Initial simulations are run with a baseline population of 30 ALLCs (or hardcore voters/partisans who will vote no matter what), 20 TFTs (swing voters who may or may not turnout), and 50 ALLDs (who will not turnout according to their pure strategy)[2]. In essence the baseline cooperation rate in the population is about 50 percent early on, with only 30 percent that will always cooperate. We establish the 30 percent baseline from a survey question that asked respondents whether they felt close to any political party (see below). In order to observe high levels of cooperation other factors must be in play. Default payoffs are the same as Axelrod's (1984) and manipulated from there.

Patronage Hypothesis (increase CC payoff)

First, we test the hypothesis that individual material rewards for voting, such as patronage or what is typically associated as vote-buying, is what drives cooperation. Specifically,

H1: Higher payoffs to cooperation increase turnout (cooperation).

Figure 6.1 demonstrates the level of turnout created by increasing the benefits to mutual cooperation (delivering patronage on top of the community and psychic benefits to voting). Figure A shows the comparative static results of moving along from the standard payoff of 3, and incrementing it up by 0.1. These increases in the payoffs (along the x-axis) produce dramatic results in the predicted level of turnout, but only in light

[2]There are a multitude of reasons why voters would not turn out in new democracies: the high opportunity costs, danger, lack of belief in the system or the population.

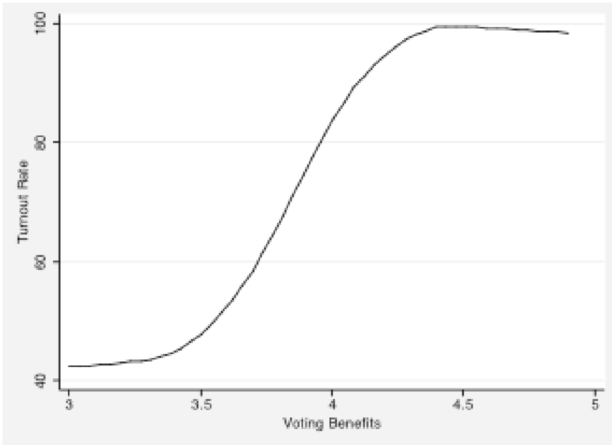


Figure 6.1: Cooperation/Turnout as benefits to mutual cooperation increase (Patronage) [Seed:7954 CC Payoff incremented from 3.0 by 0.1 over 20 increments, smoothed)]

of large pay-offs. Immediately we can see that payoffs need to be unreasonably high to obtain participation above what is observed in Ghana (70 percent turnout). Essentially, ceteris paribus, an added payoff of about 0.7 would be needed to achieve such high levels of cooperation. Therefore, we do not think that patronage alone, or any marginal payouts through vote-buying, can explain observed turnout.

Duty/Affective Ties and Psychic pay-offs Hypothesis (Increase weight on Ideal point)

Second, we test whether affectation and strong ties of identity increase the likelihood of cooperation. Specifically,

H2: A stronger sense of duty from ethnic attachments increases turnout (cooperation).

Figure 6.2 simulates the turnout obtained by switching the weight on ideology, analogous to increasing strength of affective ties of membership and therefore duty. These comparative static results show that high measures of identity/salience on these affective components should in fact slightly decrease cooperation/turnout, or localize it. Essentially, when the ideological costs to cooperating with people whose ideal points are distant from their own increase, cooperation in the population decreases– people are only willing to cooperate with those who are ideologically very similar. We should note that this population is normally distributed around 0.5; these results may vary in

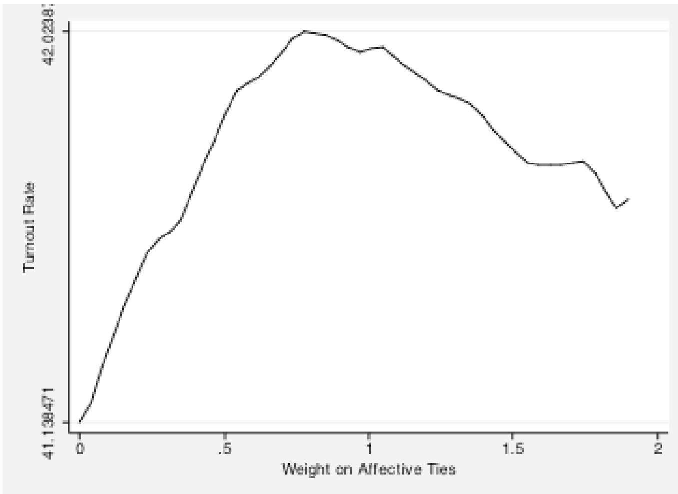


Figure 6.2: Cooperation/Turnout as strength of identity increases [Seed:45339, weight on ideology is incremented from 0 by 0.1 over 20 increments, smoothed)]

a bimodal population, or one with a tighter ideological spread.[3] When there is a tight cluster, or potentially a bimodal distribution with two groups, we might expect two clusters of cooperation, where what we see here is one cluster at the ideological center, and only a gradual decrease. Note too that as the weight on ideology increases, the level of cooperation does not vary as much as we see either above or below. Because the baseline cooperation level is not high (50 percent), we would not expect that increasing the weight on ideology should provide an incentive for added cooperation and certainly not to the levels we observe in many African democracies. These results lead us to believe that affective ties alone are unlikely drive high levels of cooperation.

Social sanctioning hypothesis (increasing negative pay-offs from DD)

Third, we hypothesize that social sanctions from other individuals within a community from not voting may drive cooperation. Specifically,

H3: As social sanctions increase, turnout (cooperation) increases.

Figure 6.3 shows the likely turnout as social sanctions for not voting increase

[3]For the sake of exploring the relative importance of various factors in explaining turnouth, we do not replicate these results in other distributions of populations. Or results from Ghana suggest that even given its ethnic diversity the country is not extremely socially polarized (see survey question on ethnic identification below), echoing newer research in Africa that ethnic divisions might prove less politically relevant than previously thought. See Gibson and Long, Hoffman and Long.

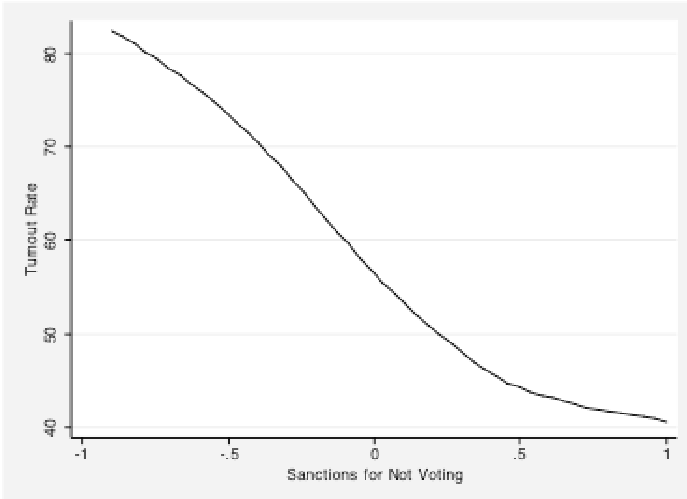


Figure 6.3: Cooperation/Turnout as Penalties for not participating increase. Seed: 738623, DD payoff decremented from 1.0 by 0.1 over 20 increments, smoothed)

(or the DD payoff becomes worse). Like the figures above, this is a comparative static result. The figure clearly demonstrates that turnout increases dramatically as the threat of negative payoffs increases. Conversely, as those penalties become less costly, turnout decreases significantly—leaving mainly strong partisans. Indeed, the net payoff to such an outcome need only be slightly negative (between -0.2 and -1.0) to induce cooperation at rates well above the default cooperation rate in the population. We therefore argue that the social sanctioning mechanism is an important predictor for explaining the high level of turnout witnessed in Ghana.

Multidimensional simulation

The discussion above has focused on the comparative statics, looking at what happens to turnout when one parameter is increased or decreased. In reality it is possible, and perhaps likely, that many of these factors occur simultaneously—there may be patronage offered and social sanctioning. To look at these interactive effects, we also simulate all three potential explanations at once. We model patronage increasing the benefits to turning out, the value of affective ties increasing, as well as social sanctions punishing those who stay home on election day. Figures 6.4, 6.5, and 6.6 below reports the results. For comparative purposes, the respective comparative statics (Figures 6.1, 6.2, and 6.3 are replicated on the top while the equivalent multi-dimensional results are reported on the bottom.

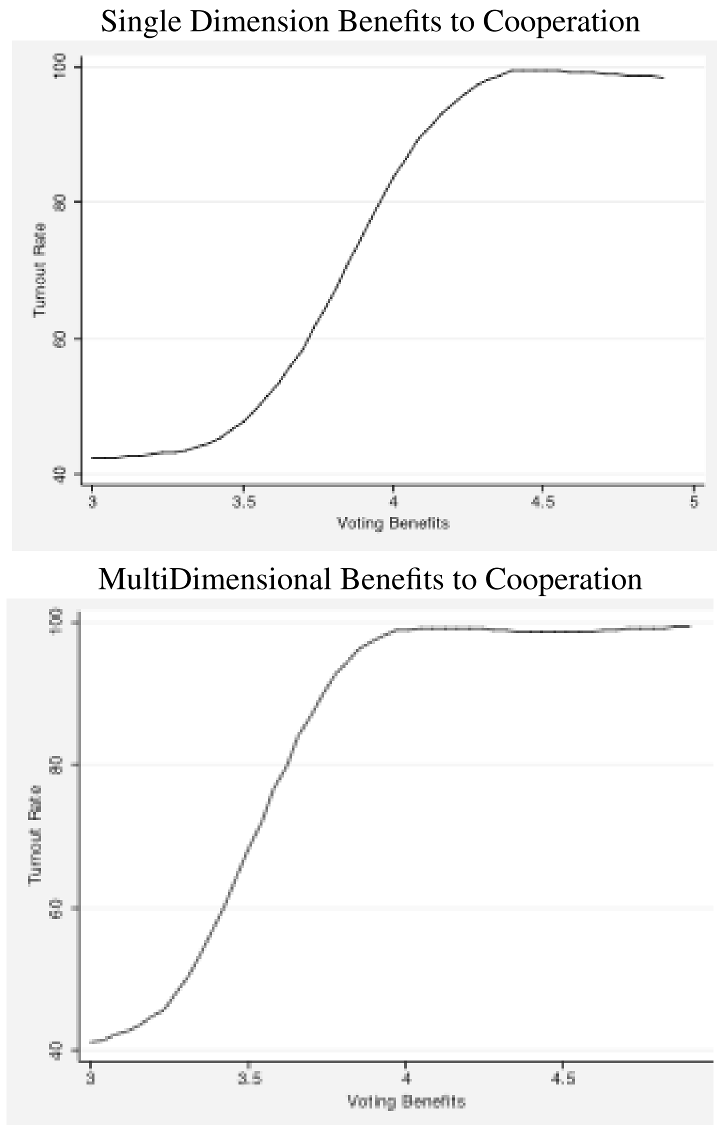
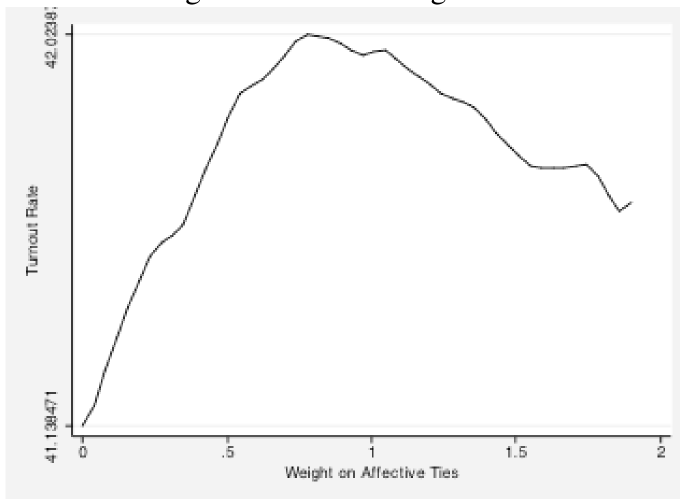


Figure 6.4: Multidimensional Simulation Benefits to Cooperation. Seed 665071.

Single Dimension Weight on Ties



MultiDimensional Weight on Ties

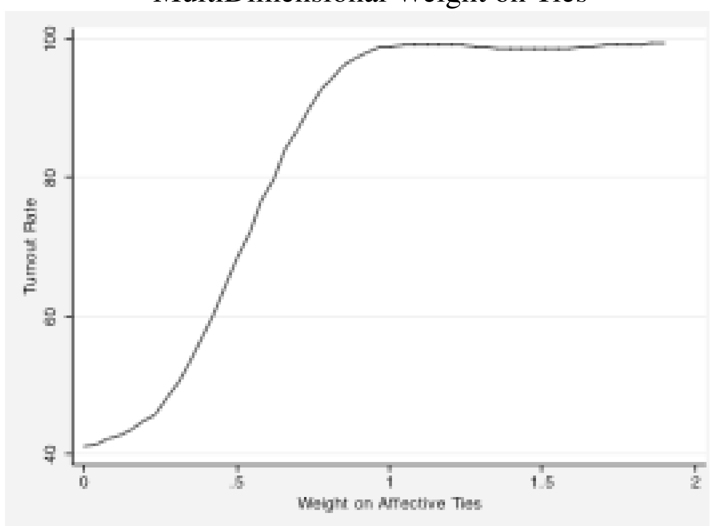
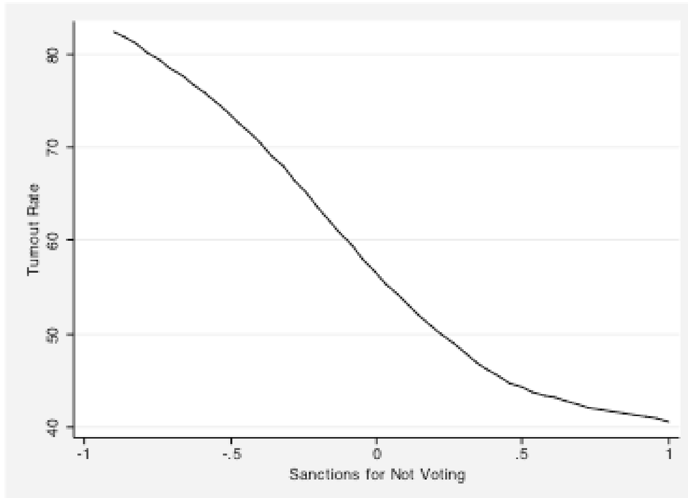


Figure 6.5: Multidimensional Simulation Weight on Ties. Seed 665071.

Single Dimension Sanctions



MultiDimensional Sanctions

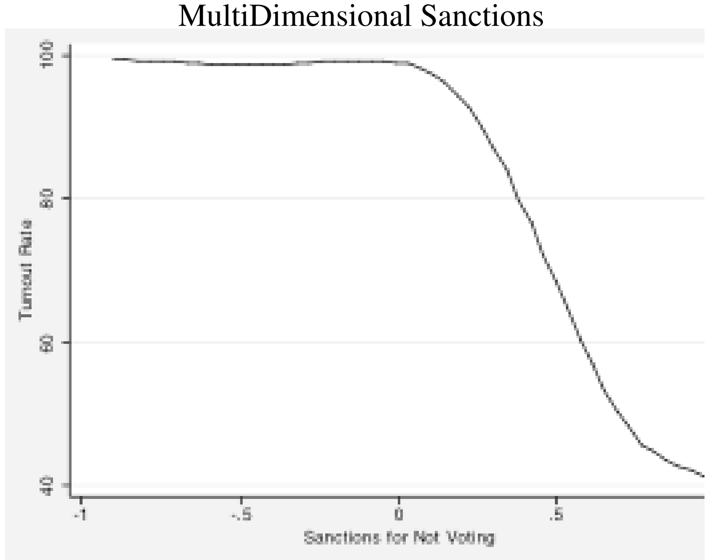


Figure 6.6: Multidimensional Simulation Sanctions. Seed 665071.

The trends from the multi-dimensional simulation confirm those in the single dimension simulations. There does appear to be an additive effect when all three factors are present—turnout jumps significantly at relatively lower levels of all variables. Lower levels of patronage as well as smaller social sanctions create larger jumps in turnout than when applied alone. Perhaps most striking is that affective ties become a stronger predictor of turnout when examined in the context of both social sanctions and patronage, lending credence to turnout being a social and multi-faceted phenomenon, rather than one explained completely by a single factor be it patronage or affective ties.

We want to emphasize the prediction with respect to social sanctioning. In the presence of other factors, the magnitude of social sanctions might be quite small (and need not lead to a negative net payoff for the actor) in order to lead to very high predicted turnout rates.

6.2.3 Organizational

The organizational story behind these results is not one that has been highlighted thus far in the dissertation, but the underlying mechanism that allows agents to achieve these high levels of cooperation is an organizational one. Without changes in the underlying population composition, save organizations, there only path for actors to use to respond to changes in incentives or disincentives to vote is to use networks and hierarchies. The possibility of punishment is a powerful piece of this.

Figure 6.7 shows that even when agnostic to the particular organization, organization usage (either network or hierarchy) increases significantly. Both population dynamics and organizational ecology help to account for this finding. In nicer populations, we expect the network is used more often, but as factors that favor cooperation increase, actors shift to both the network and the hierarchy.

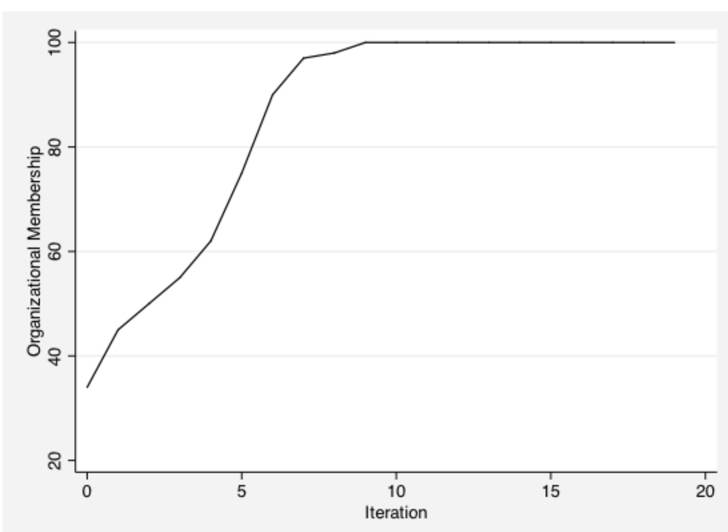


Figure 6.7: Multidimensional Organizational Distribution. Seed 665071.

6.3 Empirical Tests

In this section we provide background on Ghana's 2008 general election, and our novel dataset. We also test the three explanations for turnout in Ghana.

6.3.1 Background to Ghana's 2008 Election

On December 7, 2008, Ghanaians headed to the polls for the fourth time since the reintroduction of multiparty politics in 1992. It proved to be a contentious and close race as Nana Akufo-Addo attempted to succeed incumbent President John Kufour on the National People's Party (NPP) ticket. His main challenger was John Atta-Mills running for the National Democratic Congress (NDC). Jerry Rawlings transitioned from military to multiparty rule in 1992 leading the NDC and was re-elected again in 1996. In 2000, the NPP managed to win causing a successful party turnover, and won re-election in 2004. Given that both the NDC and NPP had won two electoral cycles each, the 2008 proved close and contentious.

The electoral rules in Ghana dictate that if no party's presidential candidate garners 50 percent +1 of the vote in a first round, the top two vote getters in the first round compete in a second round where the person with a majority of votes wins. The system is winner-take-all in a single nation-wide constituency. Parliamentary elections are held concurrently, with candidates competing in single-member simple-plurality winner-take-all constituencies (of which Ghana has 230). In the first round, Akufo-Addo/NPP garnered 49.13 percent of the vote to Atta-Mills/NDC's 47.92 percent. In the run-off, Atta-Mills won with just over 50 percent and about 40,000 votes.

6.3.2 Data

In this section, we perform a test of the emergent predictions from the ABM models using survey data from Ghana. We conducted a nationally represented household survey of registered Ghanaian voters a few weeks before its December 2008 general election. We sampled from the final registry of voters produced by the Electoral Commission of Ghana, using multi-stage sampling with proportional distributions to regions, districts, and constituencies; including random selection of enumeration areas, households, and respondents. In total, we surveyed 2,033 Ghanaians in all ten regions of the country.

The survey included a number of questions regarding perceptions and attitudes about local and national government, incumbent performance, the electoral process, ethnicity, and vote choice. Here, we focus on a few questions regarding mobilization and turnout.

6.3.3 Baseline Turnout before Incentives, Ethnicity, and Social Sanctioning are applied

In order to assess a baseline turnout scenario before the application of additional contributors to turnout, we asked voters whether they considered themselves members of political parties, and if so whether they felt close or not to that party. We assume that strong partisans will vote regardless of adjustments to the costs, benefits, or duty related to doing so. We are agnostic as to whether these partisans are fundamentally driven by any of these variables or how they assess pay-offs; rather we simply assume that for whatever reason, any election will have a baseline turnout regardless of additional factors and those who vote will be strong partisans. 36 percent percent of Ghanaians feel very close to a political party, suggesting that regardless of further adjustments to pay-offs, only a small proportion of the electorate will turn out. What explains the difference between predicted partisan turnout (36 percent) and that observed in the election (70 percent)?

6.3.4 Dependent Variable

Constructing a dependent variable from survey data with respect to voting turnout is difficult. In the run-up to an election, few registered voters will express the desire not to vote and so reply that they will vote regardless of their true intentions, especially if social sanctioning plays a role in driving turnout and respondents will not want to admit to survey enumerators that they do not want to vote. Moreover, in simply asking a potential voter whether they will vote there is no cost associated with them replying yes, regardless of whether it is true. Our suspicions are demonstrated by results from the Afrobarometer survey conducted in Ghana in 2005. The survey asked respondents whether they had voted in the last election (in 2004). Less than 1 percent responded that they "decided not to vote." Therefore, we did not suspect that asking a question about whether or not the respondent intended to vote would produce valid results, or answers with enough variation to test hypotheses against.

Rather than relying upon a survey question that we have reason to believe elicits untrue responses, we instead build a measure of turnout that is based on the actual recorded levels of voting in 2004 and 2008. For each individual in the survey, we calculate a likelihood of voting based on the real level of turnout in their constituency, the smallest and most local unit at which the Electoral Commission reports turnout. Turnout in 2008 was uniformly lower across the country than 2004, fitting expectations that turnout tends to fall across the board after founding elections. We calculate an individual's probability of turnout by subtracting the 2008 turnout from the 2004 turnout. Since this produces a positive number across the board, the question is what explains constituencies that had less of a drop-off in voting (increased mobilization) relative to those that had greater drop-off (less mobilization).

$$Pr(Voting_i) = Turnout_c2004 - Turnout_c2008 \tag{6.1}$$

Equation 6.1 above represents the construction of our dependent variable, where the probability of voting for voter i is a function of the 2004 turnout in constituency c minus the 2008 turnout in the same constituency. This helps to produce positive probabilities, which we dichotomize to 1 being values below the median (low levels of drop-off in turnout, or more mobilization) and 0 being values above the median (high levels of drop-off, or less mobilization). We argue that this construction of the DV has important advantages. First, incorporating both the 2008 and 2004 turnouts is significant given that the ABM model is dynamic and considers mobilization an iterative process in which players learn and update their beliefs about the likely behavior or other players. These beliefs affect players' behavior in subsequent rounds. Therefore, we expect voters to use turnout from one period to assess the likelihood that other voters will turnout out in a second period.[4] Second, relying upon actual turnout allows for better identification

[4]For these reasons, it might seem fruitful to test predictions using the first and second round differences

given that it is a data source completely exogenous from the survey data.

6.3.5 Independent Variables

Patronage

Measuring the extent of vote-buying in a given election is hard through a survey because respondents may be unwilling to give truthful responses given negative perceptions of patronage. For that reason, we did not ask Ghanaians directly whether they had received patronage, but rather whether they thought parties providing selective incentives to voters was important. It is important to note that this variable captures attitudes about patronage—not the de facto level of patronage or vote-buying, and therefore better fits the ABM model. We also phrased the question to read as though positive responses were not socially undesirable. We asked, "Thinking about the upcoming elections, political parties may reward their supporters with gifts and money in exchange for support. Do you think it is very important, somewhat important, or not very important that political parties reward their supporters with gifts and money in exchange for support?" We create the dichotomous variable Patronage to carry a value of 1 responding to positive responses to this question "very or somewhat important," and 0 otherwise.

Ethnicity

To create a measure for whether affective attachments to one's ethnic group and the psychic benefits voting contains drove a duty to vote, we first asked respondents their language/ethnic group, followed by "Let us suppose you had to choose between being a Ghanaian and being a [insert name of language/ethnic group]. Which of these groups do you feel most strongly attached to?" Following measures derived elsewhere from similar questions(Bratton and Kimenyi 2008; Ferree 2006; Ferree forthcoming), we create the dichotomous variable "Ethnicity" which takes a value of 1 for ethnic identifiers who

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from just the 2008 election. However, we argue that the relative weight of factors explaining turnout might drive differences in mobilization in a second round run-off; hardcore partisans are likely to vote again but swing voters or those who supported parties other than the top two are less likely to turnout a second time. In short different subsets will be mobilized more in different ounds. Additionaly, the run-off did not include concurrent parliamentary races, making an election whtiout parliamentary races harder to compare to an election with them responded that they felt strongly or mostly attached to their language/ethnic group, and 0 otherwise.

Social Sanctioning

Our key independent variable of social sanctioning is built from a question asking voters whether or not they think it is important for other members of their community to vote, even if undesirable candidates appear on the ballot. The question allows us to measure to the extent to which voters build expectations about the behavior of other players with whom they will need to cooperate in order to succeed and avoid negative pay-offs (derived from the model). Specifically, we asked "Thinking about elections in Ghana, how important is it for everyone in your community to vote, even if they do not like the candidates: is it very important, somewhat important, or not very important?" We asked the question in relation to the potential for negative candidates as we thought simply asking whether respondents thought members of their community should vote would elicit nearly universal positive responses. We generate the dichotomous variable Social Sanctioning, which carries a value of 1 if individuals respond "very important" and 0 otherwise.

Table 6.3: Summary Statistics (percent providing affirmative/positive responses)

Variable	Percent
Patronage	10
Ethnicity	6
Social Sanctioning	67
Partisanship	36

The descriptive statistics in Table 6.3 paint an interesting picture of the Ghanaian electorate the helps to understand voter turnout. First, the importance of select incentives for voters is small, but relevant: 10 percent of voters believe it is very important for parties to provide personalistic goods in exchange for voting. Second, only 6 percent Ghanaians feel a stronger attachment to their ethnic group than their national identity, suggesting a low level of social divisions as higher levels of ethnic identification ought to correlate with polarization. Neither selective incentives nor strong ethnic attachments approach the observed level of turnout. But the level of social sanctioning does: 67

percent of Ghanaians believe that members of their community should vote even if candidates are undesirable, compared to an observed 70 percent turnout.

Before presenting results on what predicts turnout, we address an important issue with respect to voter registration. Amongst the general voting population, some citizens will register to vote while others will not and important biases may exist in registration. First, citizens who are more likely to vote are by definition more likely to register since one must be registered to vote. Ghana had 12.4 million registered voters out of a total general population of 24 million. Second, parties may strategically target those whom they assess as core supporters to get them to register (and eventually vote). However, these and other biases in registration are irrelevant to our results since the survey was only administered to registered voters and the turnout data is the proportion of total votes cast against total registered voters. Put differently, because both of our data sources (survey and turnout) only include registered voters, whatever registration biases exist in that population cannot account for our results here.[5]

Table 6.4: Logit on LIkelihood of Voting

	Model 1	Model2	Model 3
Patronage	-0.200*	-0.226* * -0.195	
	0.1	0.1	0.1
Ethnicity	0.421*	0.29	0.26
	.19	0.19	
Social Sanctioning	0.196*	0.202*	0.225**
	0.1	0.1	0.1
Partisanship	0.221*	0.293**	0.264**
	0.09	0.1	0.1
Urban		-0.876***	-0.823***
		0.1	0.1
Education			-0.625***
			0.1
N	2033	2033	2033
Pseudo R2	0.0075	0.0383	0.0538

*Significance: *** 1 percent, ** 5 percent, *10 percent*

Table 6.4 presents three logit regression models on the likelihood that a voter

[5] In fact, the costliness of registration fits within the theory. The act of registering is costly. Given these costs, high registration rates like Ghana's are as puzzling as its high turnout.

will turnout, with coefficients, robust standard errors (in parentheses), and significance shown. Again, the dependent variable is a dichotomous measure on the degree of lost turnout between 2004 and 2008; a positive value indicates less drop-off in voting (more mobilization) than negative values (less mobilization). The three independent variables are presented in model 1 (Patronage, Ethnicity, Social Sanctioning), with controls for Partisanship in all models and whether a respondent lived in an urban area in model 2 and education in model 3.

The results from the table give support to some hypotheses and not others. First, our key independent variable on the importance of social sanctions is significant and positive across model specification towards predicting turnout. As voters' beliefs about the importance of their community members voting increases, so does their own likelihood of turning out.

Second, the coefficient for the patronage variable is significant but negative in two of the three models, suggesting that the impact of this variable depends on other factors. Where it is significant, we interpret the coefficient in the following way: as respondents find the delivery of patronage from parties more important, the less likely they are to turnout. While at first glance this seems counter-intuitive, we argue that it occurs because parties actually lack the resources to deliver patronage; voters valuing personalistic and material rewards are more likely to stay home relative to those who do not.

Third, the coefficient for ethnic attachment is positive across models suggesting that ethnic identifiers are more likely to turnout. But this variable is also insignificant so that for the most part, the strength of ethnic attachments does not affect turnout. Last, the partisanship control is positive and highly significant across models, suggesting that strong partisans are more likely to turnout. Controls for urban and education are negative and significant showing that urban and more educated respondents are less likely to turnout.

6.3.6 Discussion

Our results speak to a number of theoretical and empirical concerns that span the voting literature in older democracies and those in Africa. Given that Ghana is similar to most other African countries given its ethnic diversity and recent transition to democracy, we suspect the theoretical and empirical insights gained here should apply across the continent and to other multi-ethnic and emerging democracies.

Theoretically, our model and survey data allow for a test of the Popkin and Popkin et al. proposition that the core calculus of voting involves an individual investment in collective (not just personal) goods. For the collective investment analogy to be true and voting understood to produce positive social benefits, it must also incur negative social costs. We discover this through our exploration of the importance of social sanctioning, whose effect we are able to measure empirically through robust survey data. While our findings still show that individual motivations, including psychic and material rewards, may play a role in mobilization, by and large voting is a social act where individuals monitor and sanction one another.

Specifically, agent based modeling allows us to study voting, and turnout specifically, as a social phenomena. Although individual agents decide to turnout or not according to their personal expected utility, they do so within a population and over time as voting as an iterative process. Population dynamics can, and do, affect the core cooperation problem, and not necessarily in a linear way. Individuals who might be predisposed to stay home (or go to work) on election day may change their behavior as a result of these population dynamics. We often observe phase shifts or tipping points, understanding where these are will help us understand the turnout puzzle. Furthermore, agent-based modeling allows us to look at multiple factors interacting within populations at once—here patronage, ethnicity, and social sanctioning.

Empirically, our findings contribute to debates regarding mobilization and turnout in important ways. First, we contribute to the general understanding of the anomaly of voting, including within settings where democracy is new and turnouts are curiously high compared to older democracies. We suspect this is the case because although social sanctioning plays a vital role in driving turnout in both new and old democracies, voting is more easily monitored given the population dynamics we model in new democracies, including denser social networks.

Our results also help to demonstrate the relative salience of various motivations that may drive voters to the polls in new democracies beyond social sanctioning. For example, while many scholars believe partisanship to be inchoate or simply a proxy for ethnicity in Africa, our results show that partisanship is an important predictor for understanding mobilization separate from ethnic identification or the delivery of patronage. This suggests that parties may be more institutionalized than we might otherwise think, even in a country that has only had four elections. Moreover, in so far as there is an African "D" term, it is not likely driven by ethnic identification. Ethnicity plays a far less important role in understanding why people vote than previously assumed. We join a growing literature that looks at non-ethnic factors to better account for political behavior in Africa.

6.4 Conclusion

This paper investigates why citizens in Africa's emerging democracies vote. Ultimately, the act of voting and the phenomenon of community turnout is a nuanced one. The ABM generates predictions with respect to 1) additional individual pay-offs associated with patronage or vote-buying 2) the duty and strength of affective ties an individual may feel to an ethnic group or political party and 3) the negative pay-offs associated with not voting from community members (social sanctions). The ABM shows that the costs of vote-buying are likely too large for parties to afford, and that duty or affective ties lead to localized turnout but not an overall level that matches observed turnout. Social sanctions are the more likely explanation for observed levels of turnout. Testing these predictions using novel survey data from Ghana we show that patronage may actually reduce turnout as individuals who desire personal goods are less committed to candidates, but that social sanctioning remained significant in predicting committed voters and by extension turnout. Strength of ethnic attachments was not a significant predictor.

6.5 Acknowledgement

James D. Long is a co-author on this work.

Chapter 7

Conclusion

In this dissertation, I focus on how population dynamics and organizational ecology affect organizational decisions. These decisions have dramatic implications for both individual and social welfare. To emphasize both the applicability to current policy, I briefly explore some of the theoretical implications for intervention planning. I then discuss the broader contributions of the dissertation.

7.1 Intervention

By neglecting to account for population dynamics and organizational alternatives, recent intervention design has lead to sub-optimal outcomes. I argue that this failure can lead to protracted and more difficult (and costly)interventions.

As discussed in Chapter 4, hierarchic organizations have many operational advantages. The broad aim of war-fighting is to target these hierarchies. Intervention strategies centered around the destruction of rebel hierarchies without taking alternative organizational forms into account can be myopic and costly. Intervention strategy results in changing hierarchies into networks, which may be harder to fight.

We know rebels adopt a variety of organizational forms that impact duration of conflict, intensity, success, and vulnerability to intervention. Intervention can change their organizational form. Because rebel organizations will respond to the changing environment, intervention strategy should take all organizational forms into account.

From the intervener's standpoint, networks are the least preferred organizational type to face. Rebels organized as markets may produce violence, but this violence is likely to be uncoordinated and unsustained. Hierarchies can produce large, coordinated attacks, but can also be identified and decapitated. Networks are able to both coordinate attacks but are also more difficult to destroy. Intervention strategies that target rebel hierarchies may have unanticipated side-effect of producing networked rebellions.

I simulate effects of population dynamics and changes in the operational environment on organizational ecology of rebels. I show that intervention strategy should be designed taking all organizational alternatives into account. These concepts can be leveraged to understand effects of policy on choices across three organizations, effect on conflict outcomes.

There are three core effects of any intervention that result in shifts in the organizational incentives for rebels. These have analogues in the model, the effects of each are reported in Figure 7.1.

- Boots on the ground (even a fairly light footprint) make organizations that promote cooperation more necessary to conduct attacks. This effect can be modeled as increasing the benefits to mutual cooperation. In isolation, increases in the benefits to mutual cooperation make the hierarchy the strongly preferred organization for rebels.

- Intervention also increases the cost and risk of being identified and caught as a member of a rebel hierarchy. This effect can be modeled as increasing the costs of organizing as a hierarchy relative to the network. Making the hierarchy more expensive, simultaneously makes the network (and the market) more attractive alternatives.

- Intelligence gathering in the course of the intervention provides rewards and inducements (but public and private goods) for information about the rebels, or for alignment with the counter-insurgents. This effectively increases the payoffs for defection. Tracing strategy types in the hierarchy, we see that as the incentives to defect become large, all actors save the most committed (ALLCs) will leave the hierarchy for the market or the network.

Because it is difficult to parse these effects on the ground and they predict movement in different directions, it is important to think about the net effects when all three effects occur simultaneously. Those effects are reported in Figure 7.2. The net effect of invasion is a rapid shift in rebel organization from hierarchy to network.

Current intervention strategy focuses on an initially light footprint. As we know from the 2003 invasion of Iraq, it was relatively easy to destroy the existing hierarchy, but the critical question is where these actors go. Thinking about intervention and rebel organization in an ecological framework helps to understand the potentially counterproductive secondary effects of intervention. The result theoretically, and in the case of Iraq, was a networked rebellion. From the coalition's point of view, this is a suboptimal outcome; networked rebellions are inconsistent with goals of either negotiation or decapitation.

The model highlights the difficulty faced by intervention, but it also helps to highlight an alternative component to the design. Slowing the movement from the hierarchy to the network may not immediately decrease violence, but it would allow critical time for state-building to take place. The model's insight into how to do this is to think about making the alternative organization, in this case the network, a less attractive alternative. If the costs of rebels organizing as a network are increased, actors will remain in the hierarchy longer. Figure 7.3 shows the results of the same multi-dimensional simulation, but with the costs of joining the network increased. The delay in the phase shift between hierarchy and network increases the time that the intervention has to create an alternative hierarchy (a state) that will be a more attractive alternative than joining a network. This organizational path allows the intervention to avoid facing a rebel network. If an alternative hierarchy is not in place before that phase-shift happens, it will be more costly to create that alternative.

Understanding organizations as alternatives to one another provides new analytical purchase on rebellion, primary and secondary effects of intervention, and post-intervention organization. This sketch of an application demonstrates the value of thinking through the effects of population dynamics and particularly organizational alternatives when designing policy. In the remainder of this chapter I discuss the contributions of the dissertation as a whole and some limitations.

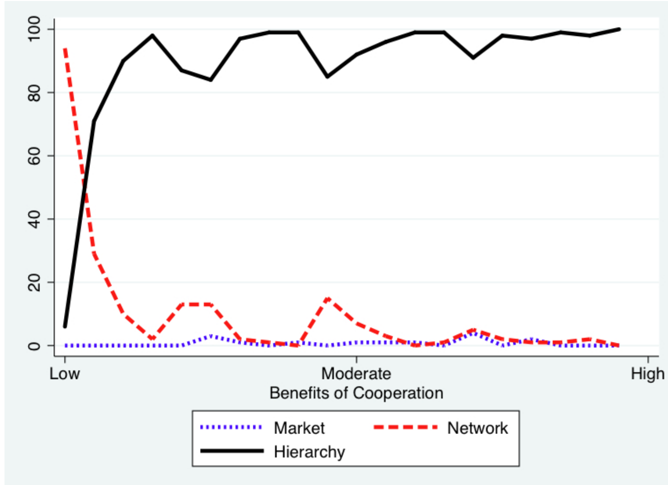
7.2 Contributions of the Dissertation

This dissertation makes several broad contributions to knowledge about cooperation and social organizations. The first is to the study of organizational ecology. The literature typically treats these organizations separately, comparing networks and hierarchies to markets (or anarchy), but not to each other. The literature on transnational policy networks, for instance, does not consider hierarchy as an alternative. Similarly, the literatures on international organizations do not examine when states choose that form relative to networks. Each literature tests its solution to the problem of cooperation relative to anarchy or the "market," but seldom are organizational alternatives considered as substitutes for one another. While these organizations can coexist, organizational choice is a zero-sum game at the margin: if an actor choose one, he or she is not choosing another organization for that interaction. As more agents use networks, fewer are available to create a large block of enforced cooperation within a hierarchy, or to interact in the unconstrained market. Organizations do not survive and prosper in isolation as early work has implied. I argue that they survive or not based on their ability to attract members, at the expense of the organizational alternatives, within a given population. The intervention example described above highlights the payoffs of this approach. The agent-based model (ABM) that forms the core of my dissertation is designed to study actors' choice of alternative organizations under a range of environmental and organizational characteristics. In short, I treat organizations within an ecological approach.

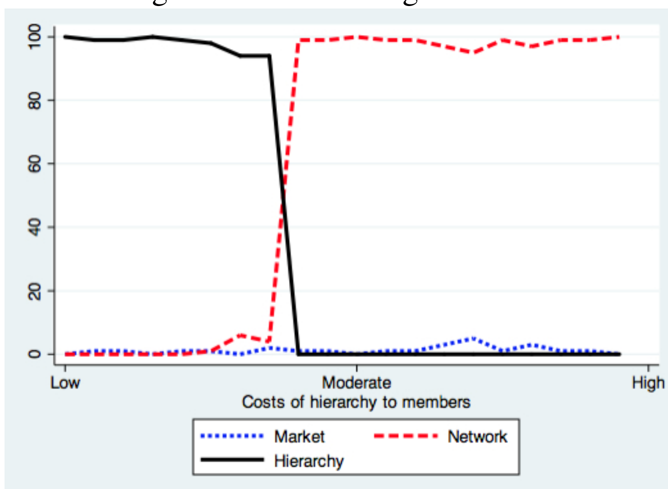
I also contribute to the theory of organizations by focusing on dynamics within the populations of actors forming these organizations. The survival of organizations varies largely based on the size and composition of the population. I find that small populations, where actors have a higher likelihood of returning valuable information from a "friend," favor networks over markets and hierarchies. As these populations grow and become more anonymous, agents will turn to the market, and increasingly the hierarchy to enhance their prospects for cooperation. Likewise, nasty or uncooperative populations favor hierarchies over markets and networks, where agents rely more heavily on "third party" enforcement to produce cooperation. Nicer populations are able to achieve high levels of cooperation in the anarchic market, or though networks that pass information about actors' past behavior. Specific actors within the population are also 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). Together these individual attributes interact with the population to determine the behavior and organizational choice of any actor within a population. I find nice actors in nasty populations join the hierarchy in greater numbers, and do so earlier than their nasty counterparts. These actors are likely the most vulnerable in the population, and do so to avoid exploitation. The same actor in a more cooperative population would likely opt to join the network or the market. Conversely, nasty actors will remain in the market to exploit nice actors, and will join the hierarchy only when it is the dominant form of organization. Likewise, pessimistic actors, who believe the population is nastier than it really is, join hierarchies, while their optimistic counterparts join markets or networks.

I also contribute to the development of agent-based models of organizations and cooperation in politics. The focus on markets, networks and hierarchies as viable alternatives to one another is unique and allows for broad application to many political problems, including those outside of international relations. The ABM is able to track the efficacy of organizations in contrast to one another, as well as the interaction with distributions of strategy types within a population, and individual choice and welfare. Many of the problems of cooperation involve populations of actors, and are not easily reducible to two unitary actors. The ABM, built from solid micro-foundations and simple rules of interaction, allows tremendous insight into the complex behavioral patterns that form the basis of social organization.

Increasing benefits to cooperation.



Increased risk/cost to being identified and caught as a member of rebel hierarchy .



Rewards and inducements (public and private goods) for information about insurgency or for alignment with counter insurgents

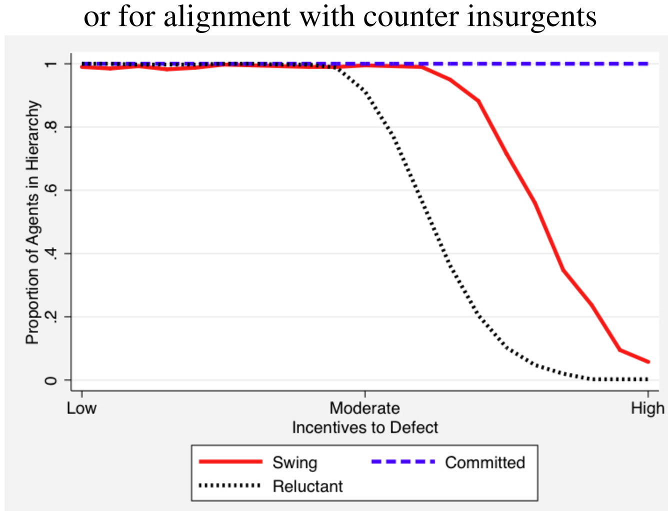


Figure 7.1: Effects of Intervention.

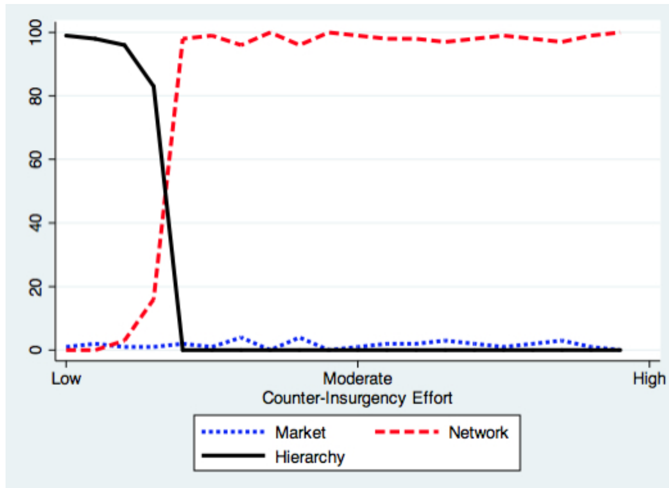


Figure 7.2: Multidimensional Simulation of effects of intervention: rapid shift from hierarchy to network.

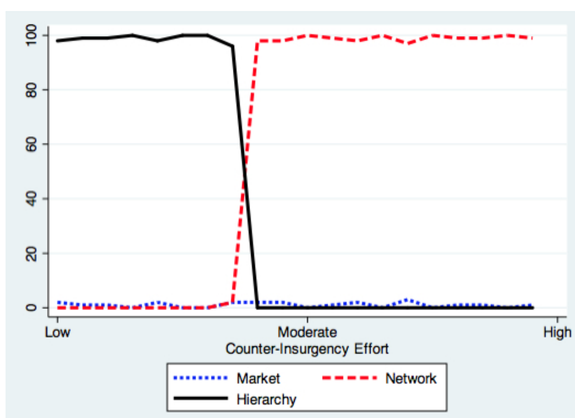


Figure 7.3: Multidimensional Simulation of effects of intervention with increasing network costs: shift from hierarchy to network is protracted.

Chapter 8

Technical Appendix

This appendix is intended to give the reader a better knowledge of the structure and parameters of the Agent Based Model (ABM or the model) used in this dissertation. The appendix includes the expected utility calculations used by the agents, the default settings and a discussion of each parameter, as well as a more in-depth discussion of the working of the model.

Following the model discussion, a set of parameter sweeps are included. We sweep each of the substantive parameters across a nice population, a nasty population, and a moderate population. These sweeps support the findings detailed in the dissertation and Jung and Lake (2011), as well as provide the reader with additional intuition as to the output of the model and other emergent properties not discussed in detail in the main dissertation.

8.1 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 Table 1, 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), $k_{ij} = w(|p_i - \rho|/2)$, where ρ is the agent's belief (continuously updated) about the mean ideal point of the population. For the hierarchy,

$k_{ih} = w|p_i p_h|$.

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:

8.1.1 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).

$$M = (\gamma\beta R - k_{ij}) + \gamma S(1-\beta) + \beta T(1-\gamma) + P(1-\gamma)(1-\beta) \tag{8.1}$$

8.1.2 Expected Utility in the Network

Expected Utility in Network for Fixed Strategy Players

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

(8.2)

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

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.

$$\eta Z + (1-\eta)(\sigma[\frac{m}{n-1}(\sum_{\gamma=1}^{n} \beta\alpha^{\gamma})(\beta R - k_{ij}) + P(1-\beta)] + M(1-\sigma)) - \phi \qquad (8.3)$$

8.1.3 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).

$$\theta\{(q^2 R - k_{ih}) + qS(1-q) + [qT(1-q) - v] + [P(1-q)^2 - v]\} - (1-\theta) \qquad (8.4)$$

8.2 Model Description

This section describes the ABM in detail. As explained in the paper, there are three major stages in play: initialization, learning, and organizational choice. Note, figure 8.1 shows a full version of the model. All features are not necessarily activated in the dissertation. For example, the model includes but does not activate multiple hierarchies, selective affinity in the hierarchy, and evolution.

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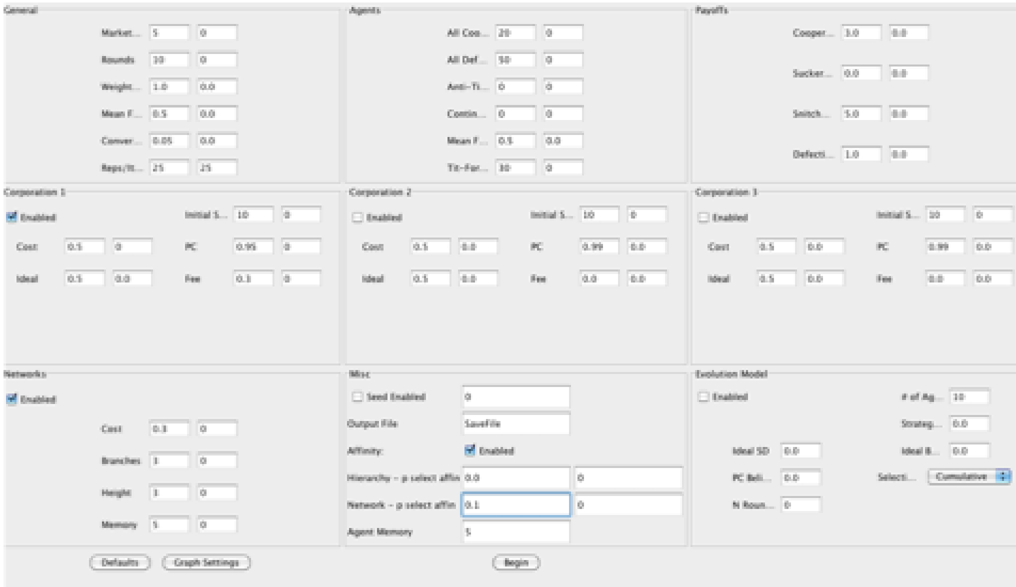


Figure 8.1: Screenshot of Initialization GUI.

8.2.1 Initialization

The model begins with the specification of 24 user-defined parameters. These parameters and their default values, used in all the simulations presented below unless otherwise specified, are listed in Table 8.2. The default values for the parameters are admittedly arbitrary, but are calibrated here to make all organizational forms somewhat likely in any given simulation. By setting certain parameters higher or lower than the defaults, it would be trivial to simulate worlds in which either markets, hierarchies or networks always predominate or never arise.

Table 8.1: Default Parameters

Parameter	***Symbol***	***Description***	***Default Value***
General			
Increments		Times the simulation is run incrementing a parameter	25
Repetitions		Times the identical simulation is repeated with different random seeds	25
Rounds		Number of rounds of play	20

Table 8.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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	5 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	5
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	0.95
Tax	τ	Tax assessed on members of the hierarchy	0.3

Table 8.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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
Selective Affinity			
Network Affinity	η	Probability of network players being able to pick their partner	0.1
Affinity Memory	m_a	How far back affinity players can look into their memory	5
Hierarchy Affinity	ι	Probability of hierarchy players being guaranteed a pairing with another member of its hierarchy	0
Evolution			
Selection Rate			
Selection mechanism		Number of Rounds or cumulative net payoffs	

General Parameters

The user sets six general simulation parameters

Figure 8.2: General Parameter Input Screen.

The number of learning rounds is the number of rounds in the learning phase of the simulation. These actions are not recorded for output. Agents play only according to their strategy type. In essence, networks and hierarchies are turned "off" during these rounds. The rounds can be thought of as a standard PD without organizations. Learning rounds is set to 5 rounds by default. Agents will be matched randomly and play the PD 5 times in order to accumulate beliefs, as described in more detail below.

The number of rounds is the number of rounds of play in the simulation. Rounds must be set to at least 1, and the default value is set to 20. Agents will go through the process of selecting an organization, being matched, playing, and determining their payoffs from play 20 times in sequence with that setting. Also note that the first round is labeled 0, so graphing round 20 requires graphing the round labeled 19.

The weight on ideal parameter allows the user to place a weight on policy preference (w) below. This weight is used by agents to calculate their expected utility in the equations above. The default weight is set to 1.0. For example, if an agent with an ideal point of 0.6 cooperates in the market with an agent B whose ideal point is 0.5, and the weight is 1.0, the assessed ideological penalty is 0.05 (or half of the spatial distance between the two actors). If those same two actors cooperate in a world where the weight on the ideal point is 2.0, they are assessed an ideological penalty of 0.1.

The Mean for Ideal Point variable varies from (0,1). The default setting for this parameter is 0.5. Moving that closer to the minimum or maximum values allows us to determine how “moderate” or “extreme” the policy preferences of agents are. Agents’ ideal points are picked from a normal distribution centered at that mean. Ideal points for individual agents also must be found within this range. If an ideal point is picked that is either above 1 or below 0, the maximum or minimum value is recorded. For example, if a population’s ideal point is centered at 0.75, and an individual agent’s ideal point is “picked” to be above the mean by more than 0.25, it will be automatically adjusted to have an ideal point of 1.0. This adjustment is most likely to happen when the mean for Ideal Point is set to a value that is relatively extreme.

The number of increments (Field Iter to the right of Reps) sets the number of times the simulation is re-run, adding the specified quantity to the relevant parameter. Increments allow us to run comparative statics on a statistically identical population. For example, in order study the effects of the cost of a network, we might set the initial network cost variable to 0.0. It will be incremented 20 times, by a value of 0.05. In the first iteration, the value of network cost is 0.0. In the second iteration, the simulation is run with a value of network cost at 0.05. This continues until the variable has been incremented the designated number of times. Also note, while the increment variable is strictly positive (the minimum setting is 1), variables can be incremented by negative amounts (you can subtract value from a variable such as network cost at each iteration).

The number of repetitions is the number of times the same simulation is run again with a different random number. The default value here is 25 repetitions. The simulations are repeated multiple times in order to create confidence that the trends observed are not the result of one particularly idiosyncratic set of population dynamics but, rather, are repeated trends. If “Repetitions” is set to 1, the simulation is only run one time. If it is set to a value greater than 1, the entire simulation will run as many times as specified. Repetitions must be set to at least 1.

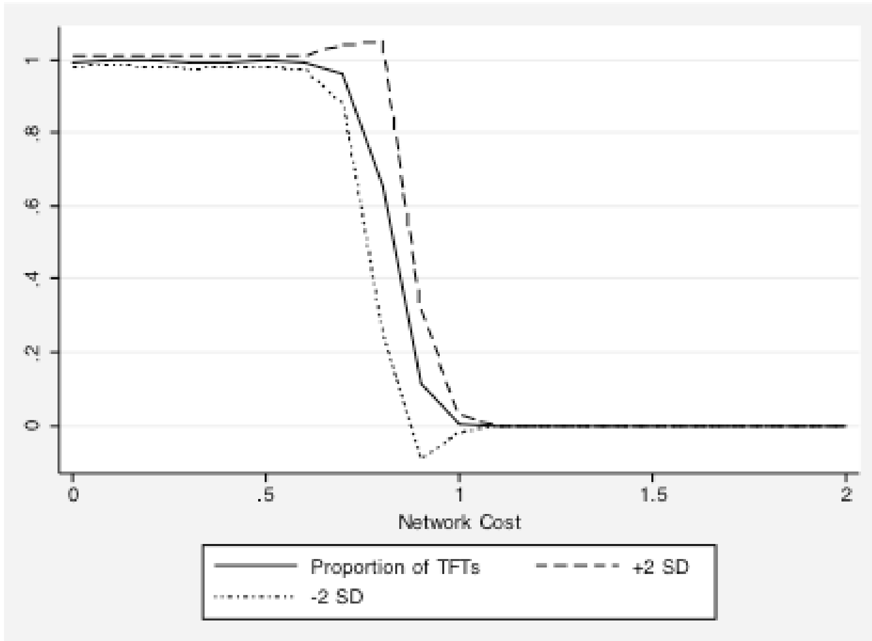


Figure 8.3: Shows network membership amongst TFT agents as Network cost increases. This figure matches figure 4a from Jung and Lake (2011). 95 percent confidence intervals are drawn around the results.

Repeating any simulation 25 times produces very reliable trends in our results. For illustration, network membership is tracked as network cost is incremented up with 95 percent confidence intervals drawn around the results in Figure 8.3. The tight fit of this confidence interval around the mean (graphed) suggests that additional repetitions would be unlikely to alter the central tendency. Since the confidence intervals make the graphs even harder to read, especially in black and white, we do not include confidence intervals for other results reported in the paper or in the parameter scans below, but the intervals in those results are similar to those in Figure 8.3.

Agent Parameters

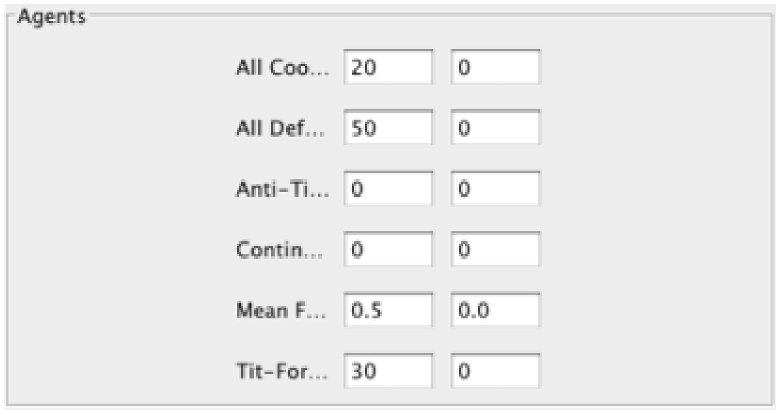


Figure 8.4: Agent specification

The user defines the population of actors, specifically the distribution of strategy types, and their preferences. Like other game-theoretic ABMs, agents are defined by their strategy types. The default total number of agents is 100. This is done for analytical ease. Some other default settings are premised on a default population of 100. For example, we expect the initial or "advertized" size of the hierarchy to be sensitive to the size of the population. The proportion of agents in the hierarchy will affect the expected utility calculations. Set at a default value of 10, the initial advertised size of the hierarchy creates a 10 percent likelihood of encountering another hierarchy member in a population of 100 agents. In a population of 25 agents, this would be 40percent, in a population of 1000, this would be 1percent. These proportions will affect organizational choice significantly.

ALLC is the number of agents who are hardwired to cooperate with certainty in the market or network. No matter whom this agent is paired with, it will always cooperate. The only circumstance in which we ever observe an ALLC agent defecting is in the hierarchy when it is randomly chosen to defect at (1-q), where q is the cooperation rate in the hierarchy.

ALLD is the number of agents who are hardwired to defect with certainty in the market or network. No matter whom this agent is paired with, it will always defect. The only circumstance in which we ever observe an ALLD agent cooperating is in the hierarchy, when it is induced to cooperate at a rate of q, where q is the cooperation rate in the hierarchy. Tit-for-Tat (TFT) is the number of agents who will pursue a tit for tat strategy. A TFT agent by default will cooperate on the first round of play with an unknown agent. If it has played an agent before, it will do what its opponent did in the last round: if its opponent defected in the prior round, it will defect in the current round; if its opponent cooperated in the prior round, it will cooperate in the current round. We expect to observe TFT cooperation and defection in all three organizations. When in the hierarchy, TFTs like ALLCs and ALLDs will cooperate at a rate of q and defect at a rate of 1-*q*. For simplicity, in all the simulations reported in the paper we include only varying combinations of ALLC, TFT, and ALLD strategy types. We find that altering the composition of the population merely within these three very simple strategies yields considerable variation in the organizational ecology. However, we have built in two other strategies. In light of the other two strategies that can be specified in the GUI—MIX (or continuous) and Anti-Tit-for-Tat (ATFT)— we describe them here for completeness as well as to pre-empt questions about their categories in the GUI.

For completeness, MIX agents cooperate probabilistically at a specified rate. That rate is determined in the manner that ideal points are drawn. The user specifies the mean of a normal distribution; cooperation rates for MIX agents are picked from that distribution. The process by which MIX agents behave is slightly different, but follows a similar process. For example a MIX agent with a probability of cooperation 0.6 will cooperate on average 6 times out of every 10 rounds. Observed cooperation may differ from this mean, but on average will converge to that mean. A number from 0,1 is picked, if it is above the rate of cooperation the agent will defect for that interaction. If the number drawn is less than or equal to the agent's cooperation rate, the agent will cooperate for that interaction. For example given an agent's cooperation rate is "set" at 0.6, if the number generated is 0.0023 then the agent will cooperate. If the number generated is 0.8324 then the agent will defect. The likelihood of 0.6000 being drawn exactly is very small, but in that event the agent will cooperate. When in the hierarchy, MIX like all other strategy types will cooperate at a rate of q and defect at a rate of 1-q.

Anti-tit-for-tat (ATFT) agents start off by defecting on the first round with an unknown player. If an ATFT agent has played its opponent before, it will do the opposite of what its opponent did in the prior interaction: if the opponent defected in their prior interaction, the ATFT agent will cooperate. We expect to observe ATFT cooperation and defection in all three organizations. When in the hierarchy, ATFTs like all other strategy types will cooperate at a rate of q and defect at a rate of 1-q.

Payoffs

Payoffs for the various outcomes are set: T, R, P, and S. We set the default cardinal payoffs in the PD game as in Axelrod (1984) for purposes of comparability. All other default parameters were then set relative to these default payoffs. The payoffs in the model can be manipulated to create any 2x2 game by changing the ordering of the payoffs.

R is the payoff a player gets for a mutually cooperative (CC) outcome. R is set by default to 3.

S is the payoff a player gets for the "sucker" outcome (CD). S is set by default to 0.

T is the temptation payoff; the payoff a player gets for suckering another (DC). T is set by default to 5.

P is the payoff for mutual defection (DD). P is set by default to 1.

The preference ordering T>R>P>S is consistent with the traditional conception of the Prisoner's Dilemma.

Figure 8.5: Payoff Speficification

Organizational Parameters

The organizational parameters are also set at the initialization stage. Networks are defined by their width (α) (labeled Branches in the GUI), the number of other agents each agent can directly ask about the agent it has been randomly paired with, and their depth (*l*) (labeled Height in the GUI), the number of levels of agents that are polled. A 3x3 (α = 3, l = 3) network is illustrated in Figure 8.7. Although each agent has a potentially infinite memory of its own interactions with each other agent in the population, the network is limited to a fixed memory (m_n) defined by the number of previous rounds over which it can poll. That is, if memory is set at five, any agent can poll only those agents with whom it has cooperated in the last five rounds whether they have interacted with the other agent with whom it has been randomly paired in the current round. The longer the memory (the larger is m_n) for the network, the more useful information it returns to the agent.

The width (α), the number of other agents each agent can directly ask about the agent it has been randomly paired with is set by default to 3. This means agent (*i*), the surveying agent, will go into its memory and ask the three most recent partners with whom (*i*) has had a cooperative interaction if they have any information about the behavior or ideal point of agent (*j*). If this number is set to 5, agents will go back into their memory and ask up to five partners.

The number of levels (*l*) along which polling takes place indicates the depth of the network. The parameter (*l*) is set by default to 3. This means that those three actors whom agent (*i*) surveyed will survey their most recent three cooperative partners, and those agents will survey their three most recent cooperative partners about that same agent (*j*). See Figure 8.7below for a visual representation of this default network.

Agents have a fixed memory for the purpose of the network. By default agents remember their past five partners, and will poll only those with whom they have cooperated (CC) within the last five rounds. In allowing an agent's own memory of past play and the network's "memory" to differ, we are essentially assuming that an individual's memory of others lasts longer than that individual's social interactions. This seems reasonable. Those of us who hold grudges and have only fleeting friendships typically remember others who have treated us badly in the past longer than we engage in sets of social relationships. This assumption is consequential only for the declining utility of networks discussed in the paper. If agent memory were limited to the same as the network memory, networks would remain more robust over more rounds of the game. Conversely, without this restriction on network memory, the network would return "too much" information in early rounds and become obsolete almost immediately. If an individual receives no information from the network, it plays its default strategy.

The cost for any agent i who wishes to use the network is set. This parameter ϕ is set by default to 0.3.

Figure 8.6: Network Specification

Selective Affinity

In order to account for the propensity for actors to play and want to play with others with whom they have interacted in the past, we have included an extension to the main model that allows for selective affinity. This extension can be switched on or off. If it is switched off, the model functions as described above. The basic intuition of the way we model affinity is that in the network a player gets to pick the player with whom it has had the best payoff in recent memory. Networks can have an informational role, as well as an affinity role. To initiate selective affinity, the user sets core parameters. The user specifies the affinity rate in the network (default is 0.1, or 10 percent of interactions for network agents) as well as the agent's affinity memory (5). If Selective Affinity is enabled, but the affinity rates are set to 0.0 the model functions essentially as in the non-affinity world. The restriction on memory causes minor differences in the model, but does not affect the results in a meaningful way. Note that selective affinity for the hierarchy is never enabled in any of the simulations reported in the paper or the

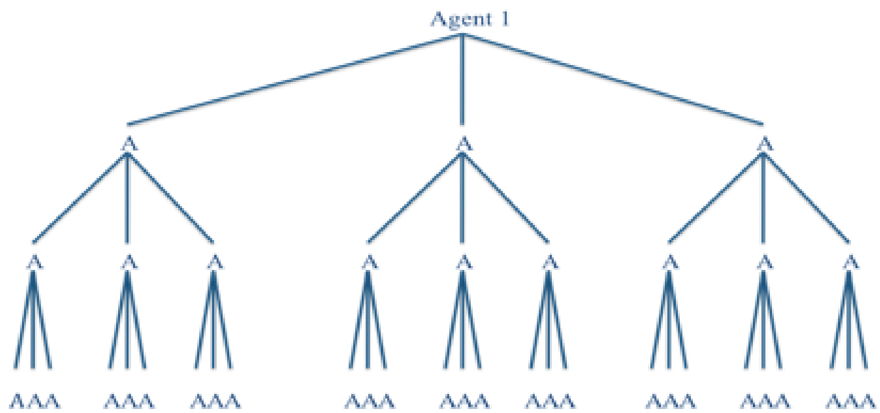


Figure 8.7: A network of width (α) 3 and depth (l) 3. Agent 1 polls up to three other agents with whom it has cooperated in the last mn number of rounds, who poll up to three other agents with whom they have cooperated in the last m_n number of rounds, who poll up to three other agents with whom they have cooperated in the last m_n number of rounds whether they have ever played the agent with whom Agent 1 is randomly paired. In a 3x3 network, Agent 1 will receive a maximum of 39 responses (depending on the number of agents each agent has cooperated with in the past m rounds). The larger the width or depth of a network, the more responses Agent 1 will receive. In addition, as each agent can only poll those agents with whom it has cooperated in the last m rounds, the more cooperative the population the greater the number of responses Agent 1 will receive, on average.

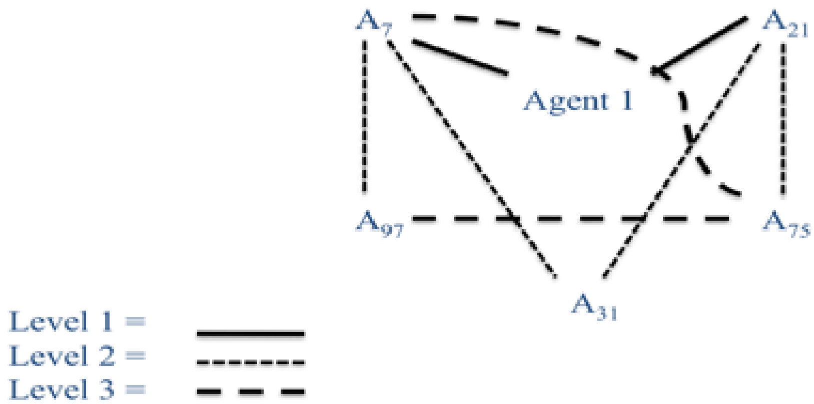


Figure 8.8: A hypothetical network with limited memory and redundant pathways. Agents polled need not be unique as in Figure 1a, and in a finite population most likely will not be (as an agent at level 1 may well be an agent at level 2 or 3 in another branch of the tree). In a population with limited numbers of cooperators and a short memory, it is unlikely that agents will cooperate with more than a small number of other agents. In this case, the number of unique responses is likely to be quite small. A hypothetical network illustrates this point. Levels correspond to those in panel 1a. In this example, Agent 1 would receive a total of eight responses but only 5 unique responses).

parameter scans below.

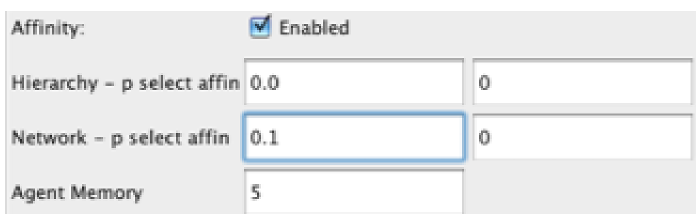


Figure 8.9: Selective Affinity Paremters

Hierarchy Paramters

A hierarchy is defined by its assigned ideal point (p_h), the probability that any agent will cooperate with other agents in the hierarchy (q), the penalty that is imposed on agents for defecting on other agents in the hierarchy (v), and the tax assessed on members (τ). These parameters are common knowledge to all agents. Since the expected utility for joining the hierarchy is contingent on the number of other agents in the hierarchy (θ), in the first round of organizational play the user sets an "advertised" number of agents in the hierarchy, which need not be the same as the actual number of agents who join. In subsequent rounds, agents know the actual number of agents who joined the hierarchy in the previous round.

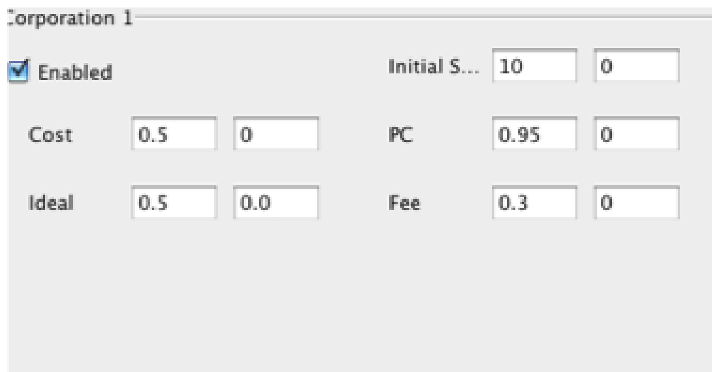


Figure 8.10: Sample hierarchy (corporation) characteristics input panel.

The size of each hierarchy (θ) is initially is set to 10. After the first round, the value of ? is set to the actual number of agents who joined that hierarchy in the previous round. The larger the initial size relative to the population size, the more attractive the hierarchy becomes. Hierarchy essentially creates enforced probabilistic cooperation. This cooperation becomes more likely and therefore more valuable as the proportion of the population in the hierarchy grows larger. Additionally, if ? is initially set to 0, or if, during the play of the game, the actual membership of a hierarchy goes to 0, no players will join in the first round or in subsequent rounds. At this point that hierarchy is effectively "dead." Although no agent will ever see it as advantageous to join an organization that has no members to enforce cooperation internally, even with a tax of 0, agents will always continue to calculate the expected utility for joining.

The ideal point of the hierarchy (ph) is set by the user. The default value of this is 0.5. This variable ranges from (0,1). The placement of the hierarchy's ideal point is very important. This is the value at which all "induced cooperation" takes place— no longer the mid-point between paired actors. It should be noted that this point is not assigned in the manner that players' ideal points are assigned, pulled from a distribution; the ideal point for the hierarchy is assigned for this particular hierarchy at that specific point.

The penalty for defection (cost in the GUI) within the hierarchy (v) is set to a default value of 0.5. This is the penalty for (probabilistically) defecting on another member within the same hierarchy. Essentially if an agent "suckers" another member of their hierarchy, the specified penalty is assessed by the hierarch. Though very unlikely, this payoff is also assessed in situations where both players defect. Most of values of internal hierarchic cooperation that we look at are well above 0.9, meaning even at this very low threshold, the likelihood of a mutual defection occurring within a hierarchy is 0.01Ñwithin hierarchic interactions, which are a subset of total interactions. As the rate of cooperation increases to the default 0.99, this probability of mutual defection shrinks to 0.0001.

The probability of cooperation (q) within the hierarchy is set to 0.95. If two agents are paired within the hierarchy, they will cooperate with this probability. A high default cooperation rate makes the choice of a hierarchy a near if not absolute certainty. The tax (fee in the GUI) assessed to members who join the hierarchy is analogous to the fee for information in the network. The tax variable ? is set by default to 0.3

8.2.2 Learning

Agents begin the simulation without any knowledge of the distribution of the other agents' strategies or the mean ideal point of agents in the population. In the learning phase, agents are randomly paired with other agents with whom they then play a round of the game according to their fixed strategy type with payoffs as specified. Each agent is an Agent i and matched with an Agent j randomly. Some agents may be picked multiple times as an Agent j within the same round of play. Agents record and remember their interactions as both Agent i and Agent j.

During this period there is no organizational choice. Networks and hierarchies are turned off—there is no enforced cooperation, selective affinity, or purchase of information. Over the course of these rounds, each agent develops beliefs about two parameters from their interactions with other agents: about the distribution of strategy types and ideal points in the population. Agents play their strategies: ALLC agents are matched and always cooperate, ALLD agents are matched and always defect; TFT agents will cooperate against an Agent j with whom they have never played, if a TFT agent has played an Agent j before it will do the same thing the Agent j did in the last round.

Agents learn about the distribution of other strategy types. Observing their own payoffs, they then back out whether the other agent cooperated or defected, store this action in memory by agent, and update a running estimate of the proportion of cooperators and defectors in the population (?i). From this, agents learn whether the environment is relatively nice or nasty. If in the (default) five learning rounds an agent experiences two defections and three cooperative interactions, its belief about the cooperation rate in the population is set to 0.6. If there were two cooperative interactions in those five, its belief is 0.4. Essentially agents keep a running average of cooperative over total interactions. Importantly, agents observe only the other's actions, limited to cooperation or defection, and not their underlying types. Thus, each agent assigns and then subsequently updates each agent it plays a single running probability of cooperation. An agent playing an ALLD agent twice would have a running probability of cooperation for that agent set to 0 since it had observed no cooperative outcomes in the number of interactions.

Second, when they cooperate with other agents, agents also learn about the distribution of preferences in the population and whether their own preferences are relatively extreme or moderate. Again, knowing only their own preference, agents who cooperate with one another examine their payoffs and back out the ideal point of the other agent, store this knowledge in memory, and then update their beliefs about the mean ideal point in the population (?). In a system analogous to the one above, agents track the ideological penalty to create a running tally of the ideal points known (which it backs out given the ideological penalty) over the number of mutual cooperative interactions (the only instances where ideal points are revealed).

In this phase of the simulation, agents are restricted to the knowledge they accumulate about other agents through direct play. Interactions in this phase are equivalent to what we later call market interactions. Intuitively it is best to think of these interactions as just a simple iterated PD—or other iterated two-player game. As mentioned above, many different types of iterated games can be represented in this format. The payoffs here are always ordered to meet the conditions for a prisoner's dilemma, but it can also capture pure coordination games, or games like battle of the sexes or stag hunt.

For simplicity, the number of rounds for the learning period is arbitrarily fixed at five. Each agent develops unique beliefs over the course of play, meaning that even agents with the same strategy type and similar or identical ideal points will make different organizational choices in the next stage. Agents who believe the population is nastier than it really is are *pessimists* and agents who believe the population is nicer than in actuality are *optimists*.

8.2.3 Organizational Choice and Play

Once the learning period is concluded, the main simulation of interest begins and continues for a fixed number of rounds. In this phase, 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.

Agents calculate their expected utility for all organizations (as defined above). They enter into the organization with the highest expected utility. After agents choose the organization they will join for that round, the next stage is actual play within each organization. As in the learning phase, agents are randomly paired with another agent for that round (except for selective affinity).

If a player selects the market it plays its fixed strategy. It gets the payoffs associated with that outcome (set above) and, if it's a mutually cooperative outcome, the payoff is adjusted for an ideological penalty. For example, if two ALLC players cooperateÑa likely situationÑtheir payoff, by default 3 each, will be adjusted by the distance between their ideal points multiplied by the weight. For example, if their ideal points were 0.4 and 0.6 and the weight on the ideal point is 1, each player would receive a net payoff for that interaction of 2.9, or 3.0 less 0.1.

If a TFT agent selects the network, it will query 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 ş 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 j, 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 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 0.75Ñweighting its own experience equally with those received from the network. In this way, we assume that all agents are sincere in their reporting and are known to be so by all other agents. Agents receive the payoff associated with the outcome, adjusted for weighted ideological penalties where applicable and the network cost.

Agents of all types including fixed strategy types who choose the network are selected into the affinity world at the specified "rate." For example, if an agent selects the network, and the probability of being chosen into the affinity world is 0.1, it has a 10 percent chance of being able to choose its partner. If an agent is selected into the affinity world and has no memory (only likely in the first round), it will play in the "regular" world, and be matched accordingly (i.e., randomly from the population). Agents with a longer history of play will be advantaged (specifically where the number of rounds is greater than or equal to the memory in the affinity world), as they are then more likely to find a nice agent within their memory. There may be situations early on where TFT agents have an unlucky draw and have been paired with only ALLD agents. In this case, their "best" partners are nasty ones, but they must select and play one accordingly. As the simulation progresses this should even out. Agents calculate their expected utilities for each organizational form, as above, but using the new equations to take the possibility and probability of affinity into account. Agents selected into the networked affinity scan their memory (within the set limit) to review their past interactions. They choose the agent with whom they have interacted and received the highest net payoff (less ideological penalties and fees if appropriate). These may be agents from the network, hierarchy, or the market. This agent may also be one that they have exploited (DC) in the past.

If agents with fixed strategies choose the network and are not selected into the affinity world, they are matched and will play as in the market, however they still pay the network fee. If a TFT agent chooses the network but is not selected into the affinity world, they will poll and will use the networks informational capacity to make their decision. Agents in the non-affinity world choose their partners at random, as in the "regular" model. After agents play, payoffs are assigned, and adjusted for organizational fees and ideological penalties. If the agent chooses to join the hierarchy, its play depends on whether or not it is matched with another player 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 it were interacting in the market. For example, if two agents (ideal points 0.3 and 0.6) within the hierarchy are matched, first they determine if they will cooperate at the assigned rate (by default 0.95), assuming both fall below the randomly generated cutoff, both will cooperate. They receive a default payoff of 3.0. Assuming the hierarchy's ideal point is 0.5 (default) and the tax is 0.3 (default), the first agent will receive a net payoff of 2.5 (3.0 - 0.2 - 0.3). The second agent will receive a payoff of 2.6. If in a new scenario, the second agent probabilistically drew a randomly generated number above 0.95, the first agent would receive a sucker (CD) payoff, less the tax; the second agent would receive the DC or temptation payoff, less the penalty (0.5 by default) and the tax.

Following play, real payoffs are calculated as a function of the outcome of play, adjusted for the players' ideal points (k) 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. Agents also update their beliefs. All results are recorded and, if appropriate, play continues for another round.

8.2.4 Evolution

The model discussed above includes a static population within each iteration and repetition. In order to study updates and shifting population dynamics, the model contains the option to account for populations that shift over the course of the model. The core of the model and its architecture remain the same: agents' expected utility calculations as well as the organizational options available to them are identical. This extension several parameters are varied to determine the shift in population.

The intuition behind the evolving model is to mimic a shifting population in which strong actors either reproduce actors that "look and act" like them or ones who mimic the better performing actors. Conversely, the weaker actors are eliminated and replaced by ones resembling "better" actors for a given population.

In addition to the parameters set above in Table 8.2, the parameters in Table 8.2 below must be specified. First, the number of agents eliminated and replaced in each round (symbol). It's important to note that the population size does not change in these simulations—every agent eliminated is replaced. The default proportion eliminated is approximately 10 percent of the population in each round.

Agents' probability of being selected as a "parent" agent is determined by the agent's share of payoffs in the selection period (i.e., over the entire simulation if ranked cumulatively, or over the past n rounds if so specified). This selection mechanism is constructed such that the probability of selection will reflect the distribution of payoffs in the population, in populations with rough equality between the highest and lowest performers, the probability of selection will reflect that, in populations with highly unequal payoffs, the probability of selection will reflect that. Agents are sampled proportional to their payoffs. Theoretically it is possible that one agent may be selected as a parent agent multiple times.

Once the parents are selected, those agents are removed from the population. The inverse probability is calculated for the remaining agents. Those agents are sampled in the same way, but not with replacement.

Parents pass mutated versions of four characteristics to their children. The first two are the agent's own characteristics: their strategy type and ideal point. For computational ease, pure strategy types are transformed into MIX types: ALLD types become MIX agents with a probability of cooperation 0; ALLC agents become MIX agents with a probability of cooperation 1. Strategy type is passed on within a specified "error band" (symbol). For example, given a 10 percent standard deviation a parent with a cooperation rate of 0.9, would produce a child agent with a cooperation rate between 0.85 and 0.95.[1] For contingent players a similar process if followed. The probability of cooperation given they have observed prior cooperation is now made to be probabilistic. TFT agents were players with a contingent cooperation rate of 1, but this now becomes a continuous variable between 0 and 1.

[1]As solved above, cooperation rates will be bounded between (0,1). Any draw that produces a cooperation rate, or ideal point outside of these bounds

As above, their cooperation is inherited within the user-specified mutation rate. Using an identical mechanism, the child agent inherits its parent's ideal point (symbol) within a set mutation band. For example a parent with an ideal point equal to 0.5, given a 20prcent error band (a normal distribution centered at 0.5) would produce a child with policy preferences between 0.4 and 0.6.

The second set of agent characteristics, beliefs about the population's ideal point and the "nice or nastiness" of the population, which also drive organizational decisions are inherited and mutated according to the same process. The user specifies the mutation rate, and parent agents pass those characteristics to their children within those rates. Child agents will play according to those initial beliefs as all agents do in the first round after the learning phase of the simulation. After the first round, they will update these beliefs according to their own experiences. All other players in the simulation have their beliefs and history with these players reset, and the child's memory of play is brand new.

Table 8.2: Evolution and Mutation Default Parameters

Parameter	***Symbol***	***Description***	***Default***
Evolution			
Agents replaced		Agents selected for replacement each round	10
Rounds to rank		Average per round net payoffs are taken over n rounds (n ranges from 1 to cumulative)	cumulative
Mutation Inheritance:			
Ideal point		Deviation from the ideal point	0.1
Strategy		Deviation from the probability of cooperation (contingent on cooperation in the past for TFT and ATFT players)	0.1
Ideal belief		Range of mutation on parent agent's ideal belief	0.1

Table 8.2 – Continued

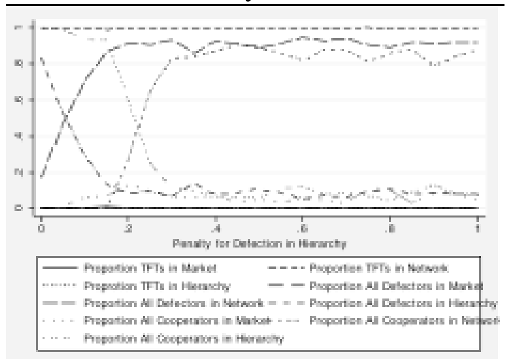
Parameter	***Symbol***	***Description***	***Default***
PC belief		Range of mutation on parent agent's PC belief	0.1

8.3 Parameter Scans

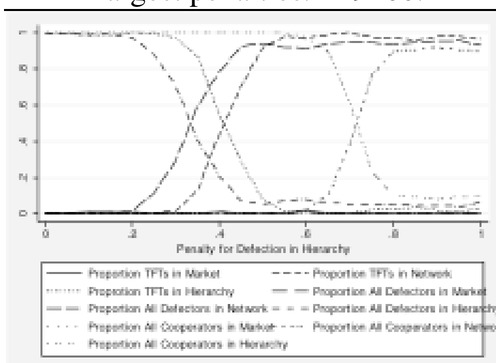
We now present parameter scans of the final model. In the following graphs, we vary each of the core parameters of interest across three populations: a nice population (10ALLCs/15ALLDs/75TFTs), a moderate population (20 ALLCs/50ALLDs/30TFTs), and a nasty population (7ALLCs/85ALLDs/8TFTs). Due to the large number of runs necessary to produce these scans, all the simulations show comparative statics at round 10 and the number of repetitions is set to 10.

8.3.1 Hierarchy Variables

A Nice World. TFTs in the network; ALLDs leave hierarchy for network as penalty increases; ALLCs leave hierarchy for market and network. 630360.



A Moderate World. All types go from hierarchy to network. ALLCs willing to pay largest penalties. 219460.



A Nasty World. ALLCs are in the hierarchy; ALLDs move from hierarchy to network; TFTs move from hierarchy to network as the penalty for defection increases. 250848.

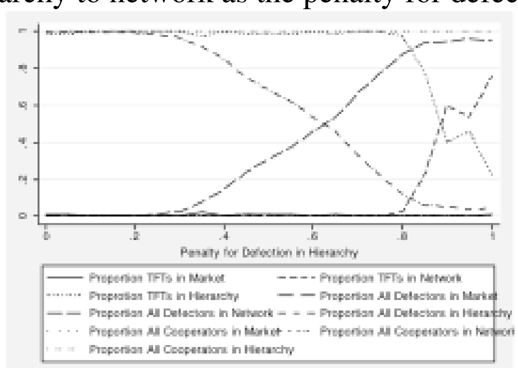
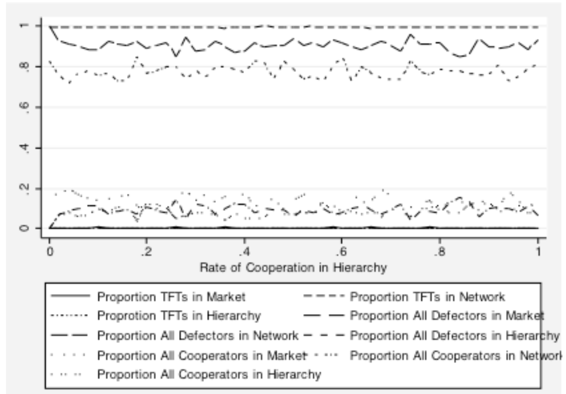
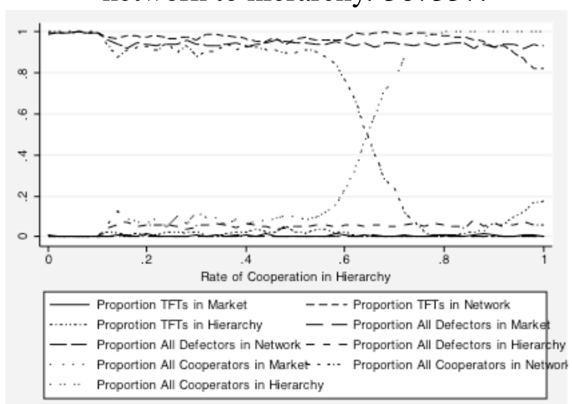


Figure 8.11: Penalty for Defection in the Hierarchy (v). Incremented from 0.0 by +0.05 over 21 increments.

A Nice World. All types predominantly in network. 250848.



A Moderate World. TFTs and ALLDs in network predominantly; ALLCs move from network to hierarchy. 367337.



A Nasty World. TFTs: start in Market and network, move to hierarchy and network; ALLDs move slowly from network to hierarchy; ALLCs move quickly from market and network to hierarchy. 158402.

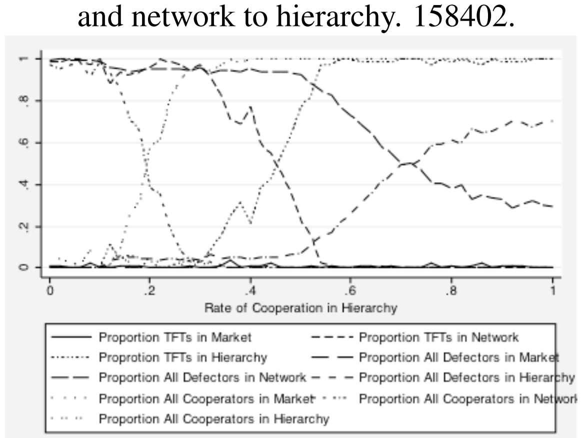
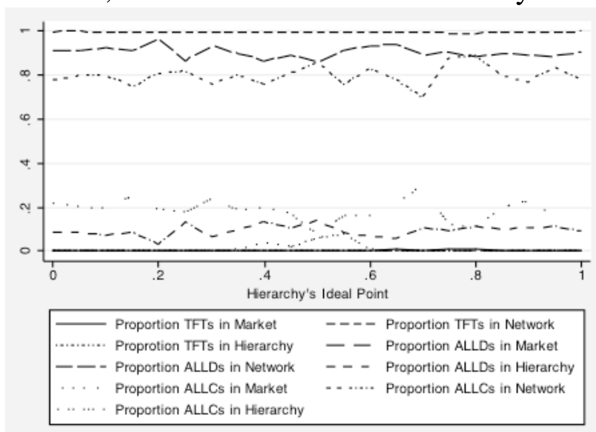
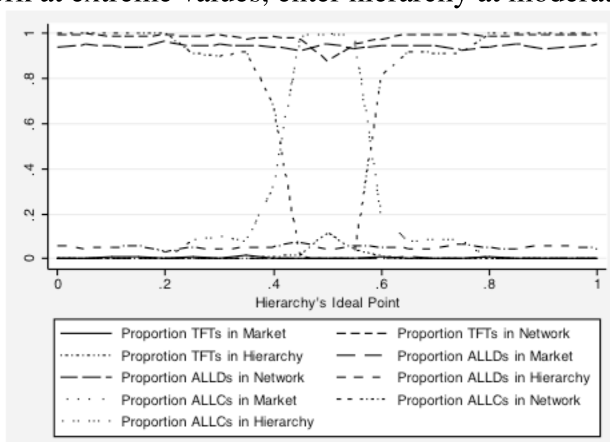


Figure 8.12: Hierarchy: probability of cooperation (*q*) (incremented from 0.0 by +0.2 over 51 increments).

A Nice World. TFTs in the network; ALLDs in network and hierarchy; ALLCs mostly in network, but also in market and hierarchy. 477755.



A Moderate World. TFTs primarily in network, except a few enter hierarchy toward center of distribution; ALLDs mostly in network, low levels of hierarchy membership; ALLCs in network at extreme values, enter hierarchy at moderate values. 323251.



A Nasty World. TFTs in hierarchy; ALLDs in network and hierarchy (peak hierarchy membership around 0.5); ALLCs in hierarchy. 130743.

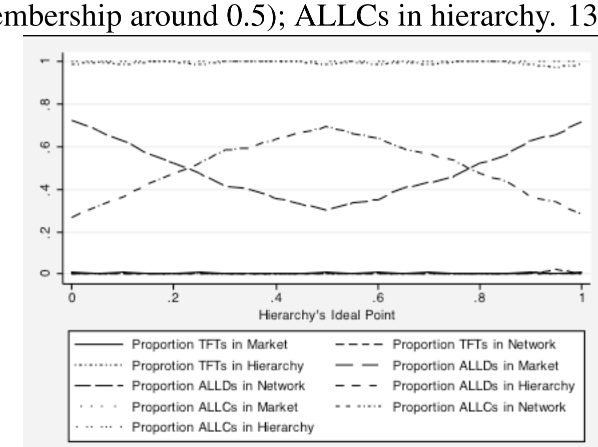
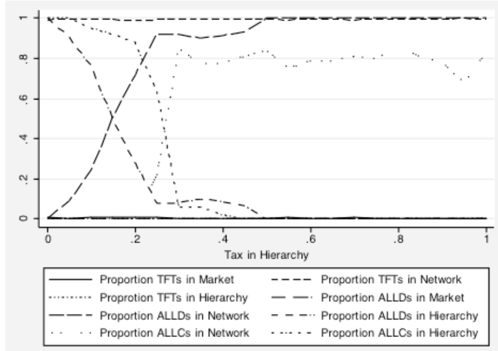
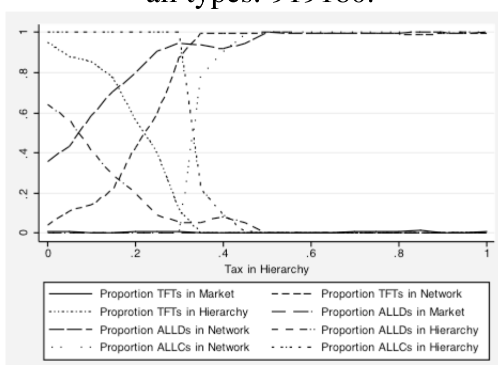


Figure 8.13: Hierarchy Ideal point (p_h) Incremented from 0.0, 21 times by +0.05. .

A Nice World. TFTs in Network; ALLDs leave hierarchy for network as tax increases; ALLCs leave hierarchy for network and market as tax increases. 856560.



A Moderate World. TFTs leave hierarchy for network as tax increases; ALLDs leave hierarchy for network earlier than TFTs; ALLCs leave hierarchy for network latest of all types. 919180.



A Nasty World. TFTs leave hierarchy for network as tax increases, low level market use throughout; ALLDs leave hierarchy for network; ALLCs leave hierarchy for network and market. 727366.

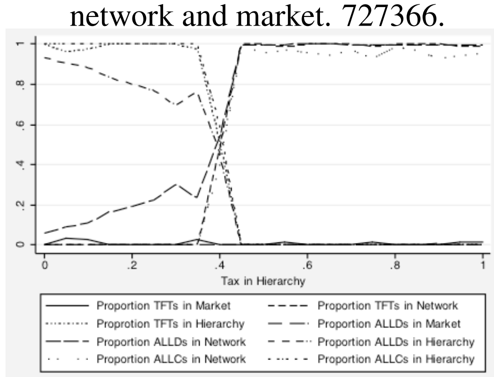
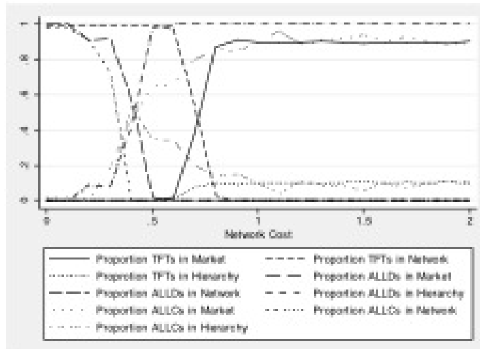


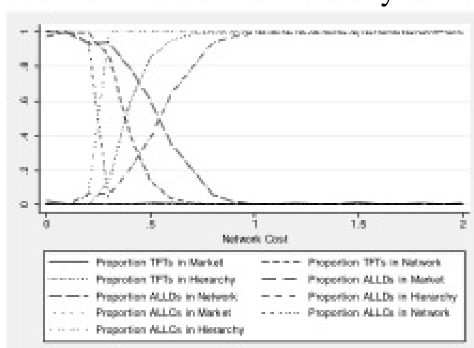
Figure 8.14: Tax in Hierarchy (τ) (fee on GUI) Incremented 51 times from 0.0 by + 0.02.

8.3.2 Network Variables

A Nice World. TFT agents leave network for the market and hierarchy as cost increases; ALLDs leave the network for the hierarchy; ALLCs leave the network earliest for the market and some for the hierarchy. 165714.



A Moderate World. TFTs move from network to the hierarchy with low levels of agents in the market throughout; ALLDs move from network to hierarchy after TFTs; ALLCs move from network to hierarchy earliest. 333946.



A Nasty World. TFTs move from network to hierarchy and some in market; ALLDs move from network to hierarchy as net cost increase; ALLCs move earliest and fastest from network to hierarchy. 666398.

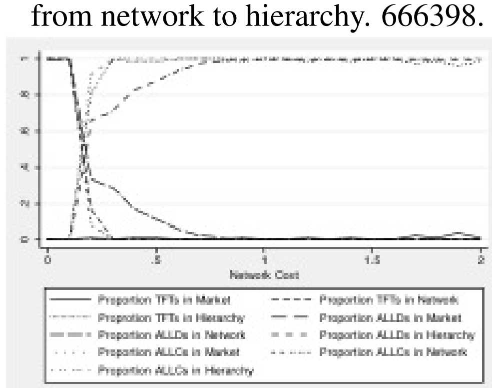
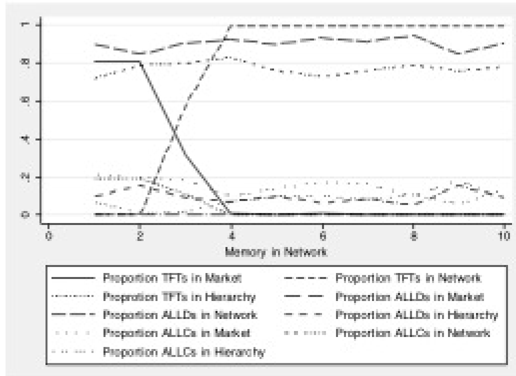
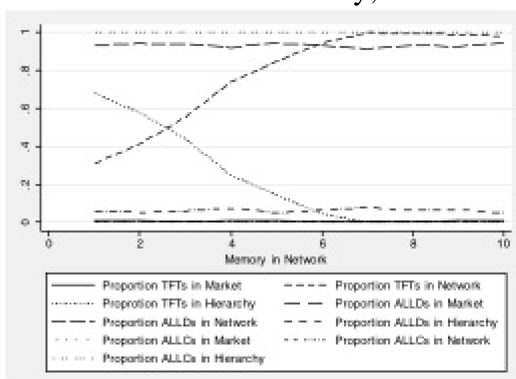


Figure 8.15: Network Cost (ϕ) Incremented 21 times from 0, by +0.1.

A Nice World. TFT agents move from the market and hierarchy into the network; ALLDs constantly in network and hierarchy; ALLCs largely in network, but also low level membership in the hierarchy and market, like the ALLDs these are stable. 475652



A Moderate World. TFTs leave hierarchy for the network as memory increases; ALLDs in network with a few in the hierarchy; ALLCs in hierarchy. 302860.



A Nasty World. TFTs in hierarchy; ALLDs in hierarchy with some in network; ALLCS in hierarchy. Across all types memory in the network does not affect organizational choice significantly. 982798.

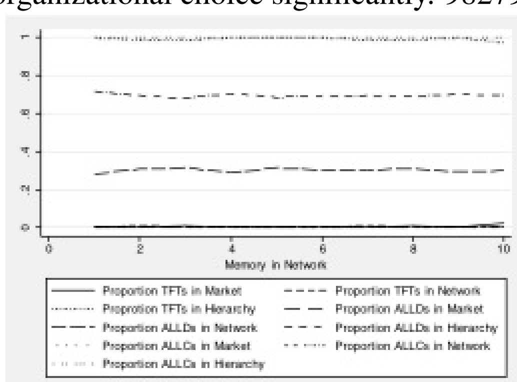
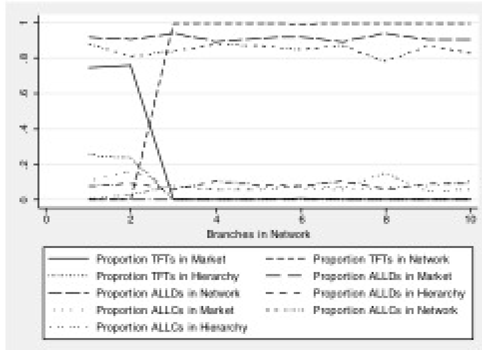
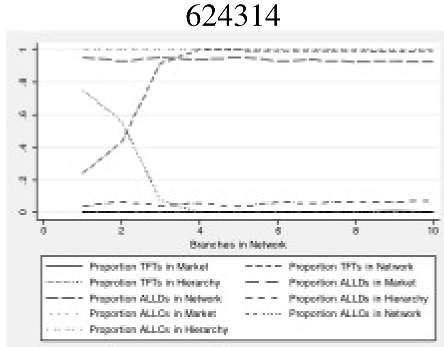


Figure 8.16: Network memory (m_n) Incremented 10 times from 1 by +1.0.

A Nice World. TFTs move from market and hierarchy into the network as branches increases above 3; ALLDs in network and low levels in the hierarchy; ALLCs in Network with low levels of market and hierarchy membership. 101983.



A Moderate World. TFT agents move from hierarchy to network as the branches increase, but more slowly than in the nice population; ALLDs predominantly in network with low levels of hierarchy membership throughout; ALLCS in hierarchy. 624314



A Nasty World. TFTs move from hierarchy to network as branches increase; ALLDS are largely in hierarchy with some in the network; ALLCS are all in hierarchy. 686749

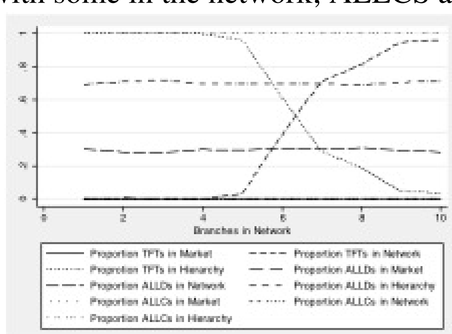
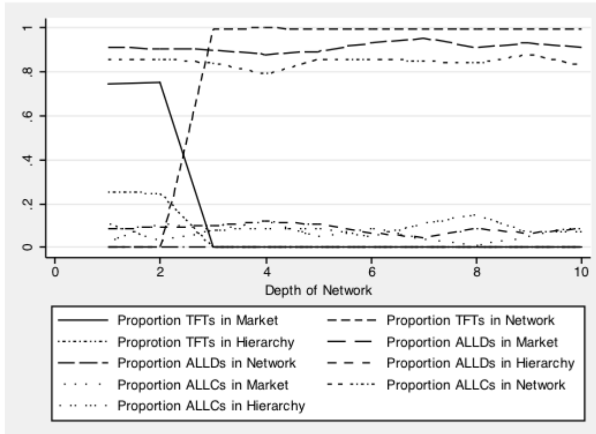
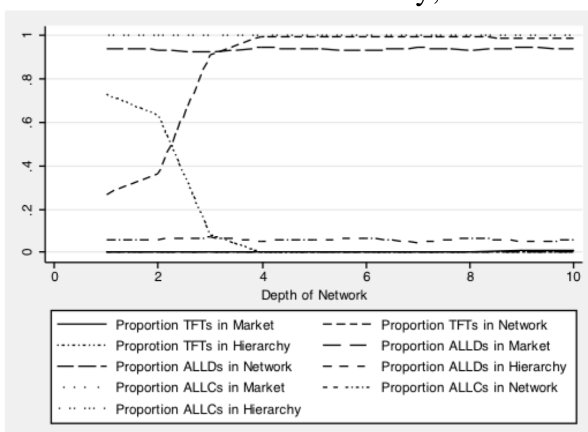


Figure 8.17: Network Width (α) (Branches in GUI). Incremented 10 times, from 1 by +1.

A Nice World. TFTs leave market and hierarchy for network as the depth increases; ALLDs in network with a few in the hierarchy; ALLCs in network predominantly, with a few in the market and hierarchy. 64654.



A Moderate World. TFTS leave hierarchy for network as height of network increases; ALLDS mostly in network with some in hierarchy; ALLCs in hierarchy. 809536.



A Nasty World. TFTs leave hierarchy for network and market; ALLDs in hierarchy with some in network; ALLCs in hierarchy. 991212.

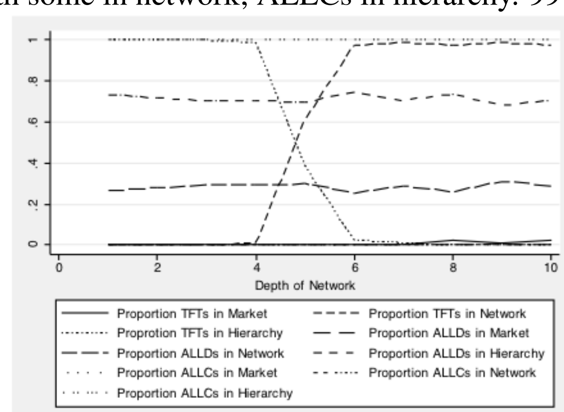
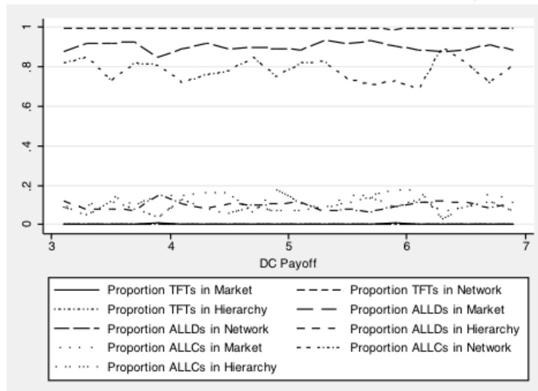


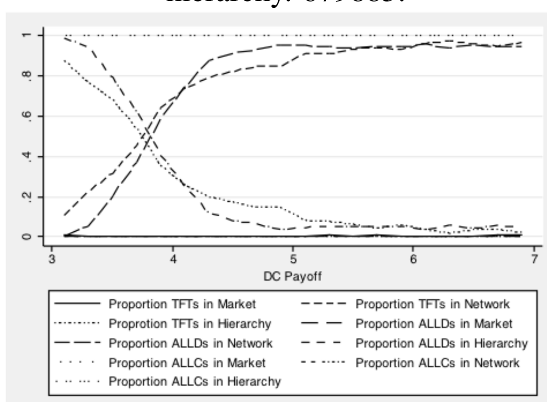
Figure 8.18: Network Depth (*l*) (Height in GUI). Incremented 10 times starting from 1 by +1.

8.3.3 Payoffs

A Nice World. TFTs in network; ALLDs in Network and Market; ALLCs largely in network, but also in market and hierarchy. 645478.



A Moderate World. TFTs and ALLDs leave hierarchy for network; ALLCs all in hierarchy. 679885.



A Nasty World. TFTs almost exclusively in hierarchy, very low levels of market; ALLDs leave hierarchy and enter network as DC payoff increases; ALLCs in hierarchy. 389580.

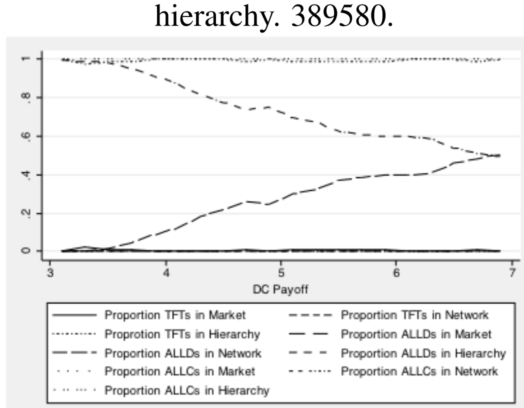
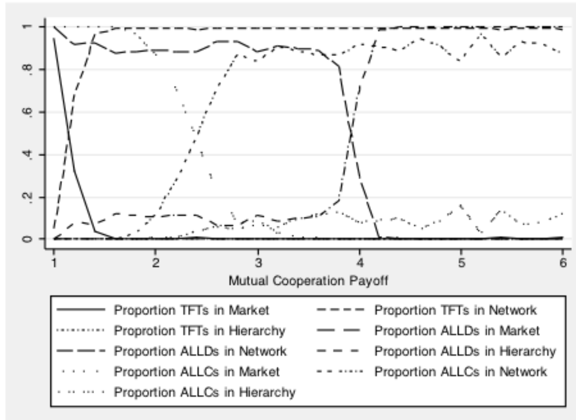
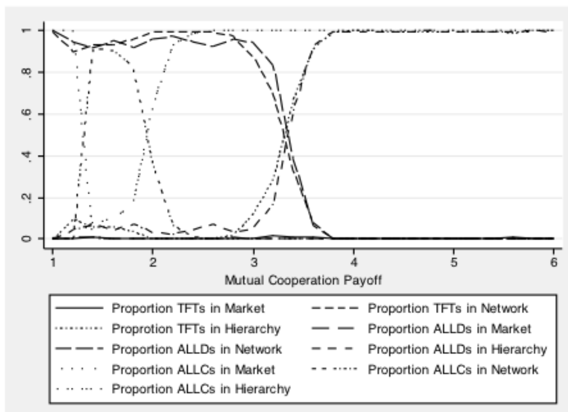


Figure 8.19: DC payoff (T) Incremented 50 times from 3.1 by +0.1.

A Nice World. TFTs leave market for network; ALLDs leave network for hierarchy above 4; ALLCs leave market for network and a few for the hierarchy. 299007.



A Moderate World. TFTs leave network for the hierarchy; ALLDs leave network for hierarchy; ALLCs move from market to network to hierarchy. 71721.



A Nasty World. TFTs move from network to hierarchy; ALLDs move from network to hierarchy; ALLCs move from market to hierarchy. 526741.

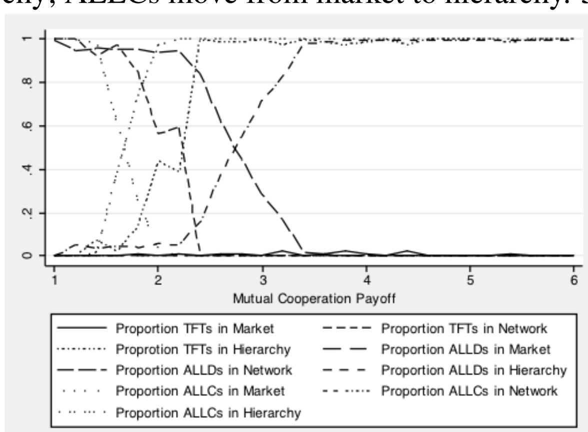
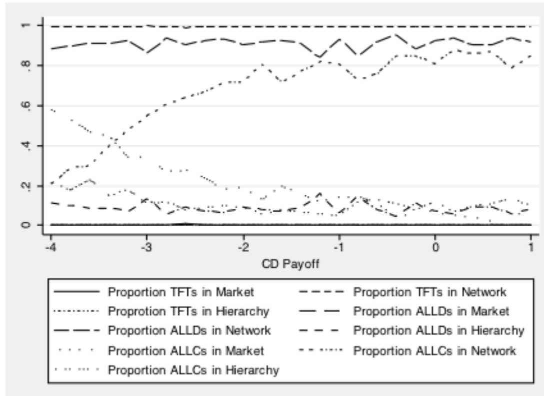
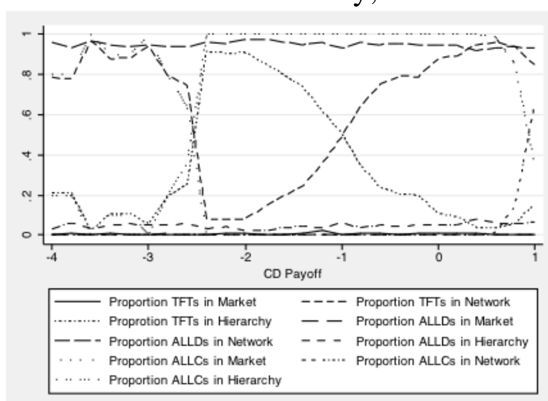


Figure 8.20: Mutual cooperation (CC) payoff (R). Incremented from 1.0 by increments of +0.2 over 26 increments.

A Nice World. TFTs in network; ALLDs in network with a few in the hierarchy; ALLCs leave market and hierarchy for the network. 658535.



A Moderate World. TFTs leave network for hierarchy over middle values then re-enter network as CD payoffs become positive; ALLDs in network and some in hierarchy; ALLCs in market and leave for hierarchy; then enter network. 83359.



A Nasty World. TFTs.in hierarchy; ALLDs in hierarchy and network; ALLCs in hierarchy. 90234

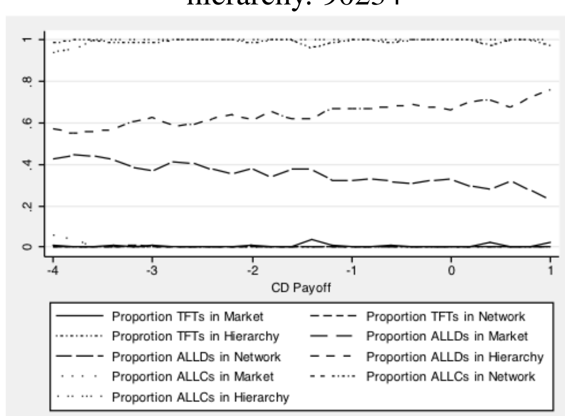
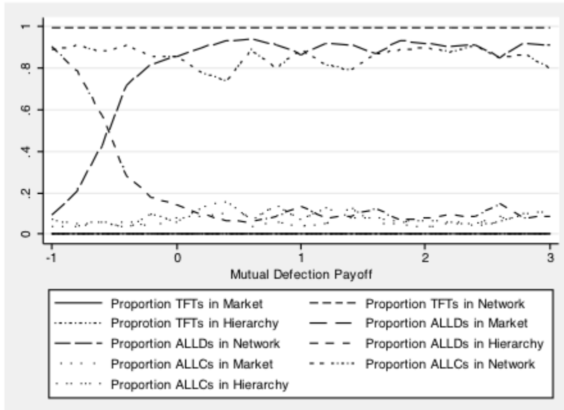
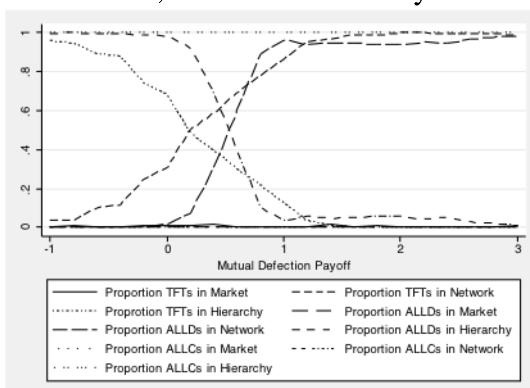


Figure 8.21: CD Payoff (*S*) Incremented 21 times from 1.0 by -0.2 .

A Nice World. TFTs use network primarily; ALLDs go from hierarchy to network; ALLCs primarily in network, low levels of market and hierarchy. 177667.



A Moderate World. TFTs leave hierarchy for the network; ALLDs leave hierarchy for the network; ALLCs in hierarchy. 720862.



A Nasty World. TFTs leave hierarchy for network; ALLDs leave hierarchy for network before TFTs; ALLCs in hierarchy. 29576.

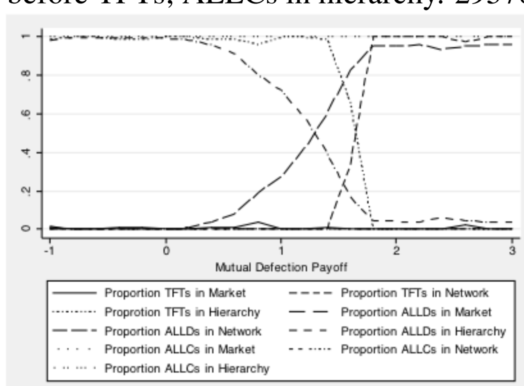
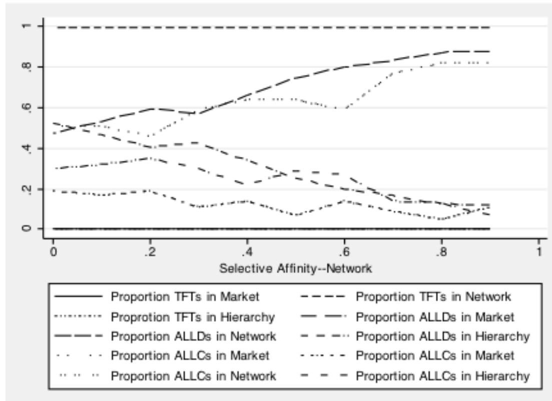


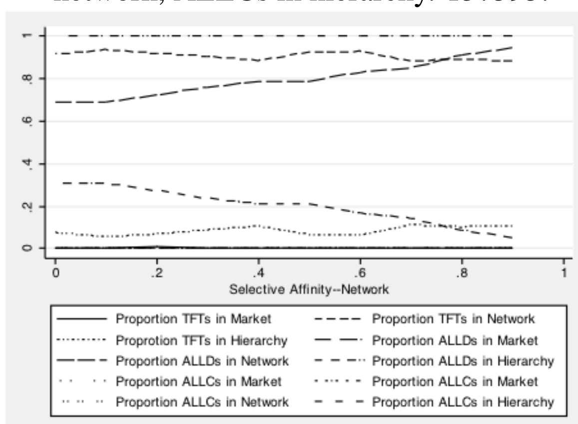
Figure 8.22: DD Payoff (*S*) Incremented 21 times from 1.0 by -0.2 .

8.3.4 Selective Affinity and Ideal Point

A Nice World. TFTs in network; ALLDs leave hierarchy for network; ALLCs leave hierarchy and market for the network. 535767.



A Moderate World. TFTs in network predominantly; ALLDs leave hierarchy for network, ALLCs in hierarchy. 137593.



A Nasty World. TFTs in hierarchy; ALLDs in hierarchy and network; ALLCs in hierarchy. 147005.

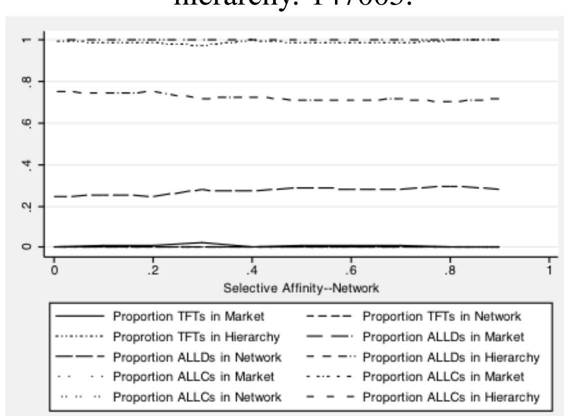
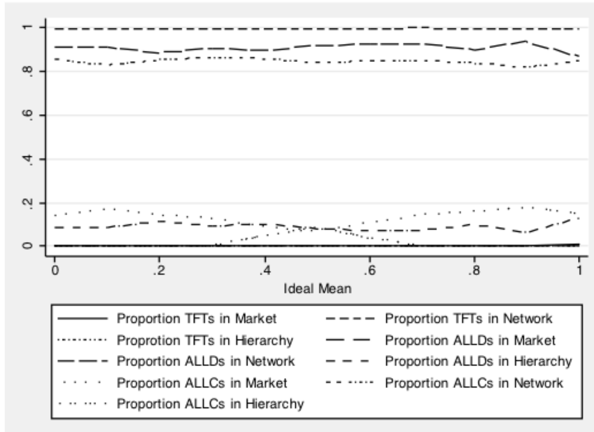
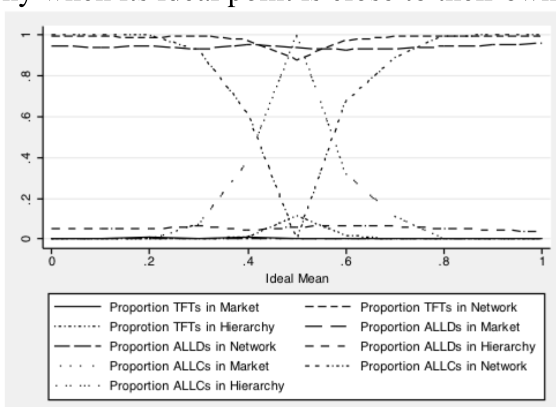


Figure 8.23: Selective Affinity (η) incremented 10 times from 0 by increments of 0.1.

A Nice World. TFTs in Network; ALLDs in network; ALLCs in Network, with a few in market and hierarchy. 974363.



A Moderate World. TFTs in network, at center of distribution will enter the hierarchy; ALLDs primarily in network; ALLCs in network until the center; they leave for the hierarachy when its ideal point is close to their own. 756209.



A Nasty World. TFTs in hierarchy; ALLDs leave network for hierarchy in the middle and reverse; ALLCs in hierarchy. 1260

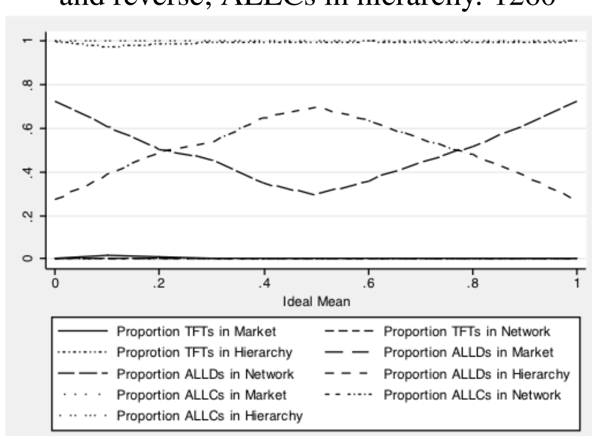
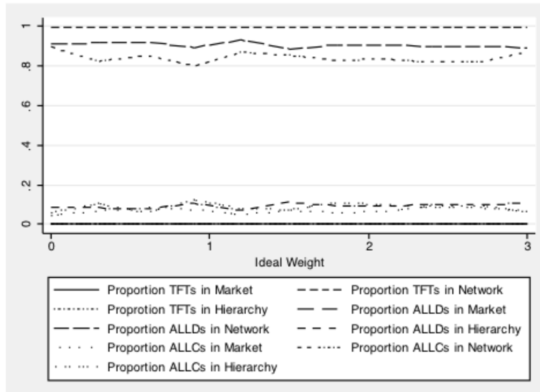
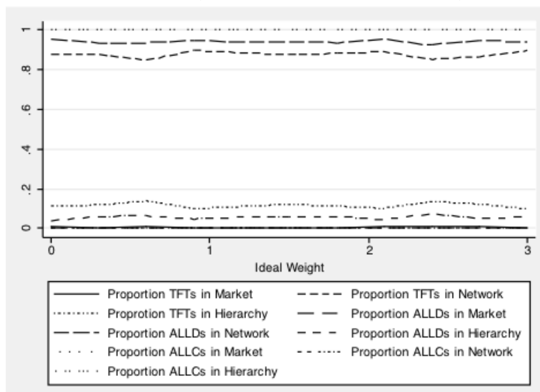


Figure 8.24: Population Ideal Mean Incremented 11 times from 0 by +0.1

A Nice World. TFTs and ALLDs in network; ALLCs in network with a few in market and hierarchy. 177219.



A Moderate World. TFTs in network; ALLDs in network; ALLCS in hierarchy. 90378.



A Nasty World. TFTs in hierarchy; ALLDs in hierarchy and network; ALLCs in hierarchy. 544247.

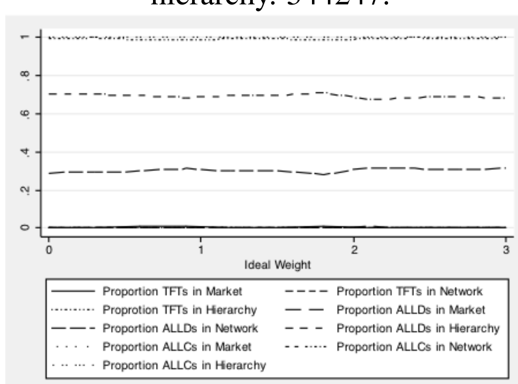


Figure 8.25: Weight on Ideal (w) Incremented 11 times from 0.0 by +0.3

Appendix A

Chapter 3 Appendix

A.1 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 Table 1, 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), $k_{ij} = w(|p_i - \rho|/2)$, where ρ is the agent's belief (continuously updated) about the mean ideal point of the population. For the hierarchy, $k_{ih} = w|p_i p_h|$.

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.1.1 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).

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

A.1.2 Expected Utility in the Network

Expected Utility in Network for Fixed Strategy Players

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

(A.2)

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

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.

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

A.1.3 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).

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

A.2 Intuitive Organization Propositions

Here I report simulations on the more intuitive properties of the organizations.

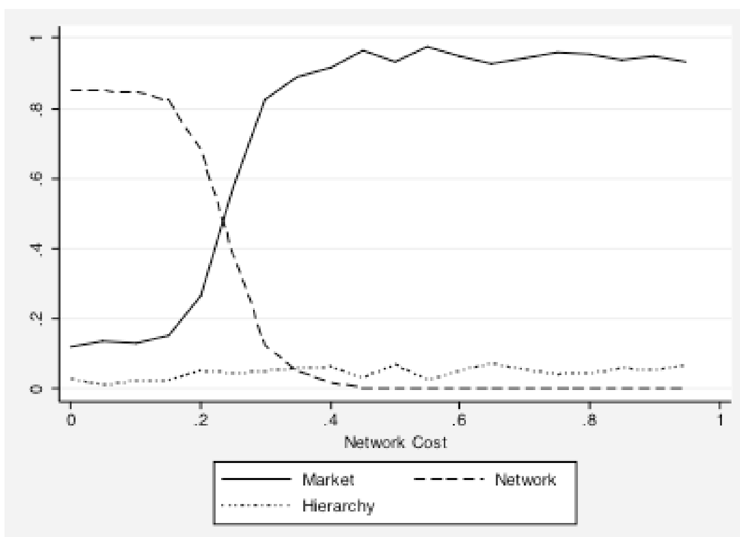


Figure A.1: Organizational Choice as Network Cost increases. Population composed of 15 ALLDs and 85 TFT agents, the network fee is increased from 0 by 0.05 at each increment. This is a relatively nice population. In relatively nastier populations, increases in network costs drive agents into the market or hierarchy only. [Seed: 126574, Hierarchy penalty: 0.25]

Proposition : Relatively inexpensive networks are preferred by all strategy types. As the probability of getting more information out of the network increases, so does the use.

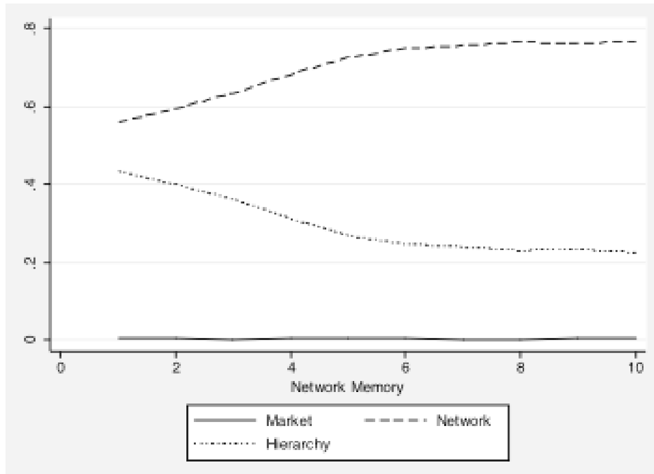


Figure A.2: Organizational Choice as Network Memory increases. Intuitively, as the memory in the network—the number of agents back an agent can survey increases, the network becomes more valuable. Increased TFT membership accounts for this swing. [302860; population of 20ALLCs 50ALLDs and 30TFTs]

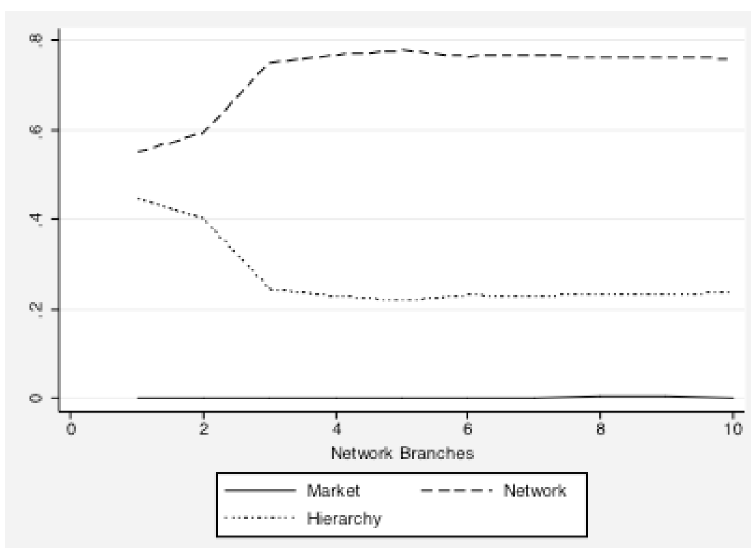


Figure A.3: Organizational Choice as Network Width increases As the number of branches—the number of people an agent can survey–in the network increase, the proportion of agents in the network increases. [624314]

The first part of this proposition, that relatively inexpensive networks are preferred by all types, is a story about transaction costs. All else equal, as the cost of seeking out information increases, we will be less willing to do so. Likewise, the more an agent for your money, the more it is willing to pay for information. Expanding the network memory, branches and depth all increase the polling mechanism in the network. As that mechanism returns more information, and is more likely to converge on the true strategy type of an agent, the network is more valuable.

Hierarchy Parameters

The location, effectiveness, and cost of the hierarchy determine who joins the hierarchy, and when they join. Agents of all types will join hierarchies—even those that are relatively extreme– given certain conditions. Figure A.4 shows membership in the hierarchy by strategy type in a relatively nasty population. In “nicer” populations, agents enter the hierarchy closer to the population mean—around 0.5, and drop out of the hierarchy—often for the network—toward the extremes. The most vulnerable agents, ALLCs, universally enter the hierarchy first, followed by TFTs, and finally ALLD agents. Nice agents are willing to trade off greater “security” in the hierarchy for ideological distance more quickly than nasty agents.

Hierarchy effectiveness also impacts membership overall, as well as timing of membership. Hierarchies that are relatively ineffective at inducing cooperation amongst their own members will get some membership, but become much more populated as the rate of cooperation increases (see Figure A.5). Repeating the patterns observed above, nice agents are willing to trade off effectiveness more readily than are nasty agents (see Figure A.5)./ALLDs only join hierarchies that are able to sustain high levels of internal cooperation. Related, as the penalty for defecting on another member of your hierarchy increases, membership drops precipitously (see Figure A.6). Figure A.7 shows that as the tax on members in the hierarchy increases, agents exit the hierarchy. Nice agents are willing to pay high taxes longest, but all agents leave the hierarchy as that rate grows too high (see Figure A.8).

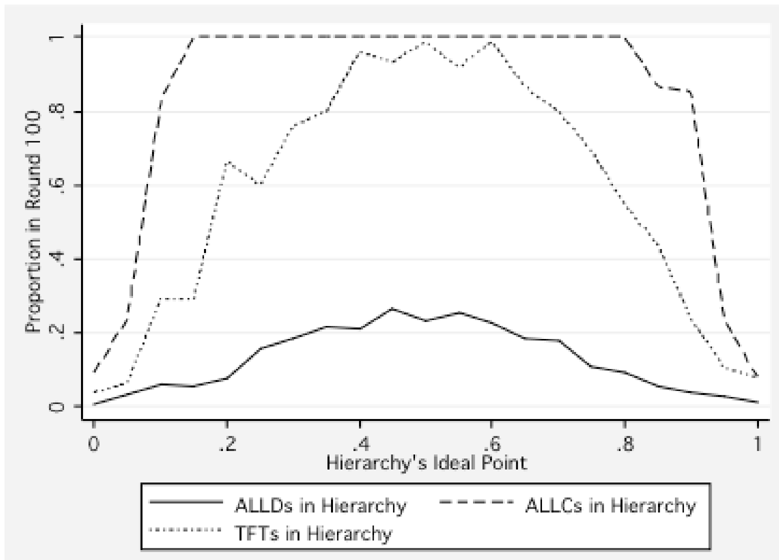
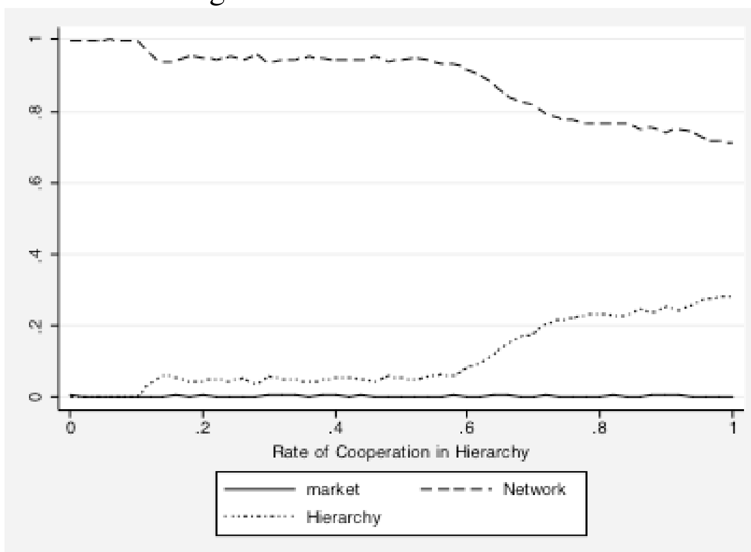


Figure A.4: Proportion of each strategy type joining hierarchy as hierarch's ideal point varies. This is a relatively nasty population of ALLD = 70, ALLC = 15, and TFT = 15 agents, corresponding roughly to the point where all TFT agents enter the hierarchy in Figure 8. Ideal points of agents are normally distributed with a mean of 0.5. As the hierarch's ideal point moves toward either extreme (closer to zero or closer to one), fewer agents joint the hierarchy. Importantly, however, except for very extreme values, agents still join the hierarchy for the cooperation it facilitates. [Seed 454279, ALLD = 70, ALLC = 15, TFT = 15, 100 rounds, Network fee: 0.5, Hierarchy's ideal point incremented from 0 by 0.05].

Organizational membership by probability of cooperation in the hierarchy. The hierarchy attracts members even when the internal rate of cooperation is fairly low. In this moderately nice population of 20ALLCs, 50 ALLDs and 30 TFTs, as the rate of cooperation increases, agents begin to move to the hierarchy, primarily from the network. While agents begin to enter into the hierarchy around 0.15, they begin to enter in larger numbers above 0.6. Seed: 367337.



Probability of cooperation in the hierarchy—hierarchy membership by strategy type. Even in fairly moderate populations, nice agents are willing to enter the hierarchy at low rates of cooperation. It seems that even relatively ineffective guarantees of cooperation are valuable to the most vulnerable agents. Toward the upper levels of cooperation, TFTs begin to move into the hierarchy. Same population as in **??** above.

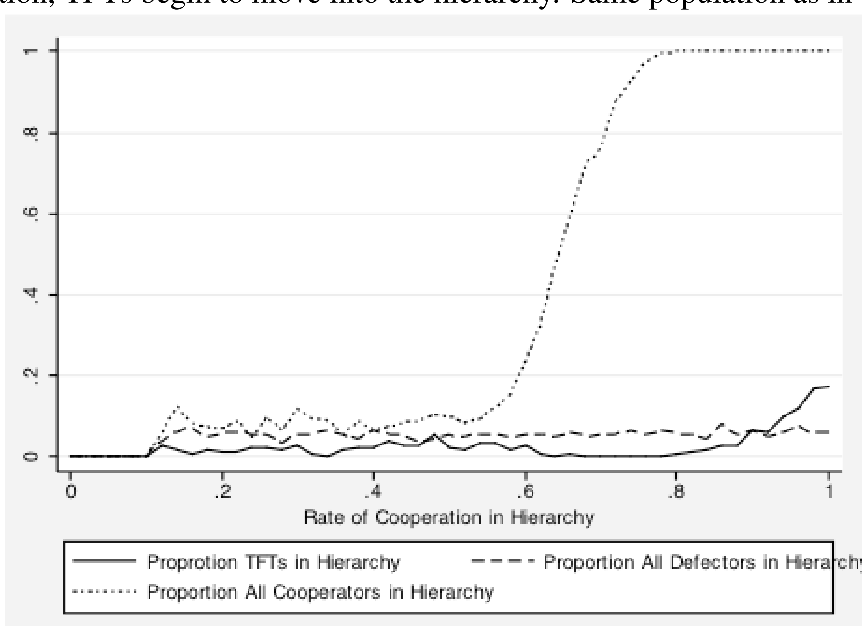


Figure A.5: Rate of Cooperation in Hierarchy

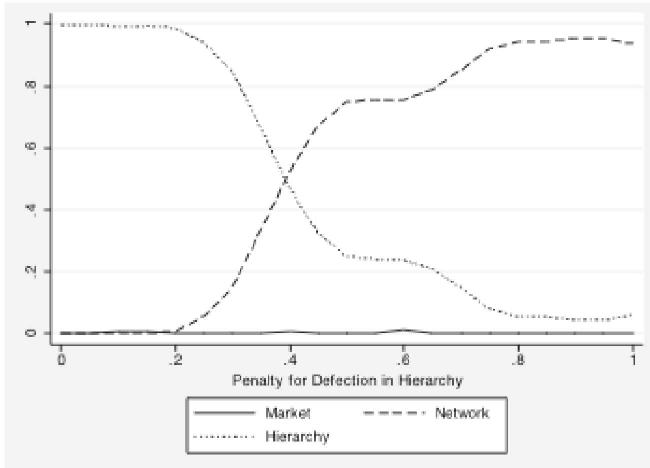


Figure A.6: Organizational membership as punishment for defection in the hierarchy varies. As the penalty for defecting within the hierarchy increases, hierarchy membership declines. This moderate population can support penalties in the hierarchy of 0.25 until membership declines steeply, but the hierarchy retains some membership until the penalty approaches 1.0. Seed: 219460; 20ALLCs, 30ALLDs, 50TFTs.

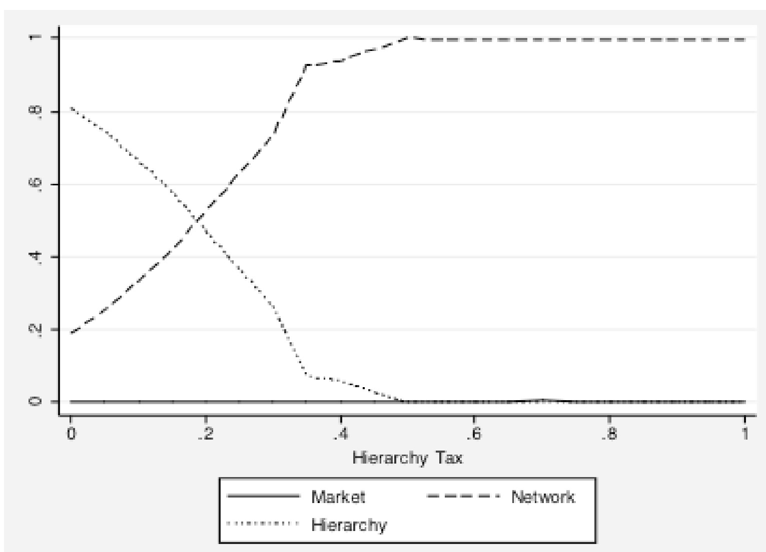


Figure A.7: Organizational choice as Tax in the Hierarchy Varies. As the tax in the hierarchy increases, membership in the hierarchy decreases. The hierarchy sustains some membership until the tax increases above 0.5. [919180]

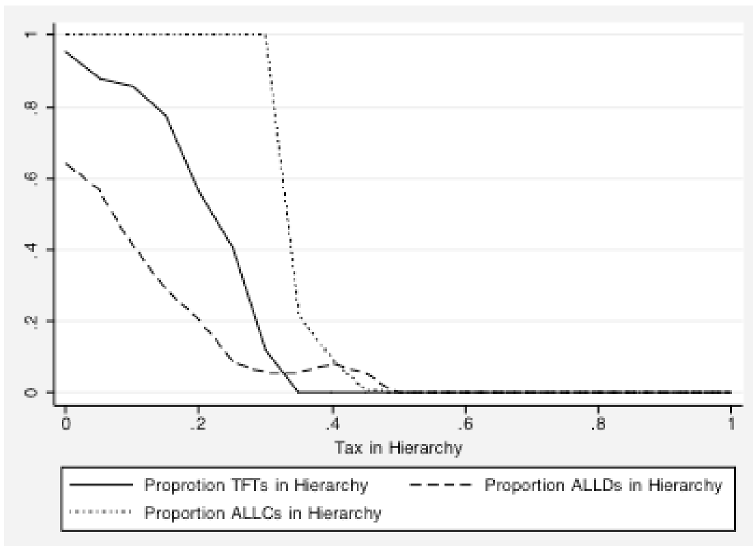


Figure A.8: Tax in hierarchy by strategy type. In general, nice types are willing to pay higher taxes in the hierarchy than nasty types. In this fairly moderate population, the ALLCs are universally willing to pay taxes of almost 0.4 before leaving the hierarchy. ALLDs however are willing to pay only the lowest levels of taxes before leaving. [same population as in panel e; 20ALLCs, 50ALLDs, 30TFT].

Appendix B

Rebels Chapter Appendix

Table B.1: 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 actorsÕ 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	

Table B.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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
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 Co-operation	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

B.1 Robustness checks

Table B.2: OLS. Standard errors in parentheses. DV level of centralization

Variable	Coefficient
Rebels	1.22e-06**
	(5.88e-7)
Population	-0.0284
	(0.02066)
Conflict	0.0001272**
	(0.0005)
Constant	1.256
	505

Level of significance: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table B.3: OLS on degree of centralization.

Variable	Coefficient
Opposition Proportion	-0.0064
	(0.0143)
Mobilization Capacity	0.1748***
	(0.0638)
Territorial Control	0.3432***
	(0.635)
Conflict	0.0002344***
	(0.00007)
SD Wars	-0.1917***
	(0.580)
Constant	0.5746
N	196

Level of significance: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table B.4: OLS on degree of centralization.

Variable	Coefficient
Political Wing	-0.1137
	(0.1131)
Territorial Control	0.6273***
	(0.1039)
Conflict	0.000349***
	(0.000116)
SD Wars	-0.290***
	(0.0780)
Constant	0.348777
N	82

Level of significance: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table B.5: OLS on degree of centralization.

Variable	Model 1	Model 2
Rebls	5.21e-07	8.87e-07
	(5.39e-07)	(5.80e-07)
Population	-0.0459	
	(0.0294)	
Territorial Control	-0.1248***	
	(0.0598)	
Conflict	0.000233***	
	(0.00008)	
SD Wars	-0.135**	
	(0.0599)	
Constant	1.0349	1.231
N		637

Level of significance: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table B.6: OLS on degree of centralization.

Variable	Coefficient
Political Wing	0.0501
	(0.0760)
Rebel Strength	0.2176***
	(0.0400)
Conflict	2.30e-06
	(0.0000652)
SD Wars	-0.0583
	(0.05740)
Constant	1.404
N	285

Level of significance: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Appendix C

Alliance Chapter Appendix

Another possible test of the intuition from Proposition 3 is that "nice" agents will be willing to bear greater costs in terms of the alliances they join. This is operationalized in terms of the array of commitments each state takes on. This variable ranges from 0 constraints to 5 constraints. "Nice" and "nasty" agents are operationalized identically as they are above. Table C.3 below summarizes the results. As in the test of Proposition 1, a negative coefficient on the interacted variable indicates that nicer states have more restraints. The results are strong across both specifications of the model.[1]

Table C.1: Negative Binomial Estimation results: Alliance Constraints

Variable	Model 1	Model 2
Equation 1 : number		
BellicosityXExpenditures	-0.0013**	-0.0014***
	(0.0005)	(0.0005)
Bellicosity	0.095***	0.101***
	(0.028)	(0.026)
Expenditures	0.0016**	0.0018***
	(0.0006)	(0.0006)
Population		-1.53e-7
		(1.01e-7)
Clustered by State		
N	7877	7877
Number of Clusters	196	196
Controls for Type of Alliance Included	No	No

[1]These results are also robust to using an ordered probit model.

Table C.2: Rare Events Logit: IO membership on Asymmetric Alliance

	(1) Asymmetric Alliance	(2) Asymmetric Alliance	(3) Asymmetric Alliance	(4) Asymmetric Alliance
IO Membership	0.00680***	0.00689***	0.00433***	0.00165
	(0.000999)	(0.00109)	(0.00119)	(0.00116)
Number of Alliances		-0.0158	0.0381	0.879***
		(0.0505)	(0.0511)	(0.0558)
Mil Expenditures			1.68e-09***	2.79e-09***
			(2.85e-10)	(6.28e-10)
Population			-0.000000920***	-0.00000137**
			(5.65e-08)	(0.000000502)
CINC			10.04***	9.569***
			(0.279)	(0.434)
Constant	-4.815***	-4.798***	-4.942***	-2.371***
	(0.0625)	(0.0757)	(0.0790)	(0.125)
Alliance Type Control	No	No	No	Yes
Observations	186411	186411	186290	186290

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table C.3: Rare Events Logit: IO proportion to Asymmetric Alliance

	(1) Asymmetric Alliance	(2) Asymmetric Alliance	(3) Asymmetric Alliance	(4) Asymmetric Alliance
io_prop	3.567***	3.568***	2.758***	1.303***
	(0.171)	(0.171)	(0.185)	(0.137)
Number of Alliances		0.000500	0.0325	0.811***
		(0.0418)	(0.0438)	(0.0550)
Mil Expenditures			2.13e-09***	3.04e-09***
			(2.75e-10)	(6.49e-10)
Population			-0.000000519***	-0.00000166**
			(6.48e-08)	(0.000000592)
cinc			6.902***	8.479***
			(0.338)	(0.444)
(max) defense				0.843***
				(0.0914)
(max) offense				-5.521***
				(0.123)
(max) neutral				1.081***
				(0.181)
(max) nonagg				-5.870***
				(0.0922)
(max) consul				0.507***
				(0.0746)
Constant	-6.611***	-6.612***	-6.325***	-2.995***
	(0.117)	(0.127)	(0.132)	(0.134)
Observations	186411	186411	186290	186290

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix D

Turnout Appendix

Table D.1: Turnout Default Parameters

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	

Table D.1 – Continued

Parameter	***Symbol***	***Description***	***Default Value***
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	5
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
Probability of Coop	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	0.2
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

Bibliography

(1999). *Africa works: Disorder as a political instrument*. Indiana University Press.

Arquilla, J., & Ronfeldt, D. (2001). *Networks and netwars: The future of terror, crime, and militancy*. 1382. Rand Corp.

Asal, V., & Rethemeyer, R. (2008). The nature of the beast: Organizational structures and the lethality of terrorist attacks. *The Journal of Politics*, *70*(02), 437–449.

Axelrod, R. (1997). *The complexity of cooperation: Agent-based models of competition and collaboration*. Princeton Univ Pr.

Axelrod, R., & Hamilton, W. (1981). The evolution of cooperation. *Science*, *211*(4489), 1390–1396.

Bates, R. (1971). *Unions, parties and political development: A study of mineworkers in Zambia*. Yale University Press New Haven.

Bell, D. (1991). Racial realism. *Conn. L. Rev.*, *24*, 363.

Berkowitz, L., & Lutterman, K. (1968). The traditional socially responsible personality. *Public Opinion Quarterly*, *32*(2), 169–185.

Berman, E. (2009). *Radical, religious, and violent: the new economics of terrorism*. The MIT Press.

Blaise, A. (2000). *To Vote or Not to Vote: the merits and limits of rational choice theory*. Pittsburge Univ. Press.

Carroll, G. (1984). Organizational ecology. *Annual review of Sociology*, (pp. 71–93).

Cederman, L. (1994). Emergent polarity: Analyzing state-formation and power politics. *International Studies Quarterly*, (pp. 501–533).

Cederman, L. (1997). *Emergent actors in world politics: how states and nations develop and dissolve*. Princeton Univ Pr.

Cederman, L. (2002). Endogenizing geopolitical boundaries with agent-based modeling. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(Suppl 3), 7296–7303.

Cederman, L. (2003). Modeling the size of wars: from billiard balls to sandpiles. *American Political Science Review*, *97*(1), 135–150.

Cederman, L., Wimmer, A., & Min, B. (2010). Why do ethnic groups rebel? *World Politics*, *62*(1), 87–119.

Cederman, L.-E., Warren, T. C., & Sornette, D. (2011). Testing clausewitz: Nationalism, mass mobilization, and the severity of war. *International Organization*, *65*(4), 605–38.

Chandra, K. (2006). What is ethnic identity and does it matter? *Annu. Rev. Polit. Sci.*, *9*, 397–424.

Chandra, K. (2007). *Why ethnic parties succeed: Patronage and ethnic head counts in India*. Cambridge Univ Pr.

Chandra, K. (2009). Why voters in patronage democracies split their tickets: Strategic voting for ethnic parties. *Electoral Studies*, *28*(1), 21–32.

Coase, R. (1960). *The problem of social cost*. Wiley Online Library.

Cohen, M. D., Riolo, R. L., & Axelrod, R. (2001). The role of social structure in the maintenance of cooperative regimes. *Rationality and Society*, *13*(1), 5–32.

Coleman, J. S. (1974). *Power and the Structure of Society*. Norton.

Conybeare, J. (1992). A portfolio diversification model of alliances. *Journal of Conflict Resolution*, *36*(1), 53–85.

Conybeare, J., & Sandler, T. (1990). The triple entente and the triple alliance 1880-1914: A collective goods approach. *The American Political Science Review*, (pp. 1197–1206).

Cunningham, D. (2006). Veto players and civil war duration. *American Journal of Political Science*, *50*(4), 875–892.

Cunningham, D., Gleditsch, K., & Salehyan, I. (2009). It takes two. *Journal of Conflict Resolution*, *53*(4), 570–597.

Cunningham, K. (2011). Divide and conquer or divide and concede: How do states respond to internally divided separatists? *American Political Science Review*, *105*(02), 275–297.

Dickson, E., & Scheve, K. (2006). Social identity, political speech, and electoral competition. *Journal of Theoretical Politics*, *18*(1), 5–39.

Dixit, A. (1987). Strategic aspects of trade policy. In *Advances in Economic Theory: Fifth World Congress*, (pp. 329–362). New York: Cambridge University Press.

Downs, A. (1957). An economic theory of political action in a democracy. *The Journal of Political Economy*, *65*(2), 135–150.

Duverger, M. (1963). *Political parties: Their organization and activity in the modern state*. Taylor & Francis.

Eilstrup-Sangiovanni, M. (2009). The end of balance-of-power theory? a comment on wohlforth et al.'stesting balance-of-power theory in world history'. *European Journal of International Relations*, *15*(2), 347–380.

Ellickson, R. (1991). *Order without law: How neighbors settle disputes*. Harvard Univ Pr.

Epstein, J. M. (2007). *Generative Social Science: Studies in Agent-Based Computational Modeling*. Princeton Univ Pr.

Fearon, J., & Laitin, D. (2003). Ethnicity, insurgency, and civil war. *American Political Science Review*, *97*(1), 75–90.

Gambetta, D. (1996). *The Sicilian Mafia: the business of private protection*. Harvard Univ Pr.

Gartzke, E. (2000). Preferences and the democratic peace. *International Studies Quarterly*, *44*(2), 191–212.

Gartzke, E. (2010). The affinity of nations: Similarity of state voting positions in the unga. *Dataset (April 2010), available a t http://dss. ucsd. edu/˜ egartzke/htmlpages/data. html*.

Gibson, C. (2000). *People and forests: Communities, institutions, and governance*. The MIT Press.

Greif, A. (1993). Contract enforceability and economic institutions in early trade: The maghribi traders' coalition. *The American economic review*, (pp. 525–548).

Greif, A. (2006). *Institutions and the path to the modern economy: Lessons from medieval trade*. Cambridge Univ Pr.

Hafner-Burton, E., & Montgomery, A. (2008). Globalization and the social power politics of international economic networks.

Hammond, R., & Axelrod, R. (2006). Evolution of contingent altruism when cooperation is expensive. *Theoretical population biology*, *69*(3), 333–338.

Hannan, M., & Freeman, J. (1993). *Organizational ecology*. Harvard Univ Pr.

Hobbes, T. (????). 1651/1968. leviathan. *Edited with Introduction by CB Macpherson. Harmondsworth, UK: Penguin*.

Horowitz, D. (1985). *Ethnic groups in conflict*, vol. 387. Univ of California Pr.

Huckfeldt, R., & Kohfeld, C. (1992). Electoral stability and the decline of class in democratic politics. *Mathematical and Computer Modelling*, *16*(8-9), 223–239.

Huth, P. (1988). *Extended deterrence and the prevention of war*. Yale University Press New Haven.

Ilgen, & Hulin (2000). *Computational Modeling of Behavior in Organizations: The Third Scientific Discipline*. American Psychological Association.

Iyob, R. (1997). *The Eritrean Struggle for Independence: domination, resistance, nationalism, 1941-1993*, vol. 82. Cambridge Univ Pr.

Jervis, R. (1978). Cooperation under the security dilemma. *World politics*, *30*(02), 167–214.

Jung, D., & Lake, D. (2011). Markets, hierarchies, and networks: An agent-based organizational ecology. *American Journal of Political Science*.

Kahler, M. (2009). *Networked politics: agency, power, and governance*. Cornell University Press Ithaca, NY.

Katzenstein, P., & Shiraishi, T. (1997). *Network Power: Japan and Asia*. Cornell Univ Pr.

Keck, M., & Sikkink, K. (1998). *Activists beyond borders: Advocacy networks in international politics*. Cambridge Univ Press.

Keefer, P., & Khemani, S. (2005). Democracy, public expenditures, and the poor: understanding political incentives for providing public services. *The World Bank Research Observer*, *20*(1), 1–27.

Keohane, R., & Nye, J. (1975). International interdependence and integration. *Hand-*

book of Political Science, *8*, 363–414.

Kinder, D., & Sears, D. (1981). Prejudice and politics: Symbolic racism versus racial threats to the good life. *Journal of personality and social psychology*, *40*(3), 414.

Klein, B., Crawford, R., & Alchian, A. (1978). Vertical integration, appropriable rents, and the competitive contracting process. *Journal of law and economics*, *21*(2), 297–326.

Kollman, K., Miller, J. H., & Page, S. E. (2003). *Computational Models in Political Economy*. MIT Press.

Lake, D. (2009). *Hierarchy in international relations*. Cornell Univ Pr.

Lake, D., & Wong, W. (2009). The politics of networks: interests, power, and human rights norms. *Networked Politics: Agency, Power, and Governance*, (pp. 127–150).

Leeds, B., & Anac, S. (2005). Alliance institutionalization and alliance performance. *International Interactions*, *31*(3), 183–202.

Leeds, B., Long, A., & Mitchell, S. (2000). Reevaluating alliance reliability. *Journal of Conflict Resolution*, *44*(5), 686–699.

McPherson, M., Smith-Lovin, L., & Cook, J. (2001). Birds of a feather: Homophily in social networks. *Annual review of sociology*, (pp. 415–444).

Miller, J., & Page, S. (2007). *Complex adaptive systems: An introduction to computational models of social life*. Princeton Univ Pr.

Morrow, J. (1991). Alliances and asymmetry: An alternative to the capability aggregation model of alliances. *American Journal of Political Science*, (pp. 904–933).

Newman, M., Barabasi, A., & Watts, D. (2006). *The structure and dynamics of networks*. Princeton Univ Pr.

Niemi, R. (1976). Costs of voting and nonvoting. *Public Choice*, *27*(1), 115–119.

Nowak, M., & Sigmund, K. (2005). Evolution of indirect reciprocity. *Nature*, *437*(7063), 1291–1298.

Nowak, M., Sigmund, K., et al. (1993). A strategy of win-stay, lose-shift that outperforms tit-for-tat in the prisoner's dilemma game. *Nature*, *364*(6432), 56–58.

Orbell, J., & Dawes, R. M. (1991). A 'cognitive miser' theory of cooperators' advantage. *American Political Science Review*.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge Univ Pr.

Pevehouse, J., Nordstrom, T., & Warnke, K. (2004). The correlates of war 2 international governmental organizations data version 2.0. *Conflict Management and Peace Science*, *21*(2), 101–119.

Piazza, J. (2009). Is islamist terrorism more dangerous?: An empirical study of group ideology, organization, and goal structure. *Terrorism and Political Violence*, *21*(1), 62–88.

Podolny, J., & Page, K. (1998). Network forms of organization. *Annual review of sociology*, (pp. 57–76).

Pool, D. (1997). *Eritrea: Towards unity in diversity*. 1. MRG.

Popkin, S. (1979). *The rational peasant: The political economy of rural society in Vietnam*. Univ of California Pr.

Popkin, S. (1991). *The reasoning voter: Communication and persuasion in presidential campaigns*. University of Chicago Press.

Posen, B. (1993). The security dilemma and ethnic conflict. *Survival*, *35*(1), 27–47.

Posner, D. (2005). *Institutions and ethnic politics in Africa*. Cambridge Univ Pr.

Rabushka, A., & Shepsle, K. (1972). *Politics in plural societies: A theory of democratic instability*. Merrill Columbus, OH.

Rauch, J., & Trindade, V. (1999). Ethnic chinese networks in international trade. Tech. rep., National Bureau of Economic Research.

Riker, W., & Ordeshook, P. (1968). A theory of the calculus of voting. *The American Political Science Review*, *62*(1), 25–42.

Risse-Kappen, T. (1997). *Cooperation among democracies: The European influence on US foreign policy*. Princeton Univ Pr.

Rosenstone, S., & Hansen, J. (1993). *Mobilization, participation, and democracy in America*. Macmillan Pub. Co: Maxwell Macmillan Canada: Maxwell Macmillan International.

Sageman, M. (2004). *Understanding terror networks*. Univ of Pennsylvania Pr.

Sageman, M. (2008). *Leaderless jihad: Terror networks in the twenty-first century*.

Univ of Pennsylvania Pr.

Shapiro, J. (2008). Bureaucracy and control in terrorist organizations. *Princeton Uni*.

Singer, J. (1988). Reconstructing the correlates of war dataset on material capabilities of states, 1816–1985. *International Interactions*, *14*(2), 115–132.

Skyrms, B. (1996). *Evolution of the social contract*. Cambridge Univ Pr.

Skyrms, B. (2004). *The stag hunt and the evolution of social structure*. Cambridge Univ Pr.

Snyder, J. (1984). *The ideology of the offensive: Military decision making and the disasters of 1914*, vol. 2. Cornell Univ Pr.

Walt, S. (1987). *The origins of alliances*. Cornell Univ Pr.

Watts, D., & Strogatz, S. (1998). Collective dynamics of ÂŚsmall-worldÂŠnetworks. *nature*, *393*(6684), 440–442.

Williamson, O. (1979). Transaction-cost economics: the governance of contractual relations. *Journal of law and economics*, *22*(2), 233–261.

Williamson, O. (1981). The economics of organization: The transaction cost approach. *American journal of sociology*, (pp. 548–577).

Williamson, O. (1996). *The mechanisms of governance*. Oxford University Press, USA.

Wong, W. (2008). *Centralizing principles: How Amnesty International shaped human rights politics through its transnational network*. ProQuest.