The Evolution of International Politics, 1800-2000:  
A Network Analysis

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1. Introduction

If we reduce the study of international relations to a few simple precepts, we can say that it is about units—state and nonstate—interacting with one another in the process of forming, maintaining, and terminating different relationships. These relationships are extremely complex and multilayered. But if, as some in the field believe, they are guided by a set of principles and general laws, then this complexity may be reduced substantially. This complexity requires most scholars to impose severe limits on the scope and subjects of their inquiries. These include a limited time periods under study, restrictions on the number and types of units under study, restrictions on the type of relationships under study, and so forth.

These limits are slowly being expanded, however. Significant improvements in data availability and technologies for data mining, data storage and retrieval, and methodologies for handling large datasets allow more generalized study of a wide variety of aspects of international politics. The emergence of quantitative international politics as the mainstream approach in the field was largely facilitated by these developments. The expansion of this field has also produced important findings on the workings of international politics, in particular, with respect to the factors that increase or decrease the probability of conflict and war among states. At the same time, our understanding of how international relations evolved over time in a broader sense is still largely incomplete. Part of the reason for that is that in the last two decades, most of students of international politics have abandoned the systemic level of analysis in favor of the dyadic level, which seemed to have been more promising in terms of meaningful findings.

Our purpose in this paper is to present a generalized approach for studying international politics as a set of interrelated networks of relations among, affiliations, and attributes of actors. We start with a focus on states, but demonstrate that our approach is not limited to state actors. In fact, we demonstrate that it is possible to switch to substate units such as ethnic groups, or to superstate units such as international governmental organizations. We employ network analysis to examine the evolution of international politics over the last two centuries in terms of the interrelationship among several different networks. We examine how the characteristics of the system in terms of these networks affect the extent of conflict and war in the international system.

Our study examines the following issues:

1. Can we conceive of the structure of the international system in terms of the characteristics of different networks of interstate relationships?

2. If so, then how did the international system evolve over time in terms of alliance ties and trade among states? How did it evolve in terms of the ethnic composition of its member states?

3. Are there any relationships between the evolution of one network (e.g., alliance network), and the evolution of other networks (e.g., trade, ethnic composition)?
4. To what extent do changes in networks affect the extent of conflict and war in the international system?

5. To what extent does the direction to which the system goes in terms of various networks affect the degree of conflict and war in the system?

We start by discussing some of the problems that students of international politics have attributed to systemic perspectives of international politics, in general, and to the structural realist perspective, in particular. We then discuss our approach to a systemic perspective of international politics as a set of networks. The fourth section lays out research design of this study. The fifth section provides a systematic description of the evolution of international politics in terms of the attributes of the system that are derived from network analysis. The sixth section provides an analysis of the relationship between systemic attributes and international conflict. The seventh section concludes this study by discussing the theoretical and empirical implications of our study.

2. Systemic Theories: Some Problems

Kenneth Waltz (1979) told us that if we want to study international politics in ways that are general and parsimonious—that is, talk theory with a capital T—then we ought to look at the structure of the international system. Indeed, this claim has much appeal in that it does force us to cut through the enormous web of actors, their social, economic, and political attributes, their interests, their relationships, and their interactions. It has the potential of developing really elegant accounts of the way the world seems to be working. We do not have to deal with specific issues, policies, events, or problems. We can rather identify the basic structure of the world in terms of the number of major powers and the distribution of power among these states. We can then deduce a wide variety of propositions about: war and peace, state behavior, relationships between major powers and minor powers, and among minor powers.

There are different types of systemic theories of international politics, but by far the most influential one is structural realism in its various incarnations (Glazer, 2003). This theory finds its most eloquent exposition in Waltz’s (1979) classic. At the risk of oversimplification, we note that the key characteristics of this theory are fourfold:

1. It assumes that states are the principal actors in international politics.
2. It assumes that the key characteristic of international politics is the state of anarchy, that is, the absence of a central authority that is capable to enforce rules on the units.
3. It assumes that the principal motivation of units under anarchy is survival. States want to maximize the chances of surviving in an anarchic world.
4. Thus, the principal mechanism that can help state maximize their chances of surviving is the balancing rule: states wish to balance other states.

On the basis of these fairly simple principles, the theory tells us about how, why, and when war and peace are expected in world politics (Waltz, 1964, 1979); who aligns with whom and why (Walt, 1987; Christensen and Snyder, 1990); what would be the relations between major powers and minor powers (Miller, 1994), and so forth.
Yet, it is unclear when states are expected to balance, and what it is that they attempt to put on the balancing scale. Some versions posit that states attempt to balance power (Waltz, 1979). Others argue that states wish to balance threats (Walt, 1987). Some claim that states wish to maximize survival not by balancing but by seeking dominance (Mearsheimer, 2000), other argue that states seek security by trying to deter through balancing processes (Walt, 1987; Glaser, 1994-95). Theorists also differ considerably on the question of what is the relationship between balances and war. Some (e.g., Waltz, 1979; Mearsheimer, 1991) claim that balance creates mutual deterrence and hence reduces the likelihood of war. Others (e.g., Organski and Kugler, 1980; Kugler and Lemke, 2000; Geller and Singer, 1998: 192-193) claim that power parity (i.e., roughly equal balance) increases the likelihood of war.

There are quite a few problems with this approach, however, as elegant as it may appear at first blush. First, on a theoretical level it is reductionist, because it reduces its definition of the key independent variable—the structure of the international system—to a very narrow concept of the distribution of power between a few major powers. How a state becomes a member of this club of major powers is ambiguous in most studies—even those that employ highly rigorous measurement criteria. As we argue below, structure is a more complex concept, one that cannot be defined strictly in terms of a single attribute of actors. Second, structural realism is reductionist because it conceives power in strictly material—mostly military—terms. As has been argued over and over (and demonstrated by the collapse of the second “most powerful” power—the Soviet Union) material power does not count for much if it is not backed by economic capability and by social and political stability (Keohane and Nye, 1977; Kennedy, 1987).

Third, structural realism is predicated on a “top down” or “outside in” logic. This logic is both empirically problematic and logically flawed (Maoz, 1990: 547-564; Bueno de Mesquita, 2003). It generates seemingly contradictory propositions (e.g., regarding the relationship between polarity and war, or between alliances and war). It is vague on many issues that are not related to power and structure; it does not account for system transformation and is limited in scope (Maoz, 1996: 4-12).

Fourth, and perhaps most importantly, structural realism does not have a great deal of empirical support. It does not appear to be working because it leads to flawed empirical generalizations (Vasquez, 1998), because it generates seemingly contradictory propositions (Vasquez, 1997), and because the discrepancy between the original proposition of this approach and empirical reality leads adherents of structural realism to “changes” that are not in line with the basic ideas of the approach. So that not only does structural realism lend itself to contradictory propositions, but it also loses its parsimonious qualities (Vasquez, 1997).

One of the consequences of these problems with structural realism was that the theory has lost much of its appeal over time. The notion that systemic analysis of international politics has reached a dead end became increasingly prevalent (Bueno de Mesquita and Lalman, 1988; Maoz, 1990; Russett, 1995). Consequently, many scholars, mostly in the quantitative and formal genres of the field, moved on to study dyadic relationships, an area where empirical findings were becoming more definitive and meaningful. The evolution of research programs such as the democratic peace (and the more general liberal peace) tradition
But abandoning systemic analysis is not necessarily the path to go if we seek an overall understanding of international politics. Consider the democratic peace research program as an example. The real message of the findings that have accumulated in this tradition is that what emerged as arguably the most significant finding in the field, is nothing more than a level-of-analysis paradox. Democracies are equally conflict prone as are nondemocracies. However, they do not fight each other. Moreover, the extent of conflict in the international system is not consistently related to the proportion of democratic states in the system. It appears that the seemingly robust finding that democracies do not fight each other is not only quite limited in scope, but may be both theoretically and politically misleading (Maoz, 2001a: 143-147). Without a multilevel explanation of this phenomenon, the democratic peace issue will remain an unsolved puzzle, and scholars as well as practitioners need to practice extreme caution in deriving theoretical and practical inferences.

The same can be said about other factors that make up the liberal peace (Russett and Oneal, 2001). For example, we know that joint membership in international organizations reduces the probability of conflict in a dyad. But is it also the case that the extent of national participation in international organizations reduces the extent to which a state is involved in international conflict? Is it also the case that as the number of international governmental organizations in the international system increases the level of conflict declines? Given that bilateral trade reduces the probability of dyadic conflict, does it follow that as the amount of trade increases across the globe, the level of conflict declines? The answers are not self-evident. Certainly there are no straightforward empirical results to allow for such assertions. Until we can derive consistent explanations across levels of analysis, our strongest findings at the dyadic level will remain limited and suspect.

It follows therefore, that we need to look for a framework for the study of international politics that allows us to perform several tasks:

1. To establish a substantively meaningful theoretical account of the workings and evolution of international politics that is both general (i.e., allows incorporation of a multitude of units and factors that are deemed instrumental) and parsimonious (i.e., allows for a simple explanation that connects these factors).

2. To incorporate multiple levels of analysis within a single theoretical structure.

3. To provide for flexibility in the study of issues, actors, processes, and levels of analysis. In other words, to be able to apply the same logic, the same approaches and methodologies, to a wide variety of theoretical and empirical matters.

4. To be empirically useful. That is, the framework must enable us to shed substantive light on various puzzles in international relations.

In what follows, we present the basic ideas of this framework and demonstrate some of them via an empirical study of the evolution of international politics over the 1816-2000 period.

2. International Politics as a System of Networks
Just as it is difficult to construct theories of human behavior based on the underlying motivations and goals of behavior, it is difficult to construct theories of state behavior based on exploring such things as national goals and motivations. Besides the difficulty entailed in exploring motives and goals, such theories cannot be general, as each behavior may be guided by different motives. But what we do see is behavior that is repetitive. Seemingly different states do seemingly similar things. States tend to repeat actions over time and across circumstances. So whether or not there exists a common set of motives that underlies state behavior, there is a general set of behaviors that recurs over time and across states.

In the structural realist version of international politics, structure is something that is superimposed on the units. The analogy repeatedly used by Waltz (1979) is that of market structure in economics. As noted, the structure of the system is defined by the number of major powers and the distribution of power among them. However, we don’t know how to define a major power. If we define major power in terms of their relative power, then we risk biased inferences. For example, where do we draw the line between major power and minor power in terms of relative capabilities? Which aspects of states’ capabilities go into discriminating between major powers and minor powers? The Correlates of War definition of major powers is even more idiosyncratic, as it rests on what is seemingly “a consensus among diplomatic historians.”

The same applies to the question of the distribution of capabilities. Waltz discusses this matter in fairly discrete terms. A structure can be unipolar, bipolar, or multipolar. The distinction between bipolarity and multipolarity is fairly straightforward (and so is, presumably, the distinction between unipolarity and bipolarity). Yet, there are varying degrees of multipolarity. There are also varying degrees of unipolarity, in terms of the relative capabilities of the less powerful actors, their relationships with each other and with the system’s hegemon. The same applies to different types of bipolarity. Unless we conceptualize the system’s structure in continuous terms—e.g., the extent of polarization—we may end up not only eliminating useful information, but also misinterpreting structure. Also, reducing structure into a single variable—however important—may hide a great deal of complexity (Keohane and Nye, 1977; Mansbach and Vasquez, 1981).

Instead of imposing a “top-down” arbitrary definition of structure we wish to deal with the concept of structure both deductively and inductively. Specifically, the structure of the system emerges both out of fundamental characteristics of the realm of international politics—such as anarchy—and out of different patterns of behavior of states. It is not defined by a single variable but by a list of relational and affiliational variables. We can think of the structure of the system in terms of the configuration of alliances between states, in terms of the patterns of trade between them, in terms of their membership in international organizations, in terms of their geopolitical distribution. We can also think of structure as emerging out of various characteristics of states. For example, a world wherein a high proportion of the states are democracies may be said to have a different structure from a world in which only few of the states are democracies. A world in which many of the states share ethnic affinities is quite different from a world characterized by considerable ethnic diversity.

From this perspective, structure is not predetermined, but rather derived from attributes of and relations among states. It is not defined in terms of a single factor, but rather in terms of multiple factors. For example, if most alliances are formed between ethnically similar states we get a different structure than one in which alliances are
formed across ethnic divides. The same applies to the relationship between alliances and regime types.

Our approach consists of conceiving international politics as a set of networks that allow characterization and analysis of relations among states in a general, systematic, and multilayered manner. We define a network as a system that consists of N units (states in our case), and a set of relationships among these units—defined as ties on a given relationship (e.g., alliance, diplomatic representation, trade, conflict), or on a given affiliation (e.g., membership in international organizations, regime structure, ethnic groups). For example, an alliance network is a system that characterizes the presence or absence of alliance relationships between any pair of states. An International Organization (affiliational) network is a list of all states along with their membership (or non-membership) in all international organizations that exist in the world at a given point in time.

Strictly speaking, we assume that states live in an environment over which they have only partial control. Some of the characteristics of this environment are imposed upon a given state: for example, the number of neighbors it has, their capabilities, their regime structure, and so forth. Other attributes of this environment are defined by states’ choices. These choices are revealed by different types of relationships each state has with other states. For example, the alliances a state forms, its trading patterns, the conflicts it is involved in, its membership in international organizations, diplomatic representations, and so forth. Maoz (2001a) distinguished between discretionary and nondiscretionary networks. Discretionary networks are networks that are formed as a result of states’ choices. The entry into and exist from a discretionary network is a function of what states decide. Members of a discretionary network can decide whether to accept an outside actor into the network (e.g., members of the European Union can decide whether or not to accept Turkey). Members of the system can decide whether or not they wish to be part of a given network (e.g., The United Kingdom can decide whether to join the Euro regime).

Nondiscretionary networks are formed by factors that are not under the control of the units. Membership in the network is defined by factors that are outside the realm of members’ choices. States cannot choose their neighbors, but a neighborhood of states (a politically relevant international environment or PRIE, Maoz, 1996) makes up a network. A state’s ethnic composition and the extent to which it is similar or different from the ethnic composition of another state are also fairly uncontrollable.

The structure of the system, as conceived by the basic characteristic of anarchy, is not a built-in feature of the system, but a consequence of the behavior of actors. Some of this behavior may be dictated by factors outside their control. But some of their behavior may be a function of their decisions, and the accumulation of decisions may make for structural change (Maoz, 1990: 25-36; 1996: 18-21). So that in terms of our conception, the structure of international relations is seen as a set of—discretionary and nondiscretionary—networks. More specifically, international structure is defined by a set of characteristics of these networks.

In order to provide a more coherent conception of the structure of the system, we employ some basic concepts of social network approaches. A network, as noted, consists of a set of units—states, in our case—and a possible set of relationships between

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1 Schelling’s (1978) notion of “micromotives and macrobehavior” makes for a similar conception that is applicable not only to the social examples he provides, but also to international politics.
any two units, defined in terms of a given variable (the existence or absence of a formal alliance, the presence or absence of trade relations, the similarity or dissimilarity of regime types, the presence or absence of geographic contiguity, and so forth). Each such variable forms a network of its own. Each such network can be characterized in terms of certain fundamental attributes (to be discussed below). We start out by discussing individual characteristics of systems (or networks), and then we go on to review the type of networks analyzed in this study.

3.1. Characteristics of Networks: Density, Centralization, and Polarization

Political thinkers have used different metaphors of the state of nature to discuss questions of war and peace in international politics. Hobbes used his grim picture of the state of nature as characterized by eternal and universal conflict. Rousseau discussed the state of nature as one of basic harmony, where people reside in fairly isolated settings. However, over time, increasing contact among humans generates the kind of uncertainty and potentially sub-optimal outcomes as those conceptualized in the Stag-Hunt metaphor (Brown, Nardin, and Benger, 2002: 335-340, 416-425). The structure that emerges in the system where people (or states) interact is a function both of the characteristics of the people (states) and the interaction among them. Now, from this basis, we can describe the various structural characteristics of a system in terms of measures of types of relationships and affiliations among states.

It is convenient to describe these measures in terms of a given type of relationship among states—formal alliances—and in terms of a given affiliation of states—ethnic composition. An alliance network describes the alliance ties between members of the system. Two states are said to be related or tied to the extent that they have a formal alliance of any kind (Singer and Small, 1996). An ethnic composition network is a network that is derived from the size of different ethnic groups within existing states. For our case, we define an ethnic affiliation network as a set of all ethnic groups that can exist in the system (a total of 675 ethnic groups). A state is said to be affiliated with an ethnic group to the extent that ten percent or more of its population belong to this ethnic group. Of course, a state must be affiliated with at least one ethnic group, but it can be affiliated with more ethnic groups (up to ten different groups according to our restriction). From that affiliation structure, we can determine just how similar or different are any two states in terms of their ethnic composition (Maoz et al. 2003). An ethnic network, therefore, describes the extent of similarity or dissimilarity of pairs of states in terms of their ethnic composition. For our purposes, we define the relationship in dichotomous terms, although it is possible to define it in continuous terms (i.e., the extent of ethnic similarity). A pair of states is said to be ethnically tied (or related) to the extent that they share an ethnic group that comprises ten percent or more of each of the states’ populations.

To illustrate this, we present a graph description of the alliance and ethnic networks in the international system in the year 1840. These networks are given in figure 1.4

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2 As noted in a previous study (Maoz et al., 2003), such attributes can describe the network as a whole, any sub system, and subset of units, dyads, and individual units. Here we focus on the general characteristics of networks as wholes.

3 Here we provide a conceptual discussion of these properties. A more elaborate discussion is given in Maoz et al., (2003). Measures of these concepts are discussed in the next section.

4 Note that the ethnicity network is derived from the affiliation network of ethnic composition of states. See Maoz et. al., (2003) for a discussion of how this is done.
Network analytic approaches allow a systematic characterization of these systems in terms of, and some of these characteristics will serve as indicators of structure.

We start with the concept of density. The density of the system describes the extent to which units are related to each other. But the extent of ties between states depends not only on direct relationships, but also on indirect ones. This requires us to examine the reachability of the networks. Two states are said to be reachable if it is possible to get from one to another through common ties of the two states to other states. So if state A is an ally of state B, which is an ally of state C, which is an ally of state D, then states A and D may not have a direct alliance, but they have an indirect alliance. Likewise, state A and B may share an ethnic group, and states B and C may share an ethnic group, so that even though states A and C do not share any ethnic affinity, they share some indirect affinity through their common affinity with state B. Thus the density of a given network describes the extent to which states are tied to each other—directly or indirectly—in terms of a given relationship or trait. A system that is highly dense is one wherein nearly everyone in the system has some relationship with nearly everyone else. A system that is characterized by low density is a system in which states have few relationships (or bear little affinity) to other states.

The second characteristic of structure that we wish to explore is Network Centralization. This characteristic examines the extent to which a given network is centralized, such that a given state controls the ties between other states. A centralized network is one in which one actor is pivotal, such that any indirect relationship between any two other states must pass through this state. A decentralized network is one wherein each unit is equally important in terms of connecting states to each other. A system composed only of dyadic relationships, or tridac relationships, or of complete relationships (so that each state is tied to all other states) are equally decentralized. Consider the graphs given in Figure 1. Both the alliance network and the ethnicity network suggest low states of centralization because there are a large number of ties among many states.

Finally, the third characteristic of the network is the notion of network polarization. The concepts of polarity and polarization are central to the study of international politics. They are also important characteristics of economic, social, and political systems. Here we view network polarization as laying along a continuum that goes from zero polarization to maximum polarization. At the one end (zero polarization) is a network in which everybody is tied to everybody else, so that all members of the network form one clique. At the other extreme is a strictly bipolar system, one in which half of the states are tied to each other and form one clique, the other half form another clique, and there is no overlap between these two cliques. Unipolarity, that is, a situation wherein one state forms a center of a clique with some members, and other states are nonaligned is an intermediate point on the continuum. So is tripolarity and so are different types of multipolarity.

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5 Note that Li and Thompson (1977) have already discussed the concept of density as a characteristic of systemic polarity, based on the alliance structure of major powers (c.f., Wayman and Morgan, 1990).

6 See Maoz 2003 for a discussion of various conceptualizations of this term in economics, sociology, political science, and international relations.
Now, structural effects on behavior differ in terms of the kind of network we have in mind, and in terms of the specific indicators of structure. Let us now discuss how these characteristics of network structures affect a central feature of the international system: the level of conflict and war in the system.

3.2. Structural Factors and International Conflict

We consider four types of networks. Three are relational and one is affiliational. The relational networks are formal alliances, trade, and democratic. In order to consider the effects of each element of network structure on conflict, consider Table 1 below.

Let us discuss the effects of network type on conflict.

**Alliances:** As the density of the alliance network increases, the propensity of the system for conflict also increases. This is so because alliances serve as a possible state response to a sense of threat perception (Maoz, 2000). The more states form alliances, the more threatened they are. Some of these alliances are typically offensive, while others may be primarily defensive. However, the accumulation of alliances, to use Singer and Small’s idea (1968) suggests a growing level of hostility and mistrust that is typically associated with an increased propensity for conflict.

The centralization of the alliance network, on the other hand, is expected to be associated negatively with the level of conflict in the system. As noted, increased centralization suggests that a small number of states becomes pivotal to many alliances, so that if conflict is expected it is between a few sets of alliances but not among all states. The more centralized the alliance system, the more institutionalized are relations among states, and hence the less conflict is expected in the system.

4. Methodology

We start out by specifying the spatial-temporal domain and the data used for our study. We then discuss the empirical measures of the key variables, and the methods used to derive them. Finally, we discuss the process of an empirical description of the evolution of the system and the relationship between structure and war.

4.1. Spatial-Temporal Domain

We examine several international networks over the period of 1816-2000. Each international network consists of all the independent states (system members) during this time frame. The selection of the time frame is dictated by the availability of the data. Subsets of our temporal domain are also defined by available data. The networks examined in this study include the following:

1. Politically Relevant Networks. Following the concept of policy relevance established by Maoz and Russett (1993), and the concept of Political Relevant International Environment (PRIE) established by Maoz (1996). We employ the COW contiguity

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7 Democratic networks are conceptualized as in Maoz (2001). See methodology section below.
dataset (Stinnett et al., 2002; Gochman, 1991) from the COW2 website (COW2, 2002). A politically relevant network specifies the presence or absence (or extent) of contiguity between any two states in the system. It is organized as a set of 185 $N \times N$ matrices (where $N$ is the number of states in the system at a given year) covering the entire temporal domain. The contiguity variable is measured as 1 if two states had a land border or a maritime border of 150 nautical miles or less, and zero otherwise.

2. Alliance Networks. Like the politically relevant networks, the alliance networks are a set of 185 $N \times N$ matrices that specify whether or not any two states in the system had a formal alliance, as well as the type of the formal alliance between them. The source for this dataset is COW2, 2003a. And the details of the data are given in Gibler (2003) following Singer and Small (1966) and Small and Singer (1969). The elements of an alliance receive a score of one if there was an alliance between members and zero otherwise.

3. Democratic Networks. Democratic Networks (Maoz, 2001a) do not stand on their own. They are defined in terms of both policy relevance and regime type. However, to be able to define them, we use the POLITY V dataset (Jaggers and Gurr, 1995). Data available from the Center for International Development and Conflict Management (CIDCM, 2002) at the University of Maryland. The elements of this network are defined below.

4. Ethnic Networks. Ethnic Networks are affiliation networks. They consist of a set of 18 $N \times 675$ ethnic groups. The Ethnic Composition Dataset was compiled by Phil Schaffer at the University of Michigan and is available upon request. This dataset was used by Henderson (1998).

5. Trade Networks. These networks stipulate the presence or absence (volume data are also available but not used herein) of trade relations between members of the network. The dataset we used is that of Katherine Barbieri (Barbieri, 1996; 2002), and covers the period, 1870-1990. These make for 121 $N \times N$ matrices. Data are available at Barbieri’s Website (Barbieri, 2003). Elements of the trade network receive a score of 1 if there was any trade between members of the network and zero otherwise.

6. Capability Dataset. For the Capability Concentration index, we use the COW material capabilities dataset (COW2, 2003b). The source for this data and the capability measure is Singer, Bremer, and Stuckey (1972).

7. Conflict Dataset. The conflict dataset is the Maoz (2001b) dyadic MID dataset (DYMID) version 1.1. An update of this dataset to the year 2000 will be available soon. This dataset covers the 1816-2000 period.
4.2. Empirical Measures

Dependent Variables:

The dependent variables include the following:

- **Number of Dyadic Militarized Interstate Disputes (NOMIDS)**. This is simply the total number of dyads engaged in militarized interstate disputes at a given year. We used both the number of MIDs begun in a given year, and the number of MIDs underway. Results for both measures are remarkably similar.

- **Number of Dyadic Wars (NOWARS)**. This is the number of dyadic wars (begun or underway) at a given year.

- **Proportion of Dyadic MIDs (PROPMIDs)**. Proportion of all possible dyads engaged in Militarized interstate disputes during a given year.

- **Proportion of Dyadic Wars (PROPWARS)**. Proportion of all possible dyads engaged in war during a given year.

Independent Variables: Structural Features of Networks

Each of the structural features discussed below applies to all networks. Before discussing these features, a word about the transformation of affiliation networks into relational networks and about the use of clique data is in order. First, we must note that all of the matrices we employ herein are binary matrices. This is the case even for real valued data such as trade (or ordinal data such as alliances). In general, we use relational matrices (adjacency matrices or sociomatrices). In some cases, however, these matrices must be obtained from affiliation matrices. As noted, an affiliation network is specified as an $N \times k$ matrix with $N$ denoting the number of nodes (in our case—states) making up the network and $k$ the number of relevant events (in our case—ethnic groups for example, but this may apply for IGOs as well). In order to transform an affiliation matrix into a relational (adjacency) matrix we multiply the affiliation matrix by its transpose (Wasserman and Faust, 1994: 308). So that if $F$ is an $N \times k$ matrix then the first order adjacency matrix $A$ is given by:

$$A_{N \times N} = F_{N \times k} \times F_{k \times N}^T$$

(1.1)

In general, nearly all of our measures are derived from adjacency matrices. However, not all are first-order matrices. For the density measure below we use the reachability matrix. This matrix defines all pairs of relationships that are reachable in the network. It is calculated as:

$$R = \sum_{i=1}^{N-1} A^i$$

(1.2)

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8 The purpose is to simplify the analyses. Subsequent studies will use real data for some of the analyses reported herein. In other cases, binary data is necessary for deriving the measures. We report, where necessary, if and how the measures derived below apply for valued data.
Where $A'$ is the Adjacency matrix raised to the $i$th power (e.g., $A^2 = A \times A$, $A^3 = A^2 \times A$, and so forth). All matrices are transformed to binary values indicating the presence or absence of a relationship.

One of our measures, the Network Polarization Index (NPI) uses clique datasets. In general, a clique is defined as a set of three or more units that have direct ties between them (Wasserman and Faust, 1994: 254). The identification of cliques allows several datasets to be produced from a given network. One is the clique affiliation (or Clique Sets) matrix (denoted by $CA$). This matrix is a typical affiliation matrix with $N$ rows denoting all units (states), and $k$ columns that denote the cliques. Each entry $ij$ in this matrix is a binary entry that denotes whether state $i$ is a member of clique $j$. In our case (Maoz, 2003) we employ a more general clique affiliation matrix where cliques are defined to be not of size three and above, but of size one and above. This is done in order to incorporate all states whether or not they are members of cliques in the traditional sense. This definition allows including states that are not members of any clique, or only dyadic relationships.

The second dataset produced by the clique framework is the Clique Overlap dataset. This is a $k \times k$ valued matrix, denoted by $CO$ and derived as:

$$CO_{k \times k} = CA'_{k \times N} \times CA_{N \times k}$$  \hspace{1cm} (1.3)

We now proceed to the individual measures of network characteristics.

**Density ($\Delta$).** The density of a network is the proportion of all possible ties in a reachability matrix that actually exists in a network. It is defined (Wasserman and Faust, 1994: 129) as:

$$\Delta = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} r_{ij}}{N(N-1)}$$  \hspace{1cm} (1.4)

where $r_{ij}$ is any element of matrix $R$, and $N$ is the number of nodes (states) in the network.

The density of a given network measures the proportion of all possible relationships in a given network that is actually realized. For example, if all states were aligned with each other, this index would assume the value of 1. If none of the states were aligned, it would assume the value of zero. Any proportion of dyads that are aligned would provide a score between these two extremes.

**Betweenness Centrality ($C_B$).** Betweenness centrality denotes the extent to which members of the network differ in terms of the level to which they are central to a network. Each unit in the network can be a connection between two other units. In this case, the communication between two units that do not have a direct tie must pass through the intermediary unit. The more indirect communication passes through a certain unit in a network, the

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9 Density measures can be derived for valued matrices and are defined by

$$\Delta = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} v_{ij}}{N(N-1)}$$

where $v_{ij}$ is a real valued element of a valued relational matrix $V$ in which each entry denotes the amount of relationship (e.g., trade) between members $ij$. 
greater the stress on that actor. The Betweenness Centrality Index measures the extent to which the network is “stressed” in that respect (Wasserman and Faust, 1994: 189-190). To calculate this index, we first have to measure the betweenness centrality index of each actor in a network. This is given by

$$C_b(n_i) = \sum_{j<k} g_{jk}(n_i) / g_{jk}$$  \hspace{1cm} (1.5)

Where $n_i$ is the index of units (states) in a network. We refer to the shortest path between two actors as a geodesic and refer to the geodesic between actors $j$ and $k$ as $g_{jk}$. Thus, this concept of centralization betweenness of actor $i$ measures how many geodesics between actors $j$ and $k$ pass through actor $i$ as a proportion of all geodesics in the network. This index can now be converted into several distinct characteristics of the network as a whole. Here we use the concept of group betweenness centralization index that measures the extent to which the deviation between the most central actor in the network and all other actors differs from the maximum possible deviation in a network of this form. The group betweenness centralization index is given by (Wasserman and Faust, 1994: 191):

$$C_B = \frac{1}{2} \sum_{i=1}^{k} \left[ \frac{C_b(n^*) - C_b(n_i)}{g-1} \right]$$  \hspace{1cm} (1.6)

Where $C_B(n^*)$ is the actor with the largest betweenness centralization score in the network, and $g$ is the number of geodesics (states) in the system. In general, the more centralized the network, that is, the larger the difference between the actor with the largest betweenness centralization score and the other actors, the larger is the group betweenness centralization index. Thus, for each of these networks $C_B$ denotes the degree of centralization or decentralization. This measure too varies between zero and 1.

**Network Polarization Index (NPI).** This measure is discussed at length in Maoz (2003) and will not be elaborated here. However, we note that this is a measure of the extent to which a given network is polarized. Maximum polarization is obtained when the system is strictly bipolar: half of the states are in one clique, the other half is in a second clique, and no state is in both cliques. The minimum polarization takes place when all states are in a single clique. Situations where there are no cliques with two states or more, or when there is considerable overlap between cliques receive intermediate scores between these two extremes. Briefly, this index is composed of a product of two subindexes, the Node Polarization (NPOL) and the Clique Overlap Index (COI). Node polarization denotes the extent to which any given clique is polarized with respect to all units that are not in the clique. The clique overlap index denotes the extent to which cliques overlap in terms of joint membership. NPOL is derived from the clique affiliation (CA) matrix, and is given by:

$$\sum_{i=1}^{k} s_i(N-s_i)$$

where $s_i$ is the number of states in clique $i$. $Max(POL|N,k)$ is the maximum polarization possible in a network of size $N \times k$. This is given by $k(N/2)^2$ when $N$ is even and by $k(N^2-1)/4$ when $N$ is odd (Maoz, 2003).

The COI index is derived from the CO matrix and is given by:
International Relations: A Network Approach

\[ COI = \frac{2\sum_{i=1}^{k} \sum_{j=i+1}^{k} CO_{ij}}{k(k - 1)} \]  

(1.8)

where \( CO_{ij} \) is a non-diagonal element of matrix CO (with \( i \neq j \)), and \( CO_{ii} \) is the corresponding diagonal element of the matrix. (\( k \) is the dimension of the matrix.). Once these measures are defined, we compute NPI as:

\[ NPI = NPOL(1 - COI) \]  

(1.9)

**Democratic Networks (DEMNET)**. Democratic Networks are measured differently from the other types of networks. Following Maoz (2001), we start with the clique affiliation matrix of the contiguity dataset. The cliques in the contiguity network are defined in the traditional sense (i.e., cliques are of size three or larger). For each of the \( k \) contiguity cliques, we calculate the proportion of members that are democratic. We then average these proportions across the \( k \) cliques. So that DEMNET is defined as.

\[ DEMNET = \frac{1}{k} \sum_{i=1}^{k} \frac{d_i}{s_i} \]  

(1.10)

where \( d_i \) is the number of democracies in clique \( i \), and \( s_i \) is the number of states in that clique.

**Capability Concentration (CAPCON)**. As noted, we use the Singer, Bremer, and Stuckey (1972) index. This index is based on a national capability measure that uses the average proportion of a state’s capabilities over six capability indices (total population, urban population, iron and steel production, energy consumption, military personnel, and military expenditures). Capability Concentration in a system of \( N \) states is measured as:

\[ CAPCON = \sqrt{\frac{\sum_{i=1}^{N} p_i^3 - \frac{1}{N}}{N - 1/N}} \]  

(1.11)

Where \( p_i \) is the proportion of the system capabilities held by state \( i \) (Ray, 1990).

4.3. *Data Analysis*

We start with a descriptive discussion of the evolution of international politics over time in terms of the various characteristics of the networks included in our study. We examine the interrelations among the various networks and among the various indices of system structure. We then examine the effects of structure on conflict and war. In order to do that, we perform two sets of time-series analyses. First, with respect to the count dependent variables (NOMIDS, NOWARS), we conduct an autoregressive poisson estimation, suitable for event counts. With respect to the ratio-level dependent variables (PROPMIDS, PROPWARS), we use simple time-series regression with Cochr-ran-Orcutt correction for serial correlation.

5. *Empirical Results*
As noted, we start with a quantitative description of the evolution of international politics over time. We start with the density of our networks.

We can see the structure of the international system in terms of the density of the different networks is not consistent. The density of the alliance network declined through the nineteenth century, up to the early twenties of the twentieth century, and then showed an upward trend going to the 1960s. From that point on there is a process of significant fluctuation, but the density remained generally high. This changed again in the 1990s, when the density of the alliance system declined in the 1990s. On the other hand, the density of the ethnicity network declined consistently over time. As states became increasingly homogeneous and different in terms of ethnic composition from other states. This suggests a nationalism based trend in international politics. On the other hand, the density of democratic networks increased. As a growing proportion of the members of politically relevant networks became democratic. This suggests

In order to examine
Bibliography


Table 1: Networks, Structural Factors, and International Conflict

<table>
<thead>
<tr>
<th>Network</th>
<th>Type of Network</th>
<th>Density</th>
<th>Structural Factor Network Centralization</th>
<th>Network Polarization</th>
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<td>Positive Effect</td>
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Table 2: Correlations Among Indices of System Structure

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<td>0.959** (185)</td>
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<td>0.016 (185)</td>
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** p < .01, * p < .95 (N’s in parentheses)
Numbers next to the dots are Correlates of War Nation Numbers.
Figure 2: Reachability of Alliance and Ethnic Network, 1840