Political Economy of Crony Capitalism: Credible Commitments without Democratic Institutions *

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Comments Welcome

Abstract

Governance in nondemocratic settings is often characterized by its informal nature and apparent neglect of formal institutions. Two distinguishing features include (1) the private formulation and dispensation of special privileges; and (2) social connections among beneficiaries. The purpose of this paper is to gain a better understanding of these informal institutions and their impact on the credibility of growth-enhancing policies and implications for political stability. To that effect, I present a game-theoretic framework with a dictator and a number of political and economic actors who are embedded in various social networks. I posit two relational mechanisms that impact aggregate outcomes of predation (which corresponds to less policy credibility). I derive equilibrium predation conditions built around an exogenous network structure. With the use of a computational model, I explore how various network structure affects incentives for a government to respect property rights. A statistical analysis finds support for the posited relational mechanisms.

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1 Introduction

By definition, dictatorships are relatively unconstrained by formal political institutions and can use their unchecked authority to prey on others or renege on prior commitments without incurring major consequences. This potential abuse of authority highlights the core problem in the literature on institutions and economic growth (the political economy of development): whereas strong governments are deemed necessary to guarantee the security of property rights and to enforce contracts, they can also withdraw protection or otherwise engage in predatory acts, so with greater political strength comes less credibility (Weingast (1995)).

Dictators–as instances of very strong governments–should therefore have very little credibility when they make promises to promote investment. Yet several dictatorships have successfully promoted growth. Under what conditions can dictators refrain from preying on investors? What are the enabling conditions for effective governance and policy credibility in dictatorships?[1]

The extant literature does not provide an answer to these questions that readily identifies which (non-democratic) institutions can be conducive towards economic growth. To be sure, there has been widespread interest among scholars and policymakers to better understand the political foundations of economic growth. The extant research suggests that the security of property rights is paramount (North and Thomas (1973), North (1990), and Bank (2001)). The required political foundations for the security of property rights entail the existence of a relatively strong government to arbitrate disputes and enforce contracts. Given these criteria, dictators would be good candidates to promote development in principle. Unfortunately, as the record of economic growth clearly shows, most dictators do not promote growth in practice.

What is more, there is a widespread consensus that the political foundations of growth are essentially democratic. Institutions of limited government, which couple a strong government with strong institutional opponents are seen as key requirements for development (North and Weingast (1989), North (1990)). The role of formal (democratic) political institutions is to mediate the interaction between governments and other actors. Formal institutions also mitigate potential opportunism, not just by an executive, but also by other actors that could try to weaken the government. In fact, the effectiveness of limited government hinges crucially on a division of labor (a formal

[1] I use the term *governance* in a narrow sense to denote an effective exercise of government that provides adequate regulatory and legal environments to facilitate economic development. This is one aspect of governance that is highlighted in recent research (Kauffman et al. (2005)) and is closely related to the political foundations espoused in the literature on institutions and growth.

structure) that also limits other institutional actors. The term limited government is drawn from political philosophy and has greater significance beyond credibility in terms of various rights. A better term for the institutional solution to the policy credibility problem in democracies would be strong, limited government or limited-but-still-strong government; in effect, strong government *and* strong institutions.

According to the extant theory on institutions and growth, dictatorships should have a hard time generating policy credibility because they lack the right political institutions even if they satisfy the criterion of strong government. The explanatory power of the extant theory is indeed confirmed by the fact that most dictatorships are poor.[2] But theories of institutions and growth cannot explain the ample evidence that dictatorships can grow despite the apparent lack of good, democratic institutions . What is more, most recent examples of phenomenal growth have occurred under authoritarian settings (Campos and Root (1996), Przeworski et al. (2000)), most notably in the case of contemporary China.

One way to resolve this apparent contradiction is the recognition of the relevance of strong governments. To be sure, dictatorships possess the first part: a strong government that could potentially engage in benevolent acts to promote the economy. Indeed, there are various related literatures that emphasize this potentially beneficial effect. The literature on benevolent dictatorships emphasizes the ability to take decisive actions to expedite economic development (Wade (1990), Olson (2000)). What is more, dictators can take a leading developmental stance that would not occur otherwise if a more democratic environment empowered actors who were opposed to development.

We know some conditions that motivate dictators to be benevolent. Olson (2000) identifies two conditions that enable stationary banditry: encompassing interests and long-term horizons. In a nutshell, the dictator must benefit directly and permanently from economic growth.[3]

Although useful in terms of identifying relevant incentives, the theory of stationary banditry lacks a more detailed specification of the political foundations of stationary banditry. What exactly are encompassing interests? How do dictators attain longevity?

One way to signal longevity is to create institutions (Olson (2000)). Wintrobe (1998) also notes that a process of institutionalization needs to be in place. But if

[2] Although Przeworski et al. (2000) point to a potentially confounding variable related to institutional change and stability: institutions are costly to maintain, so the reason why many countries are poor may be due to the fact that they have not been able to afford "good" institutions rather than because of a particular regime.

[3] In the literature on developmental states, it has been argued that the organization of society, and embeddedness of government, are crucial factors to facilitate economic development. See Evans (1989).

what is required are formal political institutions, it remains unclear how the process works. Formal institutions need not be democratic, but if they are not, then dictators ought to worry about their security (Wintrobe (1998)).

There is no apparently easy way for a dictator to promote growth. To mitigate the security dilemma, the dictator could "democratize" a bit. But if democratization is what is required, then we are back full circle to the arguments for (democratic) limited government that would apply even to dictatorships. Moreover, if buying loyalty is predicated on revenue from economic activity, then the dictator cannot avoid the credible commitment problem of growth (unless there is an unexpected windfall). To buy loyalty, the dictator must promise growth, but promises are not credible because he is too powerful.

Clearly, a more systematic analysis of dictatorial or non-democratic institutions is required to better understand the exercise of authoritarian government. These governments can try to shape the organizational landscape; however, there is no typical political organization that characterizes all dictatorships (**?**). Just like in democracies, dictatorships accommodate a wide range of political systems with varying number of parties, legislatures, and formal and informal institutions.

The approach taken in this paper is to focus primarily on informal institutions, which can be found in all dictatorships. This is not to say that formal institutions are always irrelevant in dictatorships, but rather the approach here is to understand how authoritarian government transpires under the assumption that formal institutions are inefficient. What is more, with regards to the credible commitment of growth, there are both theoretical and empirical reasons that would justify an approach that pays more systematic attention to the informal realm of dictatorships.

On the theoretical side, the main argument in favor of further scrutiny of informal institutions lies with the fact that dictators typically have more discretion than democratic governments. Hence, formal constraints–even if they exist–are generally less binding. One would want to ask what dictators do with their added discretion. I will argue that they use it primarily to seek privileges for themselves and other political actors with exclusive access to the dictator. On the empirical side, there is ample evidence that dictators use their discretion to engage in favoritism and to provide targeted benefits to specific people. The exercise of authoritarian government is then neither public nor anonymous.

The focus of the paper will be on trying to understand the role of informal institutions in facilitating policy credibility. This paper analyzes the relational (personalistic) nature of non-democratic policymaking processes. Clearly, informal institutions can be conceptualized in different ways, but a network-analytic approach provides apt conceptual and methodological tools that enable a more realistic modeling of the types of policies we often observe in non-democratic settings.

This is an exploratory paper with a theoretical agenda. It is exploratory in the sense that the approach is relatively novel and there are a myriad of possibilities in terms of how one can apply network-analytic tools to the question at hand, as well as more general questions of political economy and comparative politics. The study of networks is not itself new, but has largely been an empirical and descriptive (endeavor Knox et al. (2006)). The aim of this paper is to use network concepts and tools not just to analyze actual networks, but to build theory.

The rest of this paper is organized as follows. In section 2, I explain the relational nature of non-democratic policymaking with a special attention to the award of special privileges (what I call private policies). These privileges exacerbate the credible commitment problem of growth because unlike democracies (where the option for universal protection may sometimes be feasible), dictators must individually commit to each and every commitment that they make. The unit of analysis therefore *changes* from societal to individual or private commitments. I further examine conditions under which private policies can be deemed credible. In subsequent sections, I explore how network structures affect the incentives of political and economic actors to maintain networks of private protection or special privileges. Section 3 discusses two relational mechanisms that can scale up individual commitments to become more like societal commitments. Section 4 introduces a more general framework that can accommodate a variety of network structures, and a corresponding game-theoretic analysis to understand how network structures have aggregate effects. Section 5 provides a preliminary computational analysis of the the formal theory. Section 6 concludes. For readers who are unfamiliar with network analysis, the paper includes two appendixes with key concepts.

2 Dispensation of Privileges and Selective Commitments

Non-democratic regimes are characterized by lack of widespread political competition and by concentration of political authority. Clearly, on the political side, the dictator and close allies have a privileged position: other actors have limited access, if any, to the political system. Are economic opportunities also restricted? Who gets benefits under dictatorships? What selection process determines beneficiaries of dictatorial policies?

Both the theoretical and empirical literature on dictatorships highlight the fact that economic benefits are not distributed randomly. On the theoretical side, Wintrobe (1998) notes that dictators award benefits strategically. Wintrobe characterizes the political economy of dictatorships in terms of a so-called dictator's dilemma: with greater power, the dictator is more insecure. In this context, the motivation for the distribution of benefits is to appease potential challengers or actors that may attempt against the dictator.[4]

But "buying loyalty" is just one of two costly instruments available to the dictator. In fact, the focus on benefits or privileges obscures the fact that dictators can also punish selectively. Dictators will generally use a mix of privileges along with the second available instrument of repression. All in all, the probability of being selected for either privileges or punishment is not equal for every member in society, depending on their perceived threat for the dictator.[5]

The empirical literature on dictatorships also emphasizes the important role that dictators have in allocating privileges to selected members of society. A common term used to describe this behavior is *crony capitalism*(Kang (2002), Krueger (2002)). The term depicts the fact that the recipients of privileges appear to be close associates of the dictator. For instance, when Ferdinand Marcos came to power in the Philippines, he rewarded long-time military associates. His wife, Imelda, who came from an illustrious family, also had her own network of cronies, a situation that has been characterized by Thompson (1998) as a "conjugal dictatorship." There are multiple other examples of enrichment of both dictators and their relatives or cronies. It is well-known, for example, that former President Suharto of Indonesia, for instance, diverted vast public resources to family enterprises (Vatikiotis (1998)).

Special privileges are often perceived as evidence of corruption, and for that reason the term crony capitalism is often conflated with corruption. There seems to be some justification for this connection as those cases where dictators favored cronies are also well-known for their misuses of public office for private gain, especially in East Asia but also in other regions like Latin America (Khan et al. (2000), Haber (2002)). Indeed, the crony capitalism that once was considered a foundation for East Asia's economic success, later was demoted to be main catalyst for widespread regional corruption

[4]A similar logic of survival that leads governments, including dictators, to dispense benefits is presented in Bueno de Mesquita et al. (2001)

[5]Clearly, no society expects equal treatment for all citizens under all circumstances. Generally, there will be a consensus that some people deserve rewards for some worthy behavior, whereas others deserve punishment for transgressions. Otherwise, citizens should not expect special treatment.

(Campos (2002)).

Despite the conceptual confusion between crony capitalism and corruption, the first term conveys an important notion regarding the relational aspect of these privileges.[6] The term identifies a group of people who benefit from special favors because of their relationship to a public authority, typically a dictator. For that reason, social networks–to the extent that they identify the dictator's cronies–can be an important determinant of who will receive special treatment by a dictator.

But the "crony" label can also be misleading insofar as it limits the number of actual beneficiaries. It is not always the case that only close associates receive privileges, even in cases that are known for their crony capitalism. For instance, whereas Ferdinand and Imelda Marcos did give special privileges to their cronies, political opponents also benefited. Major economic groups or influential family groups were awarded, or able to retain, various monopolies. Clearly, these groups did not receive all their wealth from the dictator, but they derived additional privileges from a power struggle that forced Marcos to make some concessions (Thompson (1998), Hutchcroft (1991)).

In general, there are various mechanisms that can affect the selection of beneficiaries of special privileges. Crony networks–defined with an explicit connection to the dictator–are likely to be an important mechanism. The political environment will also be an important factor to the extent that a dictator cannot exclude certain groups from society.[7] Finally, other social networks can play a role when cronies and other political actors attempt to get benefits for their own associates.

Clearly, special privileges are not an exclusive feature of dictatorships. Democracies also face problems with rent-seeking and undue influence to award special privileges to special interests (Murphy et al. (1993), Peltzman (1976)). Moreover, corruption can also be found in all types of regimes (Rose-Ackerman (1999), Haber (2002)).

Dictatorships, however, have a greater ability to award special privileges due to fewer institutional constraints. By definition, dictators are somewhat above the law, so they have more discretion than democratic governments both in terms of policy-making powers as well as how they may allocate available public resources.[8] Regarding non-democracies, one would expect less discretion in cases that approach a totalitarian

[6] I will briefly discuss some implications of this paper for the study of corruption towards the end of this paper, but the concept requires a separate, more detailed analysis than is possible here.

[7] Various processes of rent-seeking will also determine access to the dictator (Khan et al. (2000)

[8] Throughout this paper, I will make a distinction between democracies and dictatorships as distinct types of regimes with different properties to facilitate the presentation. I am aware that discretion varies considerably within regimes. On the democratic side, one can find cases where governments have a lot of discretion and hence would behave as the dictators I describe in this paper (e.g., Mexican presidents during the 20th century, Weldon (1997)).

system where ideologies impose more constraints on governments (Linz (2000). Sometimes, there may even be constitutional dictatorships that impose real–but not unsurmountable constraints–on authoritarian government (Barros (2003)). On the other extreme of unconstrained dictators, one would find the more sultanistic or personalistic regimes studied in the literature (Chehabi and Linz (1998), Geddes (1994)).

The rest of this section will explore the implications of dictators' greater discretion and ability to offer special privileges for policy credibility. First, I relate the distribution of special privileges to the questions of how governments can make credible commitments to promote growth. Second, I present a basic game-theoretic model to establish conditions under which individual promises by the dictator can be deemed credible. I discuss briefly the role of social networks in facilitating selective commitments as a roadmap for subsequent sections.

2.1 Selective Commitments

I argue that the political economy of dictatorships rests on the dispensation of special privileges. That is, policymaking will be driven by attempts to obtain privileges directly from the dictator. For that reason, "public policies" in dictatorships will be qualitatively different from those of democracies in that they will not, in effect, be public: dictatorial policies will have an inherently private character. Unlike the wide applicability and anonymity of many policies in democracies, policies in dictatorships will be formulated to provide specific benefits to particular actors. Henceforth, I will then use the term private policy instead of special privileges to denote their narrow construction from a policymaking perspective.[9]

I will refer to the recipients of private policies as asset holders to motivate a connection to the literature on institutions and growth. As I noted above, there are several mechanisms that allow or force the dictator to identify recipients. A careful analysis of the selection process is beyond the scope of this paper. In what follows, I will assume that the selection process has already taken place and identified N asset holders denoted by the set $\{A_1, A_2, ..., A_N\}$.

Asset holders are interested in deploying their assets into investment projects. Recognizing the dictator's discretionary power,asset holders will be primarily motivated to invest because of the prospect of obtaining rents.[10] Higher rents could occur under

[9] I draw on Bueno de Mesquita et al. (2001) to make this distinction between private and public policies.

[10] *Rents* are supranormal profits beyond what would be obtained in a competitive setting.

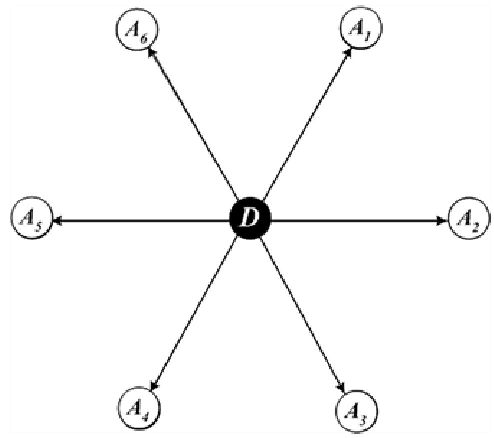

Figure 1: Awarding of private policies

various scenarios, but typically require some market or monopoly power.[11] But to obtain market power, they will need to obtain a private policy from the dictator.

The dictator will thus award private policies to many asset holders as illustrated in Figure 1. Known as a sociogram, this figure serves to visualize and introduce the notion of a social network for subsequent analysis. A social network is precisely defined in terms of a set of nodes and a relevant connection or relationship among the nodes (Wasserman and Faust, 1994, p. 71-72). Letting D denote the dictator, the set of nodes is $\{D, A_1, A_2, ..., A_6\}$. The sociogram illustrates the relationship "awards private policy to", which clarifies the one-way nature of these ties: only the dictator can dispense privileges.[12]

To actually invest, however, asset holders must be assured that their property rights are protected. However lucrative a private policy may be, property rights and market power are inherently insecure because a dictator with discretion can easily abrogate those rights. In other words, there will be no investment if the asset holder does not think that the dictator's policy is credible.

Policy credibility in dictatorships is inherently difficult for two reasons. First, dic-

[11]Note that this anticompetitive behavior appears to be the exception rather than the rule. Economic actors generally care about their own property rights (Do and Levchenko (2006)), and, if given the opportunity, would prefer market power to none.

[12]Note that this is not the only relationship possible among these actors, but is one that is particularly relevant in dictatorial settings. More generally, the concept of a relationship can be used to denote any type of connection or tie among the nodes. Relations can either be directed (as in this case from dictator to asset holder) or undirected. Note that the definition of a network requires both a set of nodes as well as a relation. Changing either the set of nodes or the relation effective defines a different network. For instance, the same group of nodes could also be related if some of the nodes were relatives, in which case there would be a separate kin network besides the crony or privileges network.

tatorships do not have recourse to the mechanisms that enable credible commitments in democracies (North and Weingast (1989). In particular, dictatorships lack public enforcement mechanisms. Without public enforcement and institutions of limited government, dictators will be tempted to induce asset holders to invest and prey on them later.[13]

The second reason identifies a unique problem for dictators. To be sure, the quality of institutions varies even within democracies, so ineffective formal institutions is not a distinct feature of dictatorships. What distinguishes dictatorships from democracies, however, is their greater reliance on private policies. The problem with private policies is that just as they are formulated to benefit individuals, these policies also need to be individually credible as explained below.

Dictators could, of course, make a promise to offer universal protection but investors would be unconvinced. This promise would not be credible due to the absence of democratic institutions and public enforcement. Just as the dictator can offer privileges, which amount to selective protection, it can also engage in selective predation. This is, in fact, a fairly typical and rather persistent scenario as there would be actors with incentives to collude with the dictators to prey on others (Weingast (1997)). Dictators therefore find themselves in a situation where offering concurrent private policies to various actors exacerbates the credibility problem. Why would they incur this additional complexity? As will be seen below, dictators may not mind multiple private policies because offering them can be very profitable for the dictator. However, the more private policies that are offered, the greater the workload and expectations for the dictator to deliver on his promises to each asset holder. I refer to this situation as the *governability dilemma* (Razo (2008)).

2.2 Incentives for private protection

Since each private policy must be deemed credible, it will be helpful to understand how the dictator can make selective credible commitments to each asset holder. I model this situation in terms of an investment game where a dictator D offers a protection policy to an asset holder A_i.[14] A's investment has the potential to generate positive rents R_i. I assume that the dictator is self-interested and motivated to offer a private policy in

[13]This problem is more general and is also known as the fundamental dilemma of government: whereas strong government may be needed for certain benevolent purposes, strong governments can also abuse their authority (Weingast (1996)).

[14]This is, in effect, a model of the so-called credible commitment problem of economic growth that underlies the literature on institutions and growth and is based on a simpler version in Razo (2008).

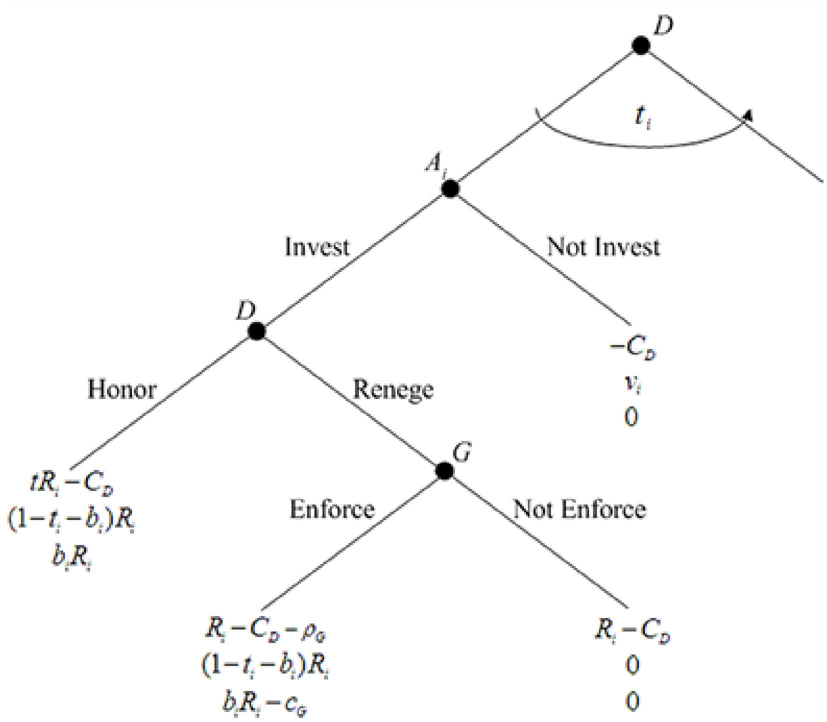

Figure 2: Investment game with private protection

exchange for a share of R_i. The sequence of this game is illustrated in Figure 2

The asset holder chooses whether to invest on the basis of D's proposed policy. Given the prospects of rents, the policy instrument chosen by the dictator is a tax rate $t \in [0, 1]$, which is the share of rents that D demands in exchange for the private policy. Admittedly, some of the rents could be used for the dictator's own consumption, but at the very minimum, D must cover his operating cost of C_D.

In a polity with secure property rights, A_i would be left with after-tax rents equal to $(1 - t)R_i$. However, the fact that A_i faces a dictator requires additional preventive measures. In general, A_i will be forced to pay for private protection.[15] For that purpose, it will recruit a private enforcer, a third-party G, who will be required to punish the dictator should the latter renege on its commitment.

Reneging in this game will occur if D wants to take more than the proposed share of rents. In fact, it is clear that taking all of A_i's rents will dominate any lesser amount, and so predation is represented by D's choice to take all of R_i as opposed to $(1 - t)R_i$.

Effective third-party enforcement, however, is costly for both G and A_i. I assume that G can impose a penalty ρ_G on D, but in so doing, G incurs a personal cost c_G. G

[15]It will be clear below that D would not be credible otherwise, although the existence of a third-party by itself does not guarantee commitments either.

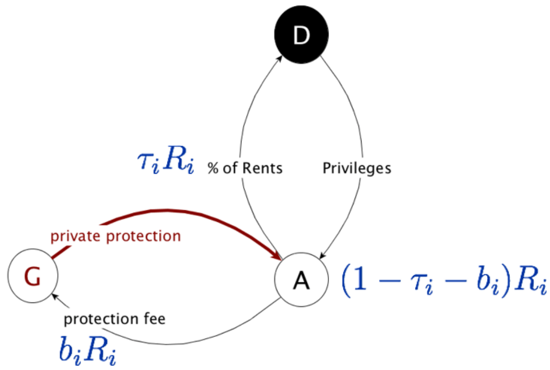

Figure 3: Unit of analysis: a private policy from G to A, enforced by G

will then not be willing to provide private enforcement without some compensation. I therefore assume that A_i must offer a share b_i of its profits to induce G to enforce the private policy. If D honors his commitment, then A_i will have a payoff of $(1-t_i-b_i)R_i$. Figure3 illustrates this informal arrangement.[16]

Player D's strategy involves two decisions, first what tax rate to propose, and secondly whether to honor the policy or not. Letting H have the value 1 when D honors the commitment and 0 otherwise, D's strategy can then be summarized as $\sigma_D = \{t, H\}$. A only as a decision to invest, or $\sigma_A = \{I\}$ where $I = 1$ if A_i accepts D's proposal and 0 otherwise. The strategy for G is defined similarly as σ_G, with a corresponding binary enforcement decision variable $E \in \{0, 1\}$.

Can the dictator make a credible commitment? For policy credibility to occur, a key condition is that G has incentives to enforce. I will therefore use backwards induction to solve this game, starting with G's enforcement decision, working my way back to D's policy decision. This process will serve to derive the game's Subgame Perfect Nash Equilibrium (SPNE), which will be defined in terms of the three players' optimal strategies.(Osborne and Rubinstein, 1994, pp. 87-116)

For G to enforce, following D's reneging, it must be the case that $b_i R_i - c_G \geq 0$.[17] If that enforcement condition holds, then D will honor its commitment if the corresponding payoff is greater than that of reneging with enforcement, which simplifies to $\rho_G \geq (1-t_i)R_i$. Let $\rho^* = (1-t_i)R_i$ be the critical value that satisfies this condition. To put the importance of third-party in perspective, define p to be the probability that $\rho_G \geq \rho^*$. The dictator will then honor his commitment if $tR_i - C_D$ is at least equal

[16] A_i has an reservation value v_i reflecting its ability deploy assets elsewhere.

[17] I assume that when indifferent, players will choose as follows: G will choose to enforce, D will choose to honor its commitment, and A_i will choose to invest.

to the expected utility of reneging. After rearranging, the *Commitment Condition* becomes

$$\rho^* \geq \frac{(1-t_i)R_i}{p} \tag{1}$$

Note that as the probability of successful enforcement vanishes, $p \to 0$, the required penalty ρ^* required to deter predation goes up to infinity. The implication for dictatorships is that no commitments are feasible if there are no available third parties with enough power to punish D. Thus, the distribution of power in dictatorships will be key to enhance credibility. An alternative interpretation for a low p is that absence of shared beliefs on the limits of public authority (Weingast (1997)). If there is no consensus on what to do following an act of predation, D will be able to prey with impunity. Higher values of p could also be related to the existence of an independent judiciary that provides public enforcement. It is important to note that enforcement is always costly. Without compensation of some sort, not even an independent judiciary would want to punish an abusive government.[18]

For A_i to invest, it must be the case that after-tax payoffs minus protection fees must exceed its reservation values. This condition simplifies to $(1-b_i) - v_i/R_i \geq t_i$. The dictator will need to satisfy A_i's participation as well as its own need to cover operating costs. If C_D is too high such that $(1-b)R_i < C_D + v_i$, then D will not be able to offer a low enough tax rate. The basic requirement will be that rents be huge–relative to A_i's reservation value. Expressed in terms of rents, both D and A_i will find the private policy attractive if

$$R \geq \frac{C_D + v_i}{(1-b)} \tag{2}$$

From a political standpoint, this condition also helps to illuminate how political stability considerations may affect policy credibility. If C_D increases, it will be more difficult to satisfy the inequality above. This situation could arise either because the dictator is stable but requires huge resources to satisfy other supporters (i.e., the dictator is rather weak and vulnerable to extreme demands). Alternatively, higher costs could also signal potential instability as the government is forced to spend more to defend against potential or actual threats.

[18]Arguably, there is a probably a weak connection between the existence of an independence judiciary and democratic government as prerequisites for credibility. For example, there are viable parliamentary systems without independent judiciaries but limited governments. Perhaps a better term would be "veto players", but there remains a requirement for these players to have shared beliefs that enables them to act as a cohesive group.

Overall, one can obtain an equilibrium with a credible private policy t^* that satisfies participation constraints and induces investment, but it will require very profitable investment opportunities and the existence of effective third-party enforcers.

Conditions 1 and 2 were derived in the context of a single private policy. The rent requirements can be somewhat mitigated by offering multiple private policies, in which case the operating costs of government can be distributed across various A_i's. But managing multiple commitments concurrently makes authoritarian government more complex, so there will also be incentives to minimize the number of beneficiaries in response to the dictator's governability dilemma.

Despite the fact that third-party enforcement is provided on an exclusive basis, offering multiple private policies may enhance the credibility of individual policies under certain conditions. Recall the commitment condition with $p = 1$: $\rho_G \geq (1-t_i)R_i$. This condition requires not just a willing, but an effective third-party that can effectively impose a penalty greater than predation gains. This is, in fact, a rather stringent condition given that dictators are typically more powerful than other actors in their societies.

As it turns out, asset holders can rely on informal institutions or private enforcement mechanisms to induce dictators to honor their commitments. These informal mechanisms are often mediated through social networks. The following two sections explain the functioning of two relevant relational mechanisms that can enhance policy credibility.

3 Relational Mechanisms and Encompassing Interests

The core problem in the literature on institutions and growth is the existence of a potentially predatory government. Unless that government makes a credible commitment, there will be limited, if any, investment. The previous section established general conditions under which credibility can be attained for the private policies that predominate in dictatorships. Selective commitments are possible, but require private enforcement mechanisms. Private enforcement, in turn, requires the sharing of rents with other actors.

The basic idea behind this paper is that social networks can facilitate the enforcement of such private policies. To be clear, private policies are the basic unit of analysis, and as done in the previous section, we need to establish their individual credibility.

However, the dispensation of special privileges is not devoid of social context. I am not speaking here of the social networks that determined who got special privileges, but rather connections among asset holders and potential third-party enforcers.[19] Under some conditions, these latter connections can provide incentives for recipients of special privileges to mobilize to protect the network.[20]

Collective action against predatory attacks can take place as a function of social structures regardless of the selfish nature of participants. As firms seek private policies and hire private enforcers, there emerges a social structure that ties their interests in various ways. In general, the pool of potential third-party enforcers is likely to be small in a dictatorship. Hence, it is likely that different firms in the pursuit of their own interest may nonetheless share common enforcers. It is also possible that firms themselves may be related in various ways. The same could be true for third-party enforcers. To properly understand the implications of private policymaking in dictatorships, we therefore need to engage in a *multilevel* analysis that contemplates individual policies in their social context.

I propose two relational mechanisms that may enable collective action or a network response against predation. The first relational mechanism entails the propagation of predation risk throughout the network. The second relational mechanisms entails the pooling of enforcement capabilities or the activation of multiple private enforcers. These mechanisms can, under certain conditions, enable the "scaling up" of what would otherwise be individual interactions with the dictator to more extensive reactions that can encompass larger segments, if not the whole network.

3.1 Propagation of Predation Risk

To motivate the first relational mechanism, it bears repeating that private policies must be deemed credible on an individual basis. As noted before, this is a more stringent requirement than in democracies where governments may be able to make universal commitments. In principle, because the dictator could prey on anyone, then everyone would be vulnerable a priori. The logic of private protection analyzed in the previous section suggests that not everyone is equally vulnerable. As long as a firm has reliable

[19] A richer framework, beyond the scope of this paper, could accommodate the mediating role of *some* networks in the distribution of privileges as well as the role of potentially distinct networks to protect such preferences.

[20] Henceforth, I will use the terms and asset holders interchangeably to denote recipients of special privileges. These terms are warranted given the paper's focus on investment decisions. However, the notion of privileges extends well beyond economic benefits. As long as participants derive some benefits, the implications of investment with private protection would apply to other domains as well.

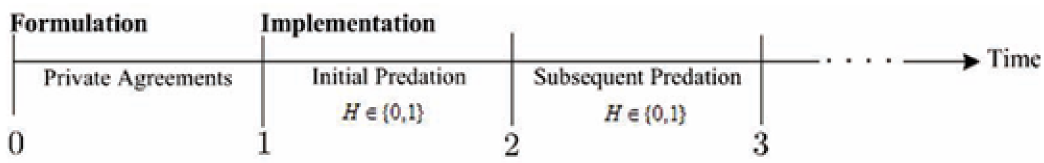

Figure 4: Private policymaking process

enforcer, it need not worry about the dictator's additional commitments. In general, firms will hire enforcers of varying qualities, not all powerful enough to take on the dictator by themselves, so the threat of predation remains imminent.

How can investors know that they are subject to predation? How can they gauge the risk of predation? Unfortunately, the private policymaking environment of dictatorships does not convey much information to answer these questions. The main reason is the lack of a public signal or mechanism that tracks the interactions of the dictator with individual asset holders. Just as the dictator can offer isolated or selective protection, it can also engage in selective protection. Put another way, the history of play between D and all A_i's need not be common knowledge.

Even if there's some knowledge of D's past behavior, it may be difficult to draw inferences based on that information.To motivate the analysis, imagine a sequential policymaking process as illustrated in Figure 4. At every point in time, the dictator can pick a victim. If at time t, the dictator has chosen firm A_i, what inferences can be made about who will be next? Note that after one act of predation, the government provides some information about its type (whether it is benevolent or predatory), but who will be next victim?

In a first stage, D offers private policies to firms, as in Figure 1. The policies are "implemented" when D makes a decision to collect either t_iR_i or all of R_i. To facilitate the analysis, suppose that implementation takes place over time after all firms have invested and generated their respective rents, and that D makes an implementation decision per period. That is, at any given point in time, D selects a firm that it may prey upon. Without prior history, it seems reasonable to assume that all firms are equally likely to be selected in the first implementation period. The question of interest is to predict who could be preyed upon in subsequent periods. Will predation proceed on a random basis as in the first period?

Random predation with equal probability for all firms is a reasonable prediction if the set of firms is homogeneous. Homogeneity in this context means that firms'

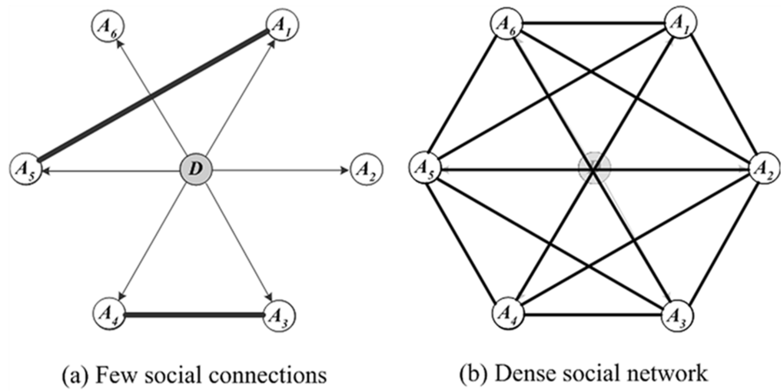

Figure 5: Privileges and underlying social connections

individual traits make them indistinguishable from one another. Among these traits, we may also incur their hired private protection and concomitant capacity for punishment.

Indeed, appeals to reputational mechanisms as a mean to deter predation are based on the implicit assumption of an underlying common risk. That is to say, the dictator either protects or preys indiscriminately, depending on whether he has a good or bad reputation. There is thus no reason to believe that one's property is more likely to be confiscated than someone else's. Expressed in terms of probabilities, the implicit assumption is that of equal and positive probabilities for all.

Note that uniform random predation effectively groups all firms in the same class. But if we allow the possibility of heterogenous agents, the risk of predation is no longer the same for all firms. This result was already established in the particular case of private protection where certain asset holders can unilaterally enforce their own property right with the assistance of third parties that can differ across firms.

But even if all firms had the same attributes and third-party assistance, their risk could be different due to a different type of heterogeneity having to do with their social networks. Firms can be embedded in various networks in different ways. If we have a reason to believe that networks may transmit predation risk, then network participants can use network structure to make inferences regarding future victims of predation.[21]

Consider, for instance, the crony network discussed in section 2. Devoid of any underlying social structure, the social aspect of that crony network can be accurately depicted by Figure 1 without any ties among the firms. But what if there were ties?

Figure 5 illustrates two possible sets of social connections superimposed on the original crony network. In panel (a), there are two ties, one between A_1 and A_5 and

[21]Concurrently, network connections may reveal to the dictator the vulnerability of linked firms as the dictator traverses the network, preying on related firms.

another connecting nodes A_3 and A_4. How would one interpret a predation attack in this context? If D were to predate against an isolate (the term used to denote nodes without connections) in terms of the second network, no information is conveyed on who would be next. Firms A_2 and A_6 may be able to protect their property rights if they have reliable enforcement. However, knowing that, say, A_2 has been attacked, should not alter A_6's beliefs about its own probability of being selected next.

In contrast, suppose that D preys on A_1. In this case, A_5 may have reason to believe that it will be next. To give a substantive example, if the relationship defined a common ethnicity, then a Chinese investor under the Suharto regime in Indonesia would feel more vulnerable if another Chinese investor was previously attacked by the dictator. By the same logic, an attack on A_4 may also increase the risk of predation for A_3.[22]Consider now panel (b) where all nodes are connected on the superimposed social network. In that case, an attack on any firm readily propagates risk to all other firms.[23]

If we consider both firm attributes as well as their social networks, then it also becomes clear that appealing to a common reputational mechanism not only implies homogeneity in terms of individual traits, but a complete social network.[24]

Different social structures will induce different propagation patterns. Suppose, for example,that for some reason D were to prey on A_1. If A_1 were part of an empty network as in panel (a) of figure 6, then it would be up to G_1 to attempt to protect the firm. If A_1 were a central node in a social network, as in panel (b), then the other nodes could easily be reached in one step (i.e., be equally likely to be the next victim).[25]

Panel (c) is an example of a more decentralized network structure. Here, an attack on A_1 propagates risk to all other firms All the nodes are reachable from any other node, so the network has just one *component* (i.e., there are no disjoint subsets of nodes). But the relative distance of other nodes with respect to A_1 varies. Thus, A_6 would face a higher risk than A_5. In contrast, Panel (d) illustrates a segmented

[22]To clarify, this paragraph does not imply that all social networks would propagate the risk of predation. It is to say, however, that it is possible to do so. It is up to analysts to clearly define a relevant social network that can perform this function. Another example that could work here would be a kin network.

[23]See Razo (2013) for a discussion of informational differences across democratic and non-democratic settings.

[24]A network is said to be complete when all of its nodes are connected. Another extreme is an empty network where all networks are isolates or disconnected from one another. The more realistic social structures will be non-empty and incomplete, especially when the set of nodes is large.

[25]Panel (b) is an example of a star network. A_1 is kept in a corner to keep the layout of nodes constant across panels, but the star shape of the network could be readily depicted by moving A_1 to the center of the sociogram.

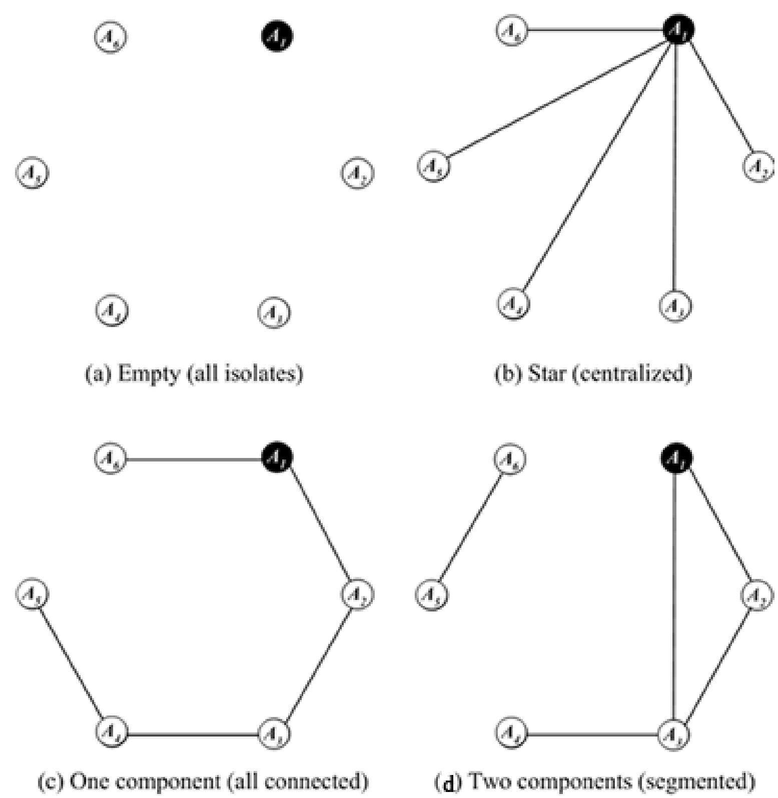

Figure 6: Propagation of predation risk through various network structures

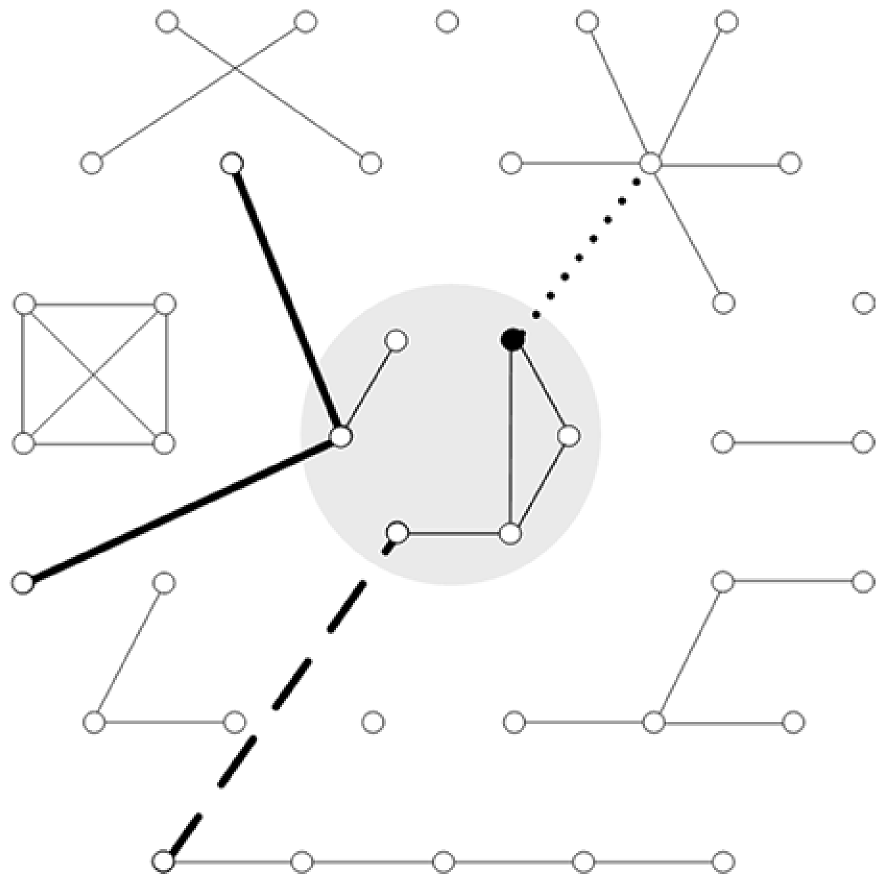

Figure 7: More complex social structures for propagation of risk

structure with two components. In this social context, an attack on A_1 does not affect either A_5 or A_6.

Figure 6 served to illustrate some canonical social structure, especially the star-shaped and one-component examples used to represent centralized and decentralized social structures. The number of nodes was kept arbitrarily low to highlight the relevant structural features. These examples are better understood in terms of local structure or the neighborhood of A_i. In general, social networks can accommodate more complex structures as well as a larger number of nodes.[26] In fact, this local structure could be part of larger network as I examine below.

How does the existence of more nodes affect the propagation of risk? Given the vast number of possibilities, I will briefly address this question using the sample sociogram shown in Figure 7. For this example, I embed panel (d) from Figure 6 into a larger network with various related nodes.

[26]see appendix for a brief overview of networks as random variables.

There are two general points to be made here. First, if none of the six firms have any ties to other nodes in the larger network, then panel (d) suffices to understand their social context. We can thus effectively ignore the global network.[27]

Second, if there were some ties, then we need to consider a wider neighborhood. For instance, we may realize that A_5 is the central node for a component of four nodes (the two extra nodes are connected with thick lines), but this larger component is immune to attacks on A_1. In contrast, if we consider A_1's and A_4's additional ties, then we see than an attack on A_1 would propagate risk to a large number of close and distant nodes. In this context, A_1 and A_4 act as *bridges* that span the scope of local network neighborhoods.

In summary, social networks can propagate the risk of predation. Despite the fact that the dispensation of special privileges is a rather decentralized process, social networks may link the fates of otherwise disconnected actors. Social networks are important for the study of the political economy of dictatorships because they make firms *more* vulnerable. More precisely, existing network structures can enable participants to perceive a *common* threat.

3.2 Collective Retaliation

This section explores a separate relational mechanisms: collective retaliation. By joining forces, private enforcers could inflict a tougher punishment on the dictator. If that were possible, individual policy commitments would be deemed more credible than with isolated G's. But given the exclusive nature of private policies, why would third-party enforcers act together, especially when it entails defending other firms from which they may not obtain direct benefits?

In general, there are various mechanisms that can enable collective retaliation. The private enforcers could be part of an organization, which compels them to provide assistance. The private enforcers could also be part of social networks that connect them and somehow activate mutual assistance. In other words, there can be both formal and informal mechanisms.

The relevant social network examined in this section is overlapping protection. Figure 8 illustrates this relationship, which arises naturally from the dispensation of special privileges and the decentralized logic of private protection. In effect, underlying the political economy of dictatorships is an affiliation network that connects two sets

[27] Nodes are kept in the same order as in Figure 1, but node names are omitted. A_1, as the target of a predation attack, is colored in black.

Figure 8: Overlapping private protection

of nodes: A and the set of third-party enforcers G.[28] In this diagram, there are two firms, A_1 and A_2 that are indirectly connected because they share one enforcer: G_2 protects both firms. This is the relationship that matters most for collective retaliation because an attack on what otherwise be disconnected firms (from the perspective of G) affects G's stake in the network.

As third-party enforcers provide protection for more firms, their stakes in the network will increase. To be clear, overlapping protection is important not because it links firms indirectly, but because it alters the behavior of third-party enforcers. For instance, if a dictator were to prey on A_2, the dictator reveals that he is undeterred by G_2's potential enforcement. But G_2 also has interests in the first firm, which produces benefits for G_1 as well. Hence, D's attempt against G_2 is also an attempt against G_1. At work here is the propagation of predation risk, as discussed in the previous section.

Overlapping protection does indeed propagate risk, but this is not its only or most important function. Unlike A_i's, which can also propagate the risk of predation through their social networks, G's have the added ability to retaliate by virtue of their position as private enforcers. Propagation of predation risk, in fact, "activates" otherwise unresponsive or disinterested private enforcers.

Whether they will actually retaliate will, of course, depend on individual traits through a cost-benefit analysis that weights the private cost of retaliating versus remaining inactive (when not being a direct target). In terms of social structure, however, the greater the propagation of risk through overlapping protection, the greater the incentive to retaliate, other things being equal.

4 Predation and Networked Enforcement

In the previous two sections, I considered two distinct, relational mechanisms. I develop here a more general framework that combines those relational mechanisms.

Suppose that there are two sets of relevant nodes: A_i and G. as in the previous

[28]To economize on notation, I will use the variable G henceforth to denote a set of enforcers that will be indexed to distinguish among its elements.

section. A network-analytic approach can accommodate rather complex interactions among these two sets. For instance, there could be a distinct social network that connects the A_i's. Denote this network by $N_A =< A, l_a >$, where l_a denotes that only ties between the firms are permitted. There could also be a separate social network that connects members of G. Denote this network as $N_G =< G, l_g >$. In addition, there could be ties that connects members of A with members of G, which I denote as $N_{GA} =< \{G, A\}, l_{ga} >$.

The third network is, in fact, fundamental to my theory. Due to the absence of public enforcement mechanisms, A_i's in dictatorships will require private enforcement. Some of this enforcement could be available in-house (A_i's with their own private police force, etc.). But in general, there will be a need for provided by third-parties. Note that D cannot be a third-party to enforce private policies because D's own lack of credibility is the reason to procure private enforcement in the first place.

How would the risk of predation and the potential for collective retaliation be affected by network structure? To the extent that all three possible networks exist, more complex social structures will enhance the propagation of predation risk. The reason is simple: there are more venues for the transmission of risk. Of course, propagation requires that participants make inferences in in relational terms: the relationship has to be meaningful for participants to condition their behavior on existing ties. For instance, an acquaintance relationship is not likely to have the same significance than a kinship relationship. To illustrate, the risk of predation should not increase for an actor observing a distant acquaintance being the victim of predation. In contrast, an attack on a family member is more likely to instill fear.[29]

More complex relationships need not lead to more enforcement, however. The reason is that the total capacity of a society to provide private enforcement is a fixed variable (given a limited supply of third parties). The relevant variable is the number of reachable nodes. Having more networks makes the system of social relations more redundant, but not necessarily a more efficient deterrent: there are multiple ways to reach or notify some G of attacks that require private protection.[30]

[29]There are interesting implications for questions regarding knowledge of these relationships. In this paper, I assume that all social relations are common knowledge. The dictator could make "mistakes" by attacking actors that are connected to others without the dictator's knowledge. Some of these mistakes could be costly, but the dictator would likely have to time to learn that relations matter; hence, he would no longer ignore relations when contemplating future attacks. More generally, it may not be warranted to assume that participants are aware of all relevant connections. See Razo (2010) for a particular application that addresses the issue of incomplete information about networks that may mediate social coordination.

[30]Having more networks can increase the speed of retaliation because some G's could be reached faster. The sequential model I present below ignores the issue of delayed responses, hence the conclu-

But if credibility is contingent upon collective retaliation, which in turn, is not directly affected by the existence of multiple networks, it will be easier to proceed with the analysis of a simpler structure. In what follows, I will therefore assume the existence of a bipartite network N_{GA}.[31] Given N_{GA}, one can derive two simpler networks that do, in fact, connect nodes of the same set. One possibility is to relate firms because they share one enforcer. I will ignore this possibility because by construction, investors cannot do anything about predation. The second possibility is overlapping protection, which was defined in the previous section, which will be the preferred network structure for the analysis of policy credibility. With these simplifications, both the propagation of risk as well as collective retaliation will be mediated through the induced network of overlapping protection among private enforcers.

4.1 General framework to analyze networked private protection

In section 2, I presented conditions for the enforcement of private policies with the use of (isolated) private enforcers. Here I explore how various patterns of overlapping protection may further enhance enforcement of private policies.

Third parties providing private protection will be included in the set $G = \{G_1, G_2, ..., G_M\}$. Let there be N firms identified by the set $A = \{A_1, A_2, ..., A_N\}$. Each firm makes independent decisions to "hire" private protectors. The choice of whom to hire is not modeled in this paper, but the outcome of this hiring process is a pattern of connections between firms and their respective protectors.[32] The sets G and A are connected by a (binary) protection relation P that exists when one element of G protects one member of A: $G_k P A_i$ means that G_k protects (or is affiliated with) A_i.

Technically, this is an affiliation or two-mode network between two distinct sets of nodes as previously noted. To avoid excessive notation, however, I will use P_i to denote the set of public officials affiliated with a particular asset holder A_i: $P_i = \{G_k \in G | G_k P A_i\}$. This notation can be used to readily summarize all actual protection connections in a vector $P = (P_1, P_2, ..., P_n)$.[33]

sion that additional network structures do not have a direct effect on collective retaliation.

[31]A bipartite network is defined by two distinct sets of nodes, in this case A and G with feasible ties across but not within sets. In other words, I will impose the restriction that networks N_A and N_G are empty.

[32]In Razo (2008) I make the argument that search costs for private enforcers will give public officials an advantage because they can be readily identified and their capacity to punish D can be more easily verified. For that reason, I refer to elements of G henceforth as public officials.

[33]This collection of sets will not generally be mutually exclusive, with the exception of the special

Since the question of interest is to understand how public officials' shared stakes in various firms affect their enforcement behavior, the analysis will be based on the second network involving public officials. To explore this issue, I will specify a new network $\mathrm{N}_{L_g} = \langle G, L_g \rangle$ representing a nondirectional, non-valued relation L_g defined as follows: for $i \neq j$, $G_i L_g G_j \Leftrightarrow G_i, G_j \in \mathrm{P}_i$ (the complement of P_i in G will be denoted as $P_{\text{-}i}$). Note that unlike N_{ga}, this simpler overlapping protection network is a one-mode network defined only over G.

As defined above, the set P_i includes those public officials in G that protect a given A_i.[34] We want to partition the set G to reflect the relationship of all public officials with respect to those in P_i. The idea is that this partitioning scheme will reflect the network distance between P_i and any $G_k \in G$. The distance, a nonnegative integer s, will correspond to the number of steps that it would take to reach a particular subset of G from the perspective of P_i. The set G can therefore be partitioned into a finite list $P_i^G = \{P_i^0, P_i^1, ..., P_i^s, ..., P_i^S\}$ where $P_i \equiv P_i^0$, P_i^d refers to the group of public officials that can be reached in s steps, and S is the maximum number of steps to reach connected public officials.[35]

Since G is a finite set, P_i^G will have at most $S+2$ or $N+1$ subsets for a given P_i. In most cases, when all public officials are related to at least another member in G, the maximum distance will be finite: $S \leq N-1$. In this case, counting the case where $s = 0$, P_i^G will have $S+1$ elements. It is nonetheless plausible for a firm to seek private protection from an unconnected public official. For completeness, I will therefore introduce a residual subset P_i^∞ to identify a group of isolated public officials (again, with respect to P_i) that cannot be reached at all (as if the distance to reach them were infinite). Hence, in general when some public officials are disconnected, the partition of G will have $(S+1)+1 \leq (N-1+1)+1 = N+1$ elements.

To illustrate how this partitioning scheme works, let us consider three exhaustive cases. First, if all public officials protect all firms, then all elements of G are found in P_i, hence trivially reachable in zero steps. We can conceptualize this situation as one where either overlapping protection is very dense. That is, $P_i \equiv P_i^0 = G$. Second, if there were no overlapping protection, as would be the case where all instances of private protection are isolated, then $|P_i| = 1$ for any A_i and the corresponding partition of G given P_i would be: $\{P_i^0, P_i^{(\infty)}\}$ or $\{P_i, P_{\text{-}i}\}$. The benchmark model of Section 2 illustrates this structure. Finally, the remaining cases involve some connected and disconnected public

case where $P_i \bigcap P_j = \{\emptyset\}$, $i \neq j$, a case of isolated firms corresponding to the model in section 2.

[34] P_i can be an empty set if no public officials protect a given A_i.

[35] Formally, $S = \max\{length(A_i, A_j)\}$, for all $A_j \in A$.

Figure 9: Sample network for private protection partition example

officials, in which case the partition of G would be $\{P_i^0, P_i^1, ..., P_i^S, P_i^\infty\}$.

4.1.1 Sample Partition

Consider the following example with five asset holders and six public officials. For simplicity, I will assume that each firm has two protectors. Figure 9 presents a line graph with firms as nodes and the names of corresponding protectors on top.

For this network, we need to derive five partitions, one for each asset holder that could be potentially attacked. For instance, if A_i is attacked, the first two protectors are called upon to enforce, and thus reachable in zero steps, or $P_i^0 = \{G_i, G_{i+1}\}$. Since G_2 shares protection of A_2 with G_3, the latter is reachable in one step. Thus, $P_i^1 = \{G_3\}$. By the same logic, the whole partition can be written as $P_1 = \{\{G_1, G_2\}, \{G_3\}, \{G_4\}, \{G_5\}, \{G_6\}\}$.

In this partition, all enforcers are connected, with G_6 being the most distant enforcer, but this distance is relative, depending on which firm gets attacked. If D predates on a given A_i, the "hired" protectors will definitely have to respond, and so they belong in the subset $P_i^0 = \{G_i, G_{i+1}\}$. The remaining asset holders will be more or less distant, as shown in Figure 10.

This simple network highlights the importance of network enforcement in two respects. First, the density of the network will be important in determining distance among network participants.[36] By construction, each enforcer protects at most two firms in this example, resulting in some large distances among some of them (as is the case under P_1 or P_5, where the maximum distance was four steps). If these actors were to protect more firms, then the distance among enforcers would be shortened, resulting

[36]The density of a network measures the actual number of connections as a fraction of the maximum number of connections. In the case where all network nodes are connected, the density equals its maximum value of 1. If there are no connections at all between any two nodes, then the density equals its minimum value of zero. For intermediate cases, the density depends on the size of the network. In this example, shared protection entails a maximum number of 15 connections, derived from six enforcers who could each be related to the remaining five, and divided by two because the relation is nondirectional ($(6 \times 5)/2 = 15$). Since the actual number of connections is five because each P_i entails just one connection, then the density of the network is 5/15 or 1/3.

P_i^0	$\{G_1,G_2\}$	$\{G_2,G_3\}$	$\{G_3,G_4\}$	$\{G_4,G_5\}$	$\{G_5,G_6\}$
P_i^1	$\{G_3\}$	$\{G_1,G_4\}$	$\{G_2,G_5\}$	$\{G_3,G_6\}$	$\{G_4\}$
P_i^2	$\{G_4\}$	$\{G_5\}$	$\{G_1,G_6\}$	$\{G_2\}$	$\{G_3\}$
P_i^3	$\{G_5\}$	$\{G_6\}$		$\{G_1\}$	$\{G_2\}$
P_i^4	$\{G_6\}$				$\{G_1\}$

Figure 10: Reachability Partition for Sample Network in Figure 9

in distance partitions with fewer subsets.

Second, the centrality of network members can also play a similar role. Looking at affected firms, it is clear that attacks on more centrally located firms like A_3 will galvanize opposition more quickly because the firms' corresponding enforcers are not too distant from one another, as the maximum distance in P_3 is reduced in half compared with that of either P_1 or P_5.

4.1.2 Collective Retaliation

This section specified a general framework that can be used to incorporate the study of social networks in the context of dictatorships. Given the level of generality, it is beyond the scope of this paper to all possible network and individual trait configurations.[37] It will be helpful, however, to briefly explore how the dictator would actually be deterred from predation because of potential collective retaliation.

Suppose that D intends to honor all of its commitments, in which case his payoffs are equal to $\Pi_D \equiv \sum_{j=1}^{N} t_j R_j - C_D$.

Under what conditions would D choose to prey? Consider an arbitrary target A_j. If D were to prey on this firm, he would obtain an additional payoff of $(1-t_j)R_j$ minus a possible penalty ρ_j^0 imposed by A_j's protectors.

If A_j were isolated from all other firms, then the commitment condition derived

[37] See appendix for a simple example of variable social structures.

earlier indicates that D would refrain from predation if that penalty were sufficiently high.

But if the firm's protector has ties to other firms, then risk would propagate through the network structure of overlapping protection and potentially induce a given number of cohorts to retaliate.

Up to this point, it has not been made clear why D would want to continue preying on related firms beyond the initial target. The reason why there would be such an incentive is that predation gains increase with the number of attacked firms. Hence, if it can be done with impunity, D will try to prey on as many firms as possible.

As D traverses the network, it can add extra predation gains from firms associated with each subsequent cohort reached at step S. Let ω_j^S be the additional predation gains from cohort S. These gains are defined as $\omega_j^S = \sum_{k \in P_j^S} (1 - t_k) R_k$.

Of course, each private enforcer must have incentives to participate and actually punish D. Assuming that the incentives are there, then each enforcement cohort responds with a penalty ρ_j^S. Given this reactive behavior, D will stop preying when it reaches a step S^* where predation gains no longer exceed the cumulative penalty, implicitly defined by the following condition:

$$\Pi_D + \sum_{s=0}^{S^*} \omega_j^s \leq \sum_{s=0}^{S^*} \rho_j^s \tag{3}$$

The magnitude of each ρ_j^S depends on two factors: (1) the network structure, which determines how many private enforcers are in cohort S; and, (2) the individual capacity of each cohort member. Various magnitudes of individual capacities and diverse network configurations can produce the same ρ_j^S. Hence, without further specification of those variables, one cannot derive exact commitment conditions for all possible networks. Once we instantiate a particular network structure, however, the above equation can be used to examine the actual incidence of predation (and, in its absence, commitments) for a given society.

The next step is to understand how this logic of private protection plays out under a wide variety of network structures. Although we lack an analytical solution, the formal theory provides two important guides: we understand how the propagation of predation risk translates into predation payoffs, which helps us understand a dictator's incentives to prey; and we also have a stopping rule that tells us when the dictator stops preying on private actors.

Armed with these equilibrium conditions, we can start thinking about empirical applications and research designs. For instance, which network structures are like to

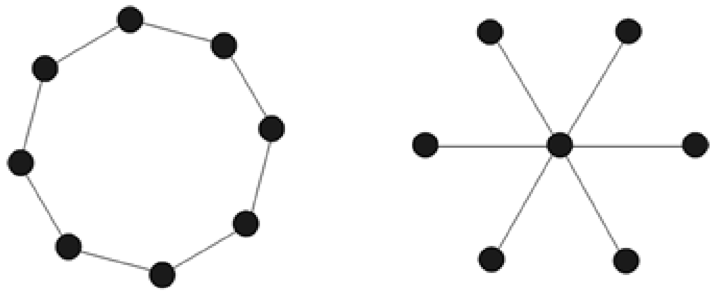

Figure 11: Decentralized and centralized networks

generate sizable size effects to inform our case selection? More generally, we can entertain hypotheses that are a function of network structures. In other words, recognizing that crony capitalism is a relational phenomenon, we are now in a position to actually build network-analytic theories and methodologies.

In order to illustrate how systematic thinking about network structures can enhance our understanding of the conditions that enhance policy credibility in dictatorships, let us consider two possible network structures. First, to understand how a centralized social network affects the outcome of the predation game, I review a small network composed of seven nodes as in Figure 11.[38]

To facilitate the analysis, assume that all enforcers are equally capable. In such a case, we might observe a cumulative penalty function (from the analysis above) that increases more rapidly in the centralized case where nodes are relatively closer to one another. The reason is that the star graph has a node that is connected to all other nodes (a *graph* is an alternate term for a network). Hence, all nodes can be reached in 1 or 2 steps. In contrast, the circle graph requires more steps for nodes that are opposite from one another along the circle's perimeter.

Another important network property is density, which accounts for the ratio of actual to maximum number of potential ties as defined above. The relevant contrast here is between a sparse network where only a few nodes are connected (i.e., a network with multiple components) to a complete network with dense connections. As illustrated in Figure 12, the network in panel (b) is fully connected; hence, an attack on any node immediately propagates to all other nodes. In contrast, the isolate nodes in panel (a) do not elicit any collective retaliation. There is some limited propagation in the case of the two small segments, but this response will not have the same weight as that of panel (b).

[38]These nodes are private enforcers; thus the network relation is overlapping protection.

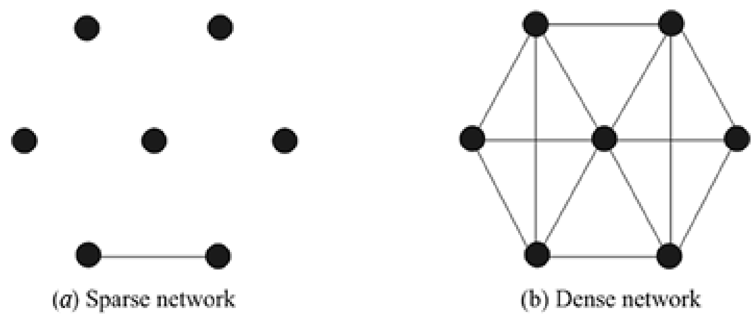

Figure 12: Sparse and dense networks

Although it is possible to focus on a few canonical structures, the fact of the matter is that the universe of potential configurations is rather large. In fact, that number increases exponentially. It is not practical to run a large number of configurations through the above equations to figure out expected equilibrium behavior, and thus gain a more general understanding of the exogenous impact of networks.

It is possible, however, to find numerical solutions on the basis of computer simulations. This is the subject of the following section.

5 Computer Modeling and Statistical Analysis

This section demonstrates the setup of a computational counterpart to the formal theory developed above. This is not mean to be a full-fledged analysis at this stage, but it does include all the required steps to illustrate how the computer models can "complete" the formal theory. This integrative approach is useful to derive testable implications that can be tested in the real world. In effect, the computer simulations do not exist in a vacuum; they are a complement of the formal theory. Both components aim to provide a theoretical foundation for a relational approach to the study of crony capitalism (and, indeed, of any policymaking process that can be modeled in terms of network structures).

The theoretical foundation is, in fact, based on a three-pronged research strategy:

1. Develop a theoretical framework to understand how networks can have aggregate effect (this was done with the equilibrium analysis of the previous section);
2. Use computer simulations to fully specify equilibrium outcomes with variable network structures; and,

3. Use computer modeling to inform statistical analysis of real-world cross-country data

This section will focus on the second item. We need computer models because the number of distinct network configurations increases exponentially with the number of nodes, and the framework needs to accommodate any number of nodes. The sheer size of the equilibrium analysis prevents an analytical solution in closed-form. It is also the case that SNA provides some guidance, but it remains incomplete. One major reason is that there is a large number of so-called network statistics. A priori, it is not always clear which network features will be better predictors of some relevant outcome. Simulations complement formal theory by helping us classify the large number of potential configurations into a smaller set of network effects.

The third item speaks to the need to translate theory into empirical analysis. Conceptually, the task is straightforward insofar as formal theory can help develop testable implications.[39] Most importantly, computer simulations can help us identify functional forms and plausible probability models that make a judicious use of relevant network properties. Put differently, we want the theory to facilitate empirical analysis by allowing us not to study network structures in their entirety, but rather relevant network summary statistics.

5.1 Monte Carlo Simulations

The results shown here are based on a model of 5000 small societies. The basic task here is to understand how variable network structures–through their impact on the decentralized behavior of self-interested participants–map onto aggregate-level outcomes, specifically the overall amount of predation (which is modeled here as the reverse case of overall policy credibility).

To clarify, the simulated network structure that serves as an input for this model is not a simple, but rather a two-mode network structure that links nodes of a certain type (G) with nodes of another (A).[40] This structure directly models private protection to guarantee existing informal arrangements between D and individual asset holders. Figure 13 illustrates this main input of the simulation process, with red circle nodes and blue diamonds denoting protectors and firms, respectively.

[39] Although we cannot really speak of continuous changes in network structures, it is possible to predict how changes in networks map onto changes on desirable dependent variables; in other words, we can entertain an analogous derivation "comparative statics" at least for some special cases

[40] These are also known as affiliation or bipartite networks.

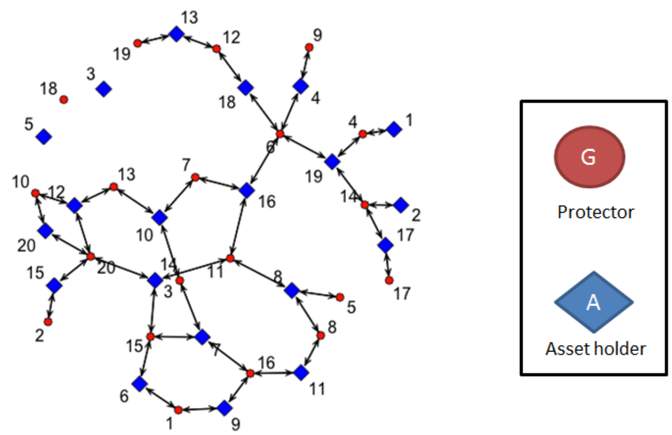

Figure 13: Bipartite network of private protection

We can think of this structure as the "raw" data. However, the theory is based on derived network structures that capture the shared fate of A_i's (i.e., propagation of predation risk) and overlapping protection(i.e., collective retaliation). The algorithm calculates these structures as needed to traverse the network and to account for activated private enforcement.

The basic algorithm consisted of the following steps:[41]

1. Set up society with one dictator, and two groups of actors of size $n_A = 25$ and $n_G = 25$.

2. Each private protector G_k was assigned to protect a single A_i with a fixed probability $p \in [0.05, 0.25]$.

3. Some parameter models were fixed. The tax rate was fixed at 0.10 for all A_i's and the cost of running the government C_D was set equal to 100. Rents and penalties were calculated to satisfy participation constraints.

4. Predation attacks were modeled as followed:

    - The dictator picked an A_i at random as a starting point. D confiscated remaining profits. A_i's protectors retaliated to impose a penalty on D.

[41] For prototyping purposes, this was coded in the R statistical environment to make use of existing SNA libraries and other statistical features. A scaled-up "production" run this summer, which will have a larger number of configurations and network sizes, will be coded in a different computer language.

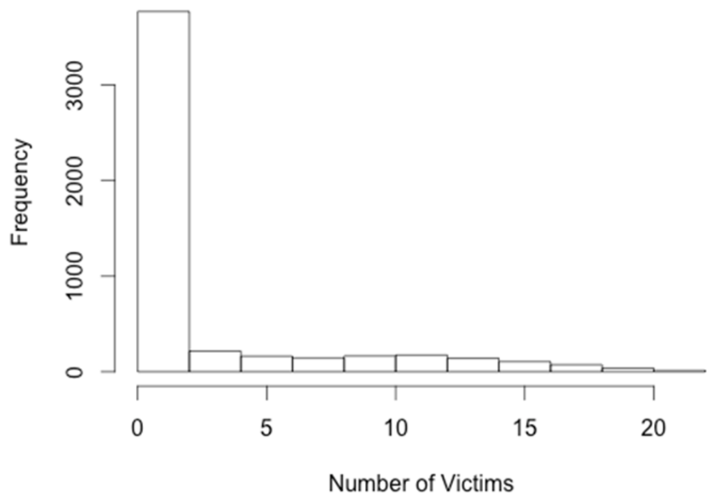

Figure 14: Aggregate Predation

- The algorithm calculated neighborhoods of A_i to figure the next set of potential victims. These neighborhoods were created sequentially, as needed, as D traversed the network. At any step, D could stop, either because there were no other reachable A_i's or if the cumulative penalties exceeded predation gains.
- Averaging of individual attacks. Because A_i's are located in different parts of the network, each attack can produce different results. For this simulation, the algorithm was designed to replicate individual attacks for all firms. The results of each of these attacks were averaged for the whole society (e.g., the average number of predation victims, the average cumulative penalty, along with many other structural properties, etc.). These are the numbers that are used in the statistical analysis below.

6 Analysis

The key dependent variable here is the amount of firms whose profits are confiscated by D (by construction, the maximum number is 25). This information is illustrated below in Figure 14

For given parameter configurations, we do not see a high incidence of predation.

At first sight, this might suggest a problem with the computer model, but this result can be perfectly explained from a network-analytic perspective: the lack of network cohesion can serve as a limiting factor for the propagation of risk.

For further descriptive analysis, we can see how variations in the derived networks of propagated risk and overlapping protection map onto different degrees of predation.

The propagation of predation risk can be assessed from different angles, but here it will be presented in terms of the relative numbers of affected firms for a particular predation attack. Specifically, I will use a proxy measure based on calculating for each predation attack the average number of additional firms that were preyed upon by D (recall that this is accomplished by traversing the network). Other things equal, more firms will be reached with a higher network density, so to control for this systemic aggregate variation, I use a weighted average that multiplies actual average numbers by the expected density of a network structure. This is the quantity shown in the horizontal axis in Figure 15.

This figure has two salient features. First, there is a clear nonlinear relationship, which can be interpreted as follows: when firms are not very connected, the aggregate impact of predation attacks is low (because D cannot continue on to other victims); as firms become more connected, there are more potential victims (indeed, more temptation for D to prey); at some point (around 4 or 5 in this diagram), the number of victims decreases with greater connectivity. We know why this happens: as firms become more connected, more G's are activated to retaliate; beyond a certain number of affected firms, there is a critical mass of G's that can discipline the dictator.

The second salient feature is the dark vertical flat line below 10, which shows that there is a large number of cases with zero victims for lower numbers of reachable firms. At first sight, this appears to be either a problematic or counter-intuitive result. It could be problematic because it undermines the previously noted non-linear relationship (albeit the darkness of this line is partly an artifice of the illustration). It is counterintuitive because we would expect more connectedness among As to facilitate more predation. One plausible structural reason for this outcome is that Gs are concentrated among a small number of As. Another related reason is that network may be fragmented into smaller components.

Still in the realm of descriptive analysis, we can also visualize how connections among Gs affect predation. This relationship is illustrated in Figure /reffig-retaliation. The horizontal axis is the average cumulative penalty until a dictator stops preying on firms.[42] As D's operating costs C_D were fixed at 100, by construction, the way to

[42] It is possible for D to prey on all firms, so he doesn't stop until all firms are attacked. In the process

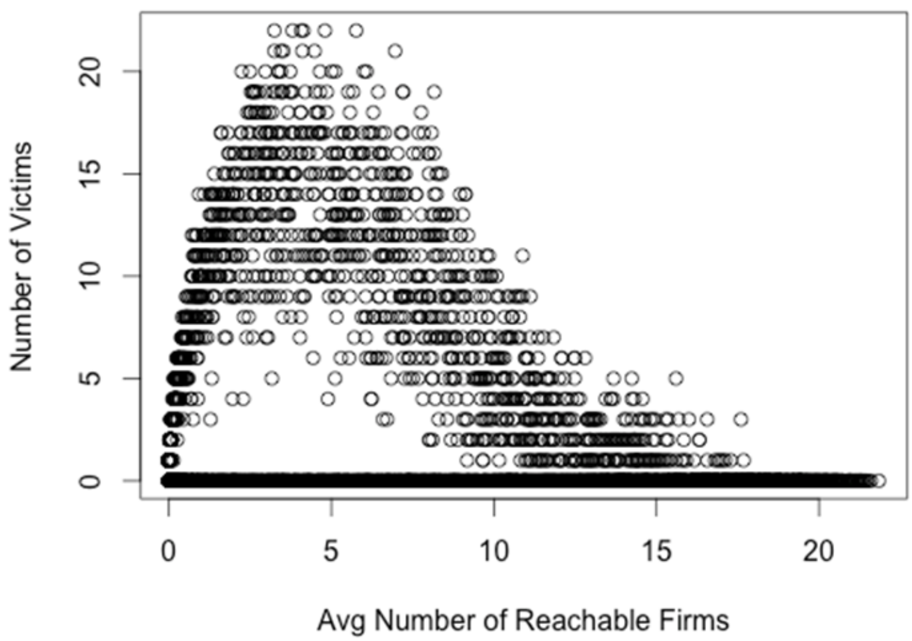

Figure 15: Predation as a function of A network

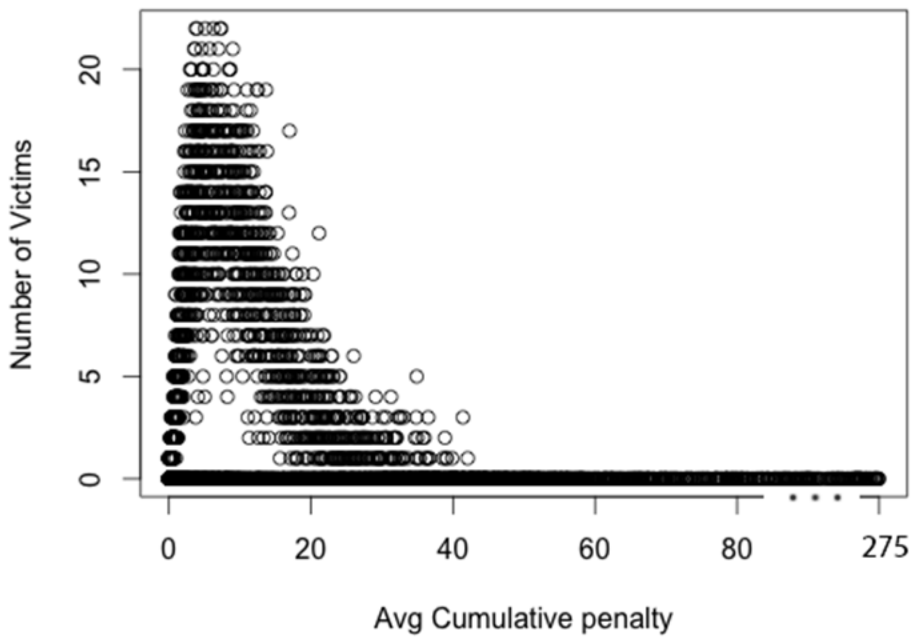

Figure 16: Predation as a function of G network

interpret the horizontal axis is relative to that critical value of 100. Basically, we see the same nonlinear relationship as in the relational mechanism of propagation of risk. But note that the initial increase in victims occurs at very small penalty levels, so the curve quickly changes direction to what we would expect to the more general impact of collective retaliation: namely, as a deterrent for predation. Again, it remains to explain why we see a flat zero-level line, but here the reason is invariably related to the fragmentation of the A network.

Although suggestive, these scatter plots offer limited information, especially because they mask other structural factors that we understand are important (per the equilibrium conditions of the formal theory above).

A better approach requires inferential statistical tools. In what follows, I test the importance of the two relational mechanisms posited by the theory. It is appropriate to test the theory in light of this artificial data set because not only is the data generating process tightly connected to the model in the formal theory, but we also because the stochastic nature of the simulation generates a wide range of network structures that

of traversing the network, however, D is accumulating penalties, albeit these are not a deterrent.

are not known in advance.

As presented, the dependent variable is a count of predation attacks, which calls for a different probability model than used in a conventional linear regression. Moreover, we are aware that there is a large number of zeros, so the model needs to account for this feature. To incorporate these factors, I estimate below a Zero-Inflated Negative Binomial Model with Overdispersion.[43]. The independent variables will be the proxy measures I discussed above for propagation and retaliation.

[43]The Zero Inflation part of the model will be useful to model why we see so many zeros in the number of Victims

Table 1: Estimation results:

Variable	IRR Coefficient	(Std. Err.)
Equation 1 : numVictims		
propagation	1.545**	(0.041)
propagation^2	0.968**	(0.002)
retaliation	0.437**	(0.048)
retaliation^2	0.581**	(0.022)
prop. * reta.	1.243**	(0.019)
Intercept	4.044**	(0.246)
Equation 2 : inflate		
aacomp	0.289**	(0.017)
Intercept	-3.742**	(0.274)
Equation 3 : lnalpha		
Intercept	-3.113**	(0.536)
N=4800		

All the estimated coefficients are statistically significant at the 5% level, and all show the expected signs. These are also shown in incidence risk ratio (IRR) forms to facilitate the presentation of findings.[44]

First, we see that when firms become more connected, they are also become vulnerable. An additional connected firm (relatively to an attacked firm) increases the number of victims by a factor of 1.544. Note also that we get a negative sign for the squared term that shows a slight reduction, which confirms our previous visual inspection of a nonlinear relationship between the propagation of risk and number of victims.

Second, collective retaliation appears to work as expected. The first order effect is negative: increasing the penalty by 1 unit (equivalent to 1% of D's operating costs) reduces the number of victims by a factor of 0.44. The quadratic term shows an even stronger effect with a factor of 0.581. Taken together, the statistical results do not give much credence to Figure reffig-retaliation, which han indicated a fairly steep in the number of victims for low penalty values. This outcome does occur, but is not as frequent as the negative impact of retaliation tends to dominate.

Third, we see how the two relational mechanisms work in tandem. On the one hand, we know from the first (propagation) coefficient that more connectivity among A's increases predation; this result is also reflected in the interaction term of propagation times retaliation, with an IRR greater than 1. On the other hand, we know that retaliation has an IRR less than 1. Put together, we see that the joint effect of making one additional firm more vulnerable, but also the immediate retaliation response, which mitigates predation a bit more (the IRR of 1.243 is lower than for propagation alone, 1.545).

The final result to discuss is the excess of zero values or null predation. Here, the hypothesis was network fragmentation would have a limiting effect on predation. Network fragmentation was operationalized as the number of components of a network.[45] A fragmented network can have several such components when small groups of firms are directly or indirectly linked to one another within but not between groups. The statistical results show a strong significant result, even stronger in magnitude than retaliation with an IRR of 0.289. The number of components is not a continuous measure

[44] A value of 1 serves as our baseline or null hypothesis, and is equivalent to saying that the variable has no effect on the number of victims. Numbers that exceed one show a positive effect, akin to an expansion factor. Numbers below one show a negative effect, akin to a contraction factor.

[45] A component is a subset of the network with the property that all contained elements can be reached from within; they need not all be directly connected, but one could find an indirect path to connect any pair.

like propagation and retaliation, however, but the applicable logic here is as follows. Imagine first that all firms can be linked either directly or indirectly (i.e., there is just one component). Then suppose that one tie is destroyed, which separates two distinct components. That change would translate into a lower number of victims, simply because if D starts in one component, it cannot find its way to the other. As the number of these tie breaks increases, D finds itself preying on a smaller number of victims.

In summary, the statistical results are consistent with the theoretical predictions. Although this is a small example, the approach serves to illustrate how one can enable a very tight connection between theory and empirics. Independent variables that are essentially relational in nature can, in fact, be measured in network-analytic ways. Moreover, we can use network measures to directly model relational mechanisms without recourse to non-relational attribute-based proxy measurements.

7 Conclusion

How can a network-analytic perspective inform our understanding of policymaking in dictatorships? I answer that question in the context of the empirical puzzle presented in the introduction: how can dictators make credible commitments to promote growth?

First, a network perspective makes it clear that the political foundations of economic growth in dictatorships cannot rest on widespread distribution of benefits and protection of property for everyone. This is not to say that dictators may withhold from making such pronouncements. Indeed, in some cases, it has been argued that successful dictatorships developed on the basis of a shared growth strategy (Campos and Root (1996)). But closer scrutiny would reveal–as it has in virtually all cases of growth under authoritarianism, that growth was predicated on the protection and awarding of special privileges or market power to a select few. It would have been very difficult to develop otherwise: with greater discretion, both economic actors as well as the dictator find it in their interest to rely heavily on private policies (Razo, 2008, ch. 2).

Indeed, special privileges–because they translate into rents–will be the driving force of dictatorships. Without rents, private policies are not potentially credible because they would not generate incentives for third-party enforcement. The implications for poor countries with non-democratic regimes are not very promising: unless there is the potential to generate rents, no selective commitments (let alone universal ones) will be forthcoming.

In addition to rents, it is necessary to have a reliable pool of private enforcers that can effectively impose penalties on the dictator should the latter renege on individual commitments. If the dictator is too powerful, high rents alone will not guarantee the credibility of policies because the dictator would be able to prey with impunity. In fact, higher rents also make it more tempting for the dictator to prey, so the greater the extent of private protection afforded by a dictator (i.e., the number of private policies), the greater the need for a more powerful set of actors to prevent predatory behavior.

Underlying both the rent and private enforcement requirements, dictators must indeed elongate their time horizons as Olson (2000) rightly notes. The main reason is not one of internalizing costs as in the theory of stationary banditry, but rather one of credibility. Private policies do not only afford special privileges, but they also create expectations for durable privileges among recipients. Just as a dictator can award a privilege one day, he can take it away later. Hence, for recipients to be assured that their private policies are credible, the dictator must find a way to signal that the agreement is long-lasting.

In closing, I reiterate the exploratory nature of this research. The focus on informal institutions seems warranted in light of the empirical literature that has brought to light the excesses of authoritarian government. The network-analytic approach I presented here has a minimal set of assumptions regarding organizational or institutional issues. In fact, we know that there is a variety of political organizations and institutions across non-democratic regimes. Rather than being a substitute for the study of formal institutions, this project aims at refining a methodology that can be used to complement more mainstream institutional studies. Along those lines, several extensions can be readily identified in terms of combining extant institutional and newer network-analytic theories. A promising area of research not discussed here is the wide set of quantitative tools from inferential statistical techniques that can be deployed to study informal as well as formal structures (see appendix).

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Appendix A: Very brief overview of Social Network Analysis (SNA)

Social Network Analysis (SNA) is neither a new field of study nor a new methodology. Its origins go back a few hundred years to the development of graph theory in mathematics; and, in applied areas, at least to the 20th century in the pioneering work of social psychologist Jacob L. Moreno. This early work was picked up in the 1920s and 1930s by a cadre of Harvard University social and organizational theorists. Around this time, SNA also resonated but had a short life in Anthropology–despite this discipline's constant interest in kinship–and later, it was mostly nurtured by mathematical sociologists until the last couple of decades when economics and other disciplines started paying more attention to networks. Circa 2000, the salient incorporation of Physics and Computer Science–along with recent computational and data advances–have become major drivers for the recognition of what is now known as "Network Science." This last term is relatively new, and so is disciplinary interest in economics and political science, but the intellectual roots of SNA are indeed fairly old. What is new about "Network Science" are new tools that actually make it feasible to conduct large-scale analysis, which was a practical impossibility for SNA scholars for most of the 20th Century.[46]

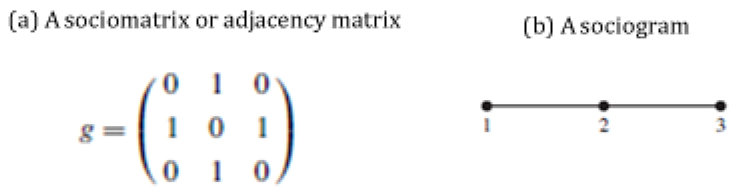
A network, or more precisely a *network structure*, is an analytic construct with two components: a set of nodes and corresponding ties among members of N. Formally, we can define a network as $W = < N, L >$.[47] The elements of N can be of any kind; for example, N could be a set of individual people, a set of groups, a set of countries, or any set for that matter. It is important, however, that all included elements be of the same type. This definition, for instance, does not accept a set of N in which we mix individuals and organizations.

The links themselves tend to be expressed in empirical terms; that is, L is a list of pairs such as $\{\{1, 2\}, \{2, 3\}, ...\}$, which means that for the first bracketed pair "1" is related to "2", for the second pair "2 is related to 3", etc. Readers may recognize this structure as a relation defined over the set N; and, in fact, it is what these (simplest) network structures are from a mathematical perspective.[48]

[46] See Freeman (2004) and Knox et al. (2006) for intellectual histories in the social sciences. See http://iuni.iu.edu for an overview of the wide variety of studies that fall under the umbrella of Network Science.

[47] The label "W" draws from the weight matrix used in spatial regression models, some of which can be used for social network analysis. A different letter is also used to avoid confusion with N, which is typically used to denote sets of people.

[48] These links are also known as ties, connections, edges, dyads, relations, etc. This long list of synonyms is an unfortunate source of confusion, which is due to the fact that networks have been



Source: Jackson (2008), Figure 2.1

Figure 17: Alternative representations of network structures

Consider the following example taken from Jackson (2008). Here, we define a set N that consists of three people, each identified by a distinct number. Suppose we recognized that 1 is connected to 2, and 2 is connected to 3. Then the corresponding network structure, which we will call g is $g =< N, L >=< \{1, 2, 3\}, \{\{1, 2\}, \{2, 3\}\} >$.

The above is a cumbersome notation that can get hard to read as the size of N (defined as the number of its elements) increases. As an alternative, network analysts have defined a couple of representations as illustrated in Figure **??**.

There, panel (a) shows what is commonly known as a sociomatrix, which is a square matrix with the number of rows and columns both equal to the number of elements in N. Ties can be valued, but in the simplest case, where we simply want to note the existence of a tie, or lack thereof, cells have either a zero or one. A value of one indicates that there is a tie among the corresponding row and column id numbers. Note also this is a symmetric matrix. Thus, given our knowledge that 1 and 2 are related, we see a "1" in cells $g_{2,1}$ and $g_{1,2}$. Panel (b) shows a representation known as a "sociogram" that most readers will be familiar with, given that these are popular depictions of social media connections nowadays. In a sociogram, we represent elements of N with a shape (usually a circle or dot) and we represent a direction by drawing a line between two shapes. Panels (a) and (b) equivalent representations to the above formal definition of g. There is a whole field of network visualization that seeks how to best represent networks. This study will show some sociograms, but its main purpose is to analyze functions of networks, not the networks themselves.

A first, and arguably the most important, step of any network analysis is to define a relevant network structure for a *particular* research question. For readers unfamiliar to network analysis, it is important to note that what we would call a "group" of people is simply just a collection of individuals, or the set N in the network definition above. A group is **not equivalent** to a network because, per the formal definition, we

studied in many disciplines for different purposes.

are missing a corresponding L. Put differently, the same group of people can serve to define multiple networks. Although purely a descriptive framework up to this point, this clarification also reveals the power of network analysis in facilitating a type of **relational accounting** that helps us precisely define and distinguish multiple network structures for the same group of people (or other node types).[49]

A second step would involve some type of descriptive or inferential analysis. A full description of related analytical tasks is beyond the scope of this appendix, but I will briefly mention the two most common approaches, both of which entail some type of "structural analysis." These two approaches will also serve to illustrate the flexibility of network analysis to enable multiple levels of analysis, either separately or concurrently.

Starting from an aggregate perspective, we can describe the whole network in terms of summary properties. The most common one, which relates to the connectivity of a network, is network density. Density is a measure than ranges between 0 and 1. When density equals zero, which is the case of an *empty* network, there are no ties among elements of N. The other extreme case of a *complete* network occurs when every node is connected to all other nodes. For a given network of size n, the maximum number of (undirected) ties is equal to $n(n-1)/2$. Density is defined as the ratio of actual ties to that maximum theoretical value.[50]

Another analytical task is to examine the "place" or "importance" of nodes within a network structure. There are a variety of related summaries known as centrality indicators, which are defined at the individual level. The simplest calculation involves so-called *degree* centrality. "Degree" is a term used to denote the number of connections of a particular node; in essence, an index of connectedness. If we collect data for a network, and we find that two nodes (call them i and j) have degrees of 4 and 10, respectively, then we would say that i is more central than j. These indicators are calculated for every element of N, so we can use this information to rank members by their degree centrality, a task usually done to characterize the relative importance of individual nodes.

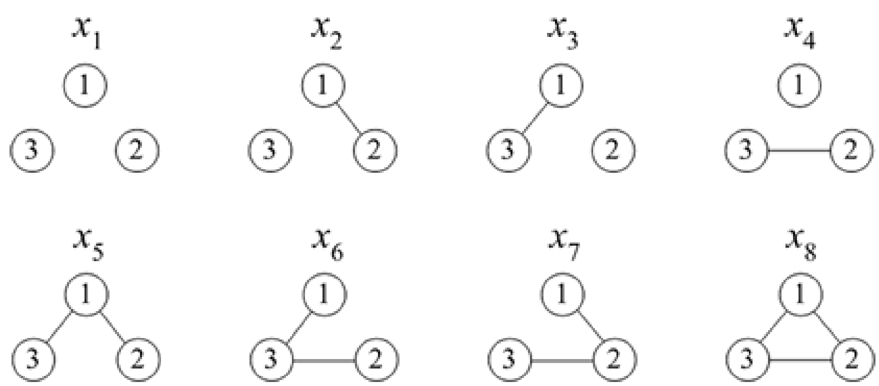
[49]It is possible to define more complicated network structures involving multiple sets. It is also possible to add more properties to L itself (e.g., ties could be directed and valued as well). The appendix focuses on the simplest network structure, which is also widely used.

[50]For a network with 5 nodes, for instance, the maximum number of possible ties is 10. If we observe a network with 5 ties, then the density will be equal to 0.5.

Appendix B: Social Networks as Random Variables

As previously noted, a network is defined by a set of nodes N and a binary relation applied to all pairs of elements of N. The actual social structure is variable, depending on observable binary ties. To illustrate, we can revisit our previous example of a network g with three nodes 1, 2, and 3, and a binary relation that may connect any two nodes.

This section also shows that one can engage in theoretical network analysis, prior to or independently from measured networks. "Theoretical" here means that we can posit a theoretical link based on any desirable criterion. Setting aside the substantive nature of such tie, and before we collect data, we can make probabilistic assessments about possible network structures. Back to the example, there are eight possible structural patterns as illustrated below.[51]



To reiterate the point that networks can be represented in different ways, below are the corresponding sociomatrices. We assume here that these are undirected ties, so it is not necessary to show cells above the diagonal, which provide redundant information. That is, if the cell corresponding to row 1 and column 2 equals 1, the same information is already captured by the entry corresponding to row 2 and column 1.[52]

$$x_1 = \begin{pmatrix} 0 & & \\ 0 & 0 & \\ 0 & 0 & 0 \end{pmatrix}, x_2 = \begin{pmatrix} 0 & & \\ 1 & 0 & \\ 0 & 0 & 0 \end{pmatrix}, x_3 = \begin{pmatrix} 0 & & \\ 0 & 0 & \\ 1 & 0 & 0 \end{pmatrix}, x_4 = \begin{pmatrix} 0 & & \\ 0 & 0 & \\ 0 & 1 & 0 \end{pmatrix}$$

[51]Excluded from the link definition are loops, where a node may be connected to itself. This property is also known as reflexivity. For most applications, it is not reasonable to assume that ties are reflexive, which will also be reflected in zero values along the diagonal of a sociomatrix.

[52]If this were a case of directed ties, then these two cells could have distinct values.

$$x_5 = \begin{pmatrix} 0 & & \\ 1 & 0 & \\ 1 & 0 & 0 \end{pmatrix}, x_6 = \begin{pmatrix} 0 & & \\ 0 & 0 & \\ 1 & 1 & 0 \end{pmatrix}, x_7 = \begin{pmatrix} 0 & & \\ 1 & 0 & \\ 0 & 1 & 0 \end{pmatrix}, x_8 = \begin{pmatrix} 0 & & \\ 1 & 0 & \\ 1 & 1 & 0 \end{pmatrix}$$

Either a sociogram or a sociomatrix can be used to describe an actual social structure. Beyond description, however, knowledge of the possible structures can also be used for probabilistic analysis of networks before we collect any data. For the example above, we can let X denote the unknown social structure for the case of three nodes and an undirected tie. If we define the set of events as the possible structures, that is $\{x_1, x_2, ..., x_8\}$, all we have to do is propose a probability distribution over these outcomes. In other words, we can construct a random variable X with a probability function $Pr(X = x_i)$ for $i = 1, 2, ..., 8$. Besides ensuring that $Pr(X = x)$ satisfies the axioms of probability, there are various possibilities for the choice of this probability distribution. For instance, if we had reason to believe that all possible social structures were equally likely, then we would have a uniform (discrete) distribution $Pr(X = x_i) = 1/8$ for all i.

It is important to note that the random variable is the *whole social structure*, rather than individual ties among nodes. Clearly, there may be connections between the overall social structure and lower-level structures. For instance, the probability of x_8, a situation where all nodes are related, may be conditional on the existence of two ties (e.g., x_5, x_6, or x_7).[53].

Summary

These appendixes have demonstrated four key features and advantages of social network analysis:

- It is possible to define networks precisely to describe a wide variety of social phenomena;
- Once defined, networks are self-contained objects that can be manipulated mathematically or computationally; and, more generally, as inputs for various analytical tasks, including theory building;
- "Network analysis" can be done at various levels of analysis ranging from global to local structural assessments; and,

[53]Indeed, the use of conditional probabilities can be used to construct what would otherwise be very complex statistical models. See Wasserman and Robins (2005) for a statement of technical conditions that enable these conditional assessments.

- It is possible to add a probabilistic foundation to enable statistical inferences. We can thus entertain hypotheses in which networks may play the role of either independent or dependent variable.