Network Analysis for International Relations

Emilie M. Hafner-Burton, Miles Kahler, and Alexander H. Montgomery

Abstract International relations research has regarded networks as a particular mode of organization, distinguished from markets or state hierarchies. In contrast, network analysis permits the investigation and measurement of network structures—emergent properties of persistent patterns of relations among agents that can define, enable, and constrain those agents. Network analysis offers both a toolkit for identifying and measuring the structural properties of networks and a set of theories, typically drawn from contexts outside international relations, that relate structures to outcomes. Network analysis challenges conventional views of power in international relations by defining network power in three different ways: access, brokerage, and exit options. Two issues are particularly important to international relations: the ability of actors to increase their power by enhancing and exploiting their network positions, and the fungibility of network power. The value of network analysis in international relations has been demonstrated in precise description of international networks, investigation of network effects on key international outcomes, testing of existing network theory in the context of international relations, and development of new sources of data. Partial or faulty incorporation of network analysis, however, risks trivial conclusions, unproven assertions, and measures without meaning. A three-part agenda is proposed for future application of network analysis to international relations: import the toolkit to deepen research on international networks; test existing network theories in the domain of international relations; and test international relations theories using the tools of network analysis.

Networks have long been a familiar feature of international politics. Networks include benign actors such as transnational advocacy networks (TANs) as well as terrorists and criminals organized in "dark" networks. Networks in international relations have typically been treated as a mode of organization, one that displays neither the hierarchical character of states and conventional inter-

The authors thank Robert O. Keohane, Daniel H. Nexon, Woody Powell, participants in the 2008 Harvard Networks in Political Science Conference, and the editors of *International Organization* for valuable comments on earlier drafts of this article.

International Organization 63, Summer 2009, pp. 559–92
© 2009 by The IO Foundation.
doi:10.1017/S0020818309090195

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

national organizations nor the ephemeral bargaining relationships of markets. The lens of network analysis offers a broader and contrasting view: networks are sets of relations that form structures, which in turn may constrain and enable agents.[1] Network analysis provides a set of theories and tools to generate puzzles and test propositions about these structures. It provides answers to key questions in international relations: when are terrorist groups created, strengthened, and dissolved, and how are they organized? How do military alliances and other international affiliations alter states' conflict propensities? Does membership in preferential trade agreements and other international organizations reduce or increase international inequality? What is the best method for halting weapons proliferation?

Network analysis complements existing structural approaches to international relations that focus on actor attributes and static equilibria. Instead, it emphasizes how material and social relationships create structures among actors through dynamic processes. It also provides methods for measuring these structures, allows for the operationalization of processes such as socialization and diffusion, and opens new avenues for reconsidering core concepts in international relations, such as power. Partial or faulty incorporation of network analysis, however, risks trivial conclusions, unproven assertions, and measures without meaning.

We assess the current and potential contributions of network analysis for international relations. In the first section, we provide an overview of the network perspective, comparing it to existing approaches in international relations. We then give a brief overview of the concepts and methods of network analysis and discuss the new dimensions that it can add to the concept of power in international relations. In the final two sections, we review current applications of network analysis to international relations research, assess the promise and risks of the approach, and propose a network analysis research agenda for the field.

Networks as an Analytic Concept in International Politics

Networks have typically been regarded in international relations as a mode of organization that facilitates collective action and cooperation, exercises influence, or serves as a means of international governance. Perhaps the most familiar example is the transnational activist network, described by Keck and Sikkink.[2] Terrorist networks have received particular attention since the attacks of September 11, 2001; governance networks also have a clear intellectual lineage in inter-

1. In this piece, we use the more general term network analysis (NA) instead of social network analysis (SNA); although many of the concepts, theories, and methods described here are derived from SNA, some are derived from graph or network theory that is not specific to social networks.

2. See Keck and Sikkink 1998; Price 1998; and Khagram, Riker, and Sikkink 2002.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

national relations, one that begins with transgovernmental cooperation, as described by Keohane and Nye.[3] The discipline of international relations has not, until recently, treated networks as structures that can constrain and enable individual agents and influence international outcomes. Research has focused on networks' effects on their environments (for example, the effects of transnational activist networks on international agreements) rather than the effects of network structures on actors and outcomes within those networks (for example, the effects of the network of intergovernmental organizations on conflict).[4] Networks have been contrasted with other modes of organization, such as state hierarchies or markets, but variation among networked organizations and the effects of that variation have received much less attention. Networks are significant actors in international politics and represent a specific mode of international interaction and governance. As such, they remain important objects of research. Too often, however, a definition of networks as any nonhierarchical mode of organization in international relations has obscured a broader, structural perspective on their place in world politics.

Rather than serving solely as a tool for examining a particular form of organization, network analysis also permits fine-grained conceptualization and measurement of structures. The neorealist concept of structure, based on the distribution of material capabilities across units, has typically dominated international relations.[5] A network approach, by contrast, defines structures as emergent properties of persistent patterns of relations among agents that can define, enable, and constrain those agents. As in other structural approaches to international relations, our interest in network structures derives from their effects. Those effects, however, must be demonstrated empirically, not assumed. Network analysis aims to identify patterns of relationships, such as hubs, cliques, or brokers, and to link those relations with outcomes of interest. Structural relations are as important as, if not more important than, attributes of individual units for determining such outcomes. As a result, the beliefs and actions of individual agents (and observations of individual behavior) are not independent. In contrast to more static conceptions of structure, such as the neorealist variant, network relations are inherently dynamic.[6] Network analysis allows structural investigation at multiple levels of analysis, including groups of units of any size as well

3. Keohane and Nye defined transgovernmental cooperation as "sets of direct interactions among sub-units of different governments that are not controlled or closely guided by the policies of cabinets or chief executives of those governments." Keohane and Nye 1974, 43; see also Keohane and Nye 1977. Networks, however, were not a central analytical category in this earlier formulation.

4. See Kahler 2009c; and especially Kahler 2009b, on these two approaches to networks in international relations: networks as structures and networks as actors.

5. Waltz 1979.

6. For overviews of the network perspective, see Wellman 1983 and 1997. On relationalism, structure, and agency, see Emirbayer and Goodwin 1994; and Emirbayer 1997.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

as the monadic, dyadic, and systemic levels familiar to international relations scholars.

In the late 1960s and early 1970s, early pioneers of network analysis in international relations examined emergent structures in the international system that resulted from network ties based on trade, membership in intergovernmental organizations (IGOs), and diplomatic exchange.[7] These early studies generally stopped short of using network analysis to test theories or predict network effects on international politics. A second wave of research based in sociology began in the late 1970s and used network analysis to investigate structural determinants of international inequality, drawing on dependency and world-systems theory.[8] This line of research has not found an audience in international relations, since its theoretical grounding is no longer part of mainstream political science.

Only a third wave of network applications, starting in the late 1990s, has begun to integrate the tools of network analysis and the core problems of international relations. To better understand this integration, the concepts and methods of network analysis, largely developed outside international relations, require introduction.

Concepts, Principles, and Methods of Network Analysis

Network analysis concerns relationships defined by links among nodes (or agents). Nodes can be individuals or corporate actors, such as organizations and states. Network analysis addresses the associations among nodes rather than the attributes of particular nodes. It is grounded in three principles: nodes and their behaviors are mutually dependent, not autonomous; ties between nodes can be channels for transmission of both material (for example, weapons, money, or disease) and nonmaterial products (for example, information, beliefs, and norms); and persistent patterns of association among nodes create structures that can define, enable, or restrict the behavior of nodes.[9] In network analysis, networks are defined as any set or sets of ties between any set or sets of nodes; unlike the study of network forms of organization, no assumptions are made about the homogeneity or other characteristics of the nodes or ties. Consequently, network analysis can be used to analyze any kind of ties, including market and hierarchical relations. Beyond these basic principles, network analysis enables calculation and mapping of structural

7. See Savage and Deutsch 1960; Brams 1966 and 1969; Skjelsbaek 1972; and Christopherson 1976.

8. See Snyder and Kick 1979; Breiger 1981; Nemeth and Smith 1985; Faber 1987; Peacock, Hoover, and Killian 1988; Smith and White 1992; Van Rossem 1996; and Sacks, Ventresca, and Uzzi 2001.

9. See Wasserman and Faust 1994, 4.

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properties of nodes, groups, or the entire network; predictions regarding the creation, growth, and dissolution of these networks; and investigation of the effects of networks on actors' behavior.[10]

Measuring Network Properties

The strength of a tie is conceptualized as a combination of the magnitude and frequency of interactions between two nodes. Ties may be binary, such as whether two states recognize each other, or of variable strength, for example, the number of phone calls between two individuals in a terrorist cell. Ties may also be symmetrical or asymmetrical (stronger in one direction than the other direction, as often occurs in international trade). Network ties need not imply positive or cooperative relations; they can also be negative, such as the enmity between two states in an enduring rivalry. Finally, ties can be derived from a number of sources: direct networks linking people or trading partners; affiliation networks of alliances, organizations, and agreements; or implicit networks among nodes linked by common identity, geography, or other characteristics.

In Figure 1, we demonstrate the derivation of network ties among five states that are members of an affiliation network of seven hypothetical IGOs, one common way of measuring ties in the international system.[11] We begin with an affiliation matrix (where 1 indicates a state's membership in a particular IGO), then multiply the matrix by its transpose to convert it to a sociomatrix, a common way of representing network data. In this case, the value 4 in row United States and column France means that there is a tie of strength 4 from the United States to France; it indicates that the United States and France share membership in four IGOs. The entire sociomatrix gives the distribution of ties across the network and is graphed in Figure 1.

The distribution of ties in a network suggests two important structural characteristics: centrality (importance) of nodes in the network and division of the network into subgroups.

Variants of centrality in a network include degree, closeness, and betweenness.[12] Degree centrality of a node is the sum of the value of the ties between that node and every other node in the network. This measure tells us how much

10. For a good overview of network analysis, see Scott 2000. The most comprehensive, if slightly dated, technical overview is Wasserman and Faust 1994. For recent additions to Wasserman and Faust, see Carrington, Scott, and Wasserman 2005. For a much more concise and up-to-date reference, see Knoke and Yang 2008. For an historical overview of the development of the field, see Freeman 2004.

11. Affiliation networks are also known as two-mode networks, in which one type of node (states in this case) is connected to other nodes of the same type through their mutual affiliations; see Wasserman and Faust 1994, chap. 8.

12. See Freeman 1979, on these particular measures; on centrality in general, see Scott 2000, chap. 5; or Wasserman and Faust 1994, chap. 5; for recent extensions, see Everett and Borgatti 2005.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

access a particular node has to the other nodes. Closeness centrality is calculated using the length of the path between a node and every other node. This measure could estimate the time required for information or resources to propagate to a given node in a network. Betweenness centrality corresponds to the number of shortest paths in the network that pass through a particular node, and therefore it measures the dependence of a network on a particular node for maintaining connectedness.

Affiliation matrix	IGO1	IGO2	IGO3	IGO4	IGO5	IGO6	IGO7
United States	1	1	1	1	0	0	0
France	1	1	1	1	1	0	0
China	0	0	0	1	1	1	1
North Korea	0	0	0	0	0	1	0
Iran	0	0	0	0	0	0	1

Sociomatrix	United States	France	China	North Korea	Iran
United States	4	4	1	0	0
France	4	5	2	0	0
China	1	2	4	1	1
North Korea	0	0	1	1	0
Iran	0	0	1	0	1

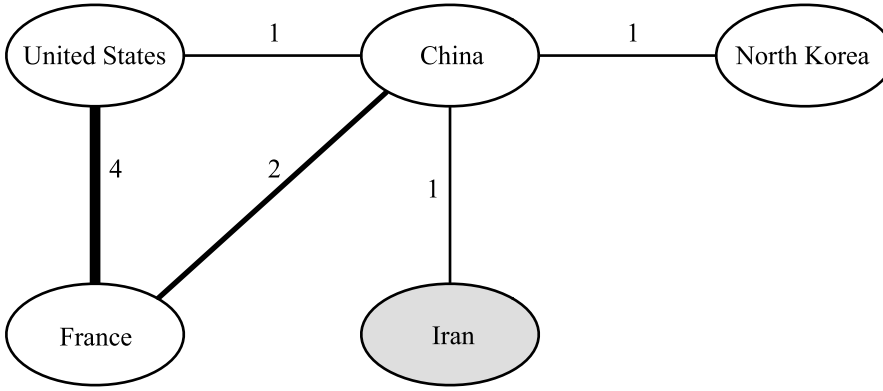


FIGURE 1. *Deriving a sample international network*

These measures do not take into account the importance of other nodes (in the case of degree centrality) or the significance of all paths (in the case of closeness and betweenness centrality). Other measures include these values. For example, eigenvector centrality incorporates not only the number of a node's links and the

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strength of those ties, but also the centrality of those other nodes.[13] In a similar fashion, information centrality differentially weights paths to account for not only distance from a given node to the other nodes but also strength of connection, taking into account the probability of transmission along all possible paths.[14] Flow betweenness centrality accounts for the strength of all paths between nodes instead of just the shortest ones, giving a measure of the proportion of total resource flow in the network controlled by a single actor.[15] The extent of centralization in a network—how much other nodes rely on a single node—can be calculated using any of these centrality concepts.

Table 1 applies the six measures of centrality described above to the network in Figure 1 and calculates the centralization of the entire network. While DEGREE centrality simply sums incoming ties, giving France the greatest centrality in this example, with the United States and China tied for second, EIGENVECTOR centrality weighs not only the tie values but also the centrality of the attached nodes.[16] In this measure, the strong ties of the United States to a particularly important actor (France) give it greater EIGENVECTOR centrality than China. Both BETWEENNESS measures and CLOSENESS centrality rank China high. INFORMATION centrality, which takes into account the likelihood of information actually passing along particular ties (proportional to their strength), also ranks both the United States and France with relatively high centrality due to their strong mutual tie. Finally, the network in this example is highly centralized in terms of BETWEENNESS and CLOSENESS centrality, mainly due to the position of China (since all paths from one part of the network to the other must pass through it). It is not very centralized with respect to measures that take into account tie strength such as DEGREE and INFORMATION centrality.

Network ties also partition a network into subgroups, a primary concern of network analysis. Two nodes belong to the same group if their direct ties to each other are dense enough (cohesive subgroups) or their ties to all other nodes are similar (structurally similar clusters). As with centrality, multiple conceptions of cohesion and structural similarity exist; here we focus on one type of cohesion (clique) and one type of similarity (structural equivalence).[17] A clique is a group in which every member has a tie of strength above a certain minimum with every

13. Bonacich power centrality generalizes degree and eigenvector centrality while broadening it to include the possibility that being strongly connected to weakly connected actors may be a source of centrality in a network. For formal definitions of eigenvector and Bonacich power centrality, see Bonacich 1987.

14. For a formal definition of information centrality, see Stephenson and Zelen 1989.

15. For a formal definition of flow betweenness centrality, see Freeman, Borgatti, and White 1991.

16. For example, China's indegree centrality is the sum of all incoming ties: 1 from Iran, North Korea, and the United States, plus 2 from France, for a total of 5. Eigenvector centrality takes into account the fact that half of China's ties are to countries with low centrality.

17. See Scott 2000, chaps. 6 and 7; or Wasserman and Faust 1994, chaps. 7 and 9. For the origins of structural similarity, see Burt 1976; for distinctions between different types of structural similarity, see Borgatti and Everett 1992; for extensions, see Doreian, Batagelj, and Ferligoj 2005.

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other member. For example, in Figure 1, the United States, France, and China are in a 1-clique, since they all have ties of strength 1 or more to each other, while the United States and France are in a 4-clique. A structurally equivalent cluster is a group where every member has ties of similar strength to every other node in the network. In Figure 1, Iran and North Korea are structurally equivalent, as they have exactly the same strength ties to the same node(s). After dividing a network into structurally similar groups, the network can be presented as a blockmodel to investigate the relationships between groups of nodes and to reveal macrostructures.[18] These basic network structures can be mapped and measured using a variety of network analysis programs.[19]

TABLE 1. *Centrality scores for Figure 1*

Function	*United States*	*France*	*China*	*North Korea*	*Iran*	*Network centralization*
DEGREE	5.00	6.00	5.00	1.00	1.00	0.25
EIGENVECTOR	0.61	0.66	0.42	0.08	0.08	0.68
BETWEENNESS	0.00	0.00	5.00	0.00	0.00	0.83
FLOW BETWEENNESS	0.13	0.25	0.60	0.00	0.00	0.51
CLOSENESS	0.67	0.67	1.00	0.57	0.57	0.89
INFORMATION	1.43	1.52	1.79	0.86	0.86	0.42

Notes: All calculations performed using the SNA package (Butts 2007), a part of the free statnet package (Handcock et al. 2008b) in R (R Development Core Team 2007).

Network Creation and Growth

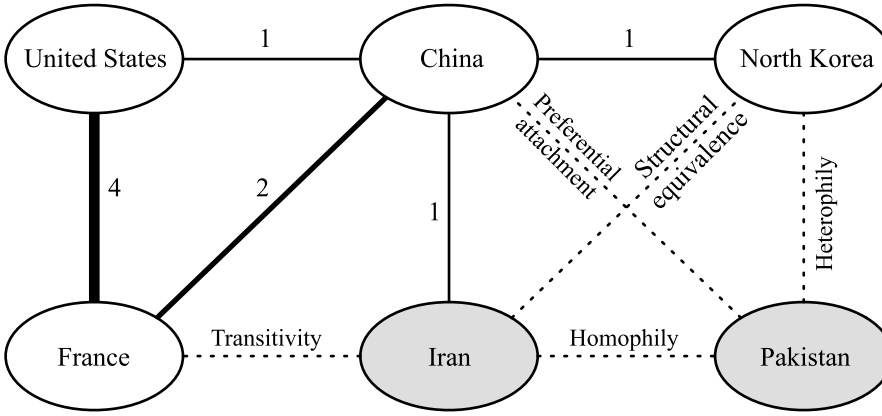
Network analysis describes relational and individual mechanisms through which new network ties are likely to be created. Relational mechanisms suggest how relative location within existing networks influences the likelihood of tie formation; individual mechanisms suggest particular attributes of nodes that make ties

18. A blockmodel is a reduced representation of the overall network that groups nodes into blocks (groups) of nodes in similar positions to examine the macrostructure of the network. For example, Figure 1 might be represented as three blocks: a very cohesive block with strong internal ties (representing the United States and France) with a weak tie to the second block (China), which in turn has a weak tie to a third block with no internal ties (Iran and North Korea). On blockmodeling, see White, Boorman, and Breiger 1976; and Boorman and White 1976; see also Wasserman and Faust 1994, chap. 10.

19. An overview of social network analysis software is available from the International Network for Social Network Analysis's Web site at http://insna.org. All of the measurements and techniques discussed in this piece are currently or will soon be available as part of the free statnet package, available at http://statnet.org. See Handcock et al. 2008b.

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more or less likely to occur. We illustrate these different mechanisms in Figure 2, where we add a node (Pakistan) to Figure 1 and denote potential ties due to different mechanisms as dotted lines.



Note: Dotted lines indicate new ties.

FIGURE 2. *Sample international network with an additional node (Pakistan), demonstrating potential mechanisms for new ties*

Two of the most prominent relational mechanisms in network analysis are structural balance and structural equivalence. Theories of structural balance (or transitivity) hypothesize that only certain patterns of positive (affect) and negative (enmity) ties can exist among three nodes.[20] Essentially, the friend of my friend is my friend, and the enemy of my enemy is my friend. From this, we might expect a tie to form between Iran and France in Figure 2, given that each has (positive) ties to China. Structural equivalence may predict that nodes in similar structural positions vis-à-vis other nodes will act in similar ways. They may be likely to form ties as long as they are not in competition for resources. Figure 2 shows that North Korea and Iran may be likely to form a tie due to their structurally equivalent positions vis-à-vis China. These mechanisms are not exclusive; North Korea and Iran may also be more likely to form ties due to structural balance as well.

Individual mechanisms in the formation of network ties include homophily, a tendency for nodes to form ties based on common attributes, or heterophily, in

20. For a technical discussion of structural balance and transitivity, see Wasserman and Faust 1994, chap. 6.

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which nodes form ties to share strengths and minimize weaknesses.[21] For example, in Figure 2, Iran and Pakistan, which share the similar attributes of geography and postcolonial status, may form a tie. Alternatively, Pakistan and North Korea, which have the complementary attributes of possessing centrifuge enrichment technology and ballistic missile technology, respectively, may form a tie.

Finally, pre-existing network connections can also affect the creation of new ties. Under conditions of preferential attachment, highly central nodes will forge more additional ties than less-connected nodes. In Figure 2, Pakistan may seek to attach itself to China because China is the most central node in the network (by information, betweenness, and closeness measures).[22] States that already have extensive ties through some networks (trade, IGOs, democracy) may be more likely to be linked in other networks. Ties that are one-sided may be reciprocated over time as well. These network mechanisms can be measured simultaneously using exponential random graph models.[23] They also figure in agent-based models.[24]

Network Effects

General theoretical propositions seek to explain the ways that individual nodes, clusters of nodes, and entire networks will affect processes and outcomes of interest. Because they are highly dependent on specific contexts and assumptions, their translations to the anarchic conditions of international relations are best regarded as hypotheses to be tested rather than propositions that apply automatically to international relations. For example, sociological findings suggest that highly central nodes in networks possess high social capital. Social capital represents the resources derived from network membership.[25] Two competing perspectives on social capital assign different structural positions greater or lesser weight. The first school holds that nodes positioned between network clusters in structural holes (high betweenness centrality) have high social capital;[26] the second holds that nodes that are well-connected in general (high degree or eigenvector centrality) have more resources to draw upon through their network connections.[27] Nodes that have high closeness or information centrality will also receive information more quickly

21. On homophily, see Taylor 1970; Cohen 1977; and Kandel 1978.
22. Preferential attachment was first characterized by Moreno and Jennings 1938, and has been given an important recent treatment by Barabási and Albert 1999.
23. See Snijders et al. 2006; and Handcock et al. 2008a.
24. See Kim and Bearman 1997; Cederman 2005; and Snijders, van de Bunt, and Steglich in press.
25. Bourdieu 1986, 348.
26. The classic work on how information can be better obtained through weak, bridging ties is Granovetter 1973.
27. See Portes 1998 on the two forms; on structural holes, see Burt 1992; on centrality as a source of capital, see Coleman 1990. Other debates concern whether social capital is possessed by individuals or by collectivities; see Lin 2001, 21–28 on this debate.

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than marginal nodes. Hypotheses regarding social capital are useful, because information and capital asymmetries affect political processes and outcomes at the international level. For example, rationalist theories of conflict rely heavily on beliefs about the distribution of material capital and thus uncertainty about the outcome of war.[28] Such reasoning could be extended to the distribution of social capital in international relations.

Studies of individual behavior in social networks also point to potential hypotheses. Group socialization of nodes through interactions in a given subgroup can prompt changes in characteristics of individual nodes. Nodes in a cohesive subgroup favor those in-group and treat those outside with enmity.[29] Nodes in structurally similar clusters face similar constraints and opportunities and therefore are more likely to act in similar ways. Similar behavior does not imply cooperation, however. Structurally equivalent nodes may also compete, depending on the roles associated with their positions. For example, two states in the same postcolonial preferential trading arrangement may compete for trade privileges and aid from the former colonial power.

Conflict and cooperation are strongly influenced by network dynamics. Social network studies of degree centrality and conflict find that more central nodes tend to be more aggressive.[30] Such hypotheses, based on network position and relying on few assumptions about individual nodes, can also be tested in the context of international relations. Constructivist scholars hypothesize that socialization processes are an important determinant of state behavior in international politics.[31] Network analysis offers a method for measuring the sources of socialization and the diffusion of norms based on the strength of ties between states, collective state identities such as security communities, and the importance of individual states.

A final theoretical transfer from network analysis concerns network efficiency and robustness. Network structure can determine efficiency in the distribution of information or material resources as well as ability to withstand threats of disruption. Most networks face a tradeoff between efficiency and robustness: redundant links make a network more robust, but they may also make it operate less efficiently. If betweenness measures indicate that a network is highly centralized (most paths go through a few nodes, such as the network in Figure 1), then investment in the important hubs may make the network more efficient, but removal of those few nodes (such as China in Figure 1) can disrupt the network. In a centralized configuration, temporary connection of nodes through "shortcuts" maintains robustness against intentional disruption and increases task efficiency. This type of simul-

28. On the role of uncertainty in the onset of war, see Fearon 1995; and Bennett and Stam 2004.

29. These are well-established findings in social psychology; see Levine and Moreland 1998.

30. Social network studies of classroom environments show this as a consistent pattern. See Hafner-Burton and Montgomery 2006, 11–12.

31. See Wendt 1992; Finnemore 1993; Meyer et al. 1997; Alderson 2001; Checkel 2001; Johnston 2001 and 2008; and Kelley 2004.

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taneous centralization and decentralization is seen in some terrorist networks and in highly reliable organizations (HROs).[32] These tradeoffs between robustness and efficiency are important for many illicit and licit networks of interest to international relations scholars.

Networks and Power in International Relations

The innovations of network analysis challenge conventional views of power in international relations. For example, a structural analysis of networks equates the power of a particular node to its position in the network, defined by its persistent relationships with other nodes. Power is no longer derived solely or even primarily from individual attributes, such as material capabilities. At the same time, new investigations of power in international relations from a network perspective could refine and enrich network analysis.

Social Power as Access

Network power, defined by Knoke as "prominence in networks where valued information and scarce resources are transferred from one actor to another," is usually related to one of several competing definitions of centrality.[33] For instance, a network node with high degree centrality (strong links with many other nodes) may possess *social power*, easily accessing resources and information from other nodes because of its central position. This proposition identifies France as the most socially powerful state in Figure 1. Social power may not only allow a node—whether a state, an organization, or an individual—to access benefits from other network members, it may also let that node shape the flow of information among nodes and alter common understandings of relative capabilities, common interests, or norms.

Some international relations scholars have adopted this notion of degree centrality as social power. Hafner-Burton and Montgomery propose that actors with higher degree centrality in the international system can "withhold social benefits such as membership and recognition or enact social sanctions such as marginalization as a method of coercion" and would "expect additional support in a conflict."[34] In a revision of world polity theory, Beckfield argues that "states and societies with privileged positions in the world polity are able, to a significant degree, to set agendas, frame debates, and promulgate policies that benefit

32. On HROs and simultaneous centralization and decentralization, see Rochlin 1993; for an excellent example of a terrorist organization using this tactic, see Krebs 2002.

33. Knoke 1990, 9. Knoke restricts his definition of network power to the ability to alter attitudes and behaviors; we would include identities and interests as well. See also Freeman 1979; and Cook et al. 1983.

34. Hafner-Burton and Montgomery 2006, 11.

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them."[35] His definition of "structural inequality" relies on the degree centralization of the IGO network.[36] These propositions, which treat degree centrality as power, could be revised by moving to eigenvector or related notions of centrality that incorporate the centrality of every node. For example, a state that has many links (such as organizational memberships or trade flows) with regional neighbors that are not well-connected themselves may be less likely to possess social power than a state that is part of a network with many other high-centrality members.[37]

Network analysis provides an intuitive association of social power with access, but it also adds an important qualification: access may impose constraints on autonomy as well as offer opportunities for influence. The direction of influence within the network is seldom one-sided, even if it is asymmetric. States that are part of an alliance network may find themselves in conflicts they would rather avoid; trade ties can be used for economic sanctions; normative bonds are deployed to force compliance through naming and shaming; and telephone and email records can be used to destroy a terrorist network. Network structures and ties also create behavioral expectations: states in certain positions can be expected to play certain roles. Perhaps no contemporary state better exemplifies the dual effects of network ties than Germany, which is deeply embedded in European, Atlantic, and global networks. Germany's role in the European economy is a preponderant one, and that economic status is reflected in the institutions of the European Union (EU). At the same time, German policy, particularly its security policy, is constrained by these same networks of influence. Germany's foreign policy orientation cannot be easily predicted by its overall capabilities, whether military or economic. Its combination of reciprocal constraint within dense, overlapping networks is one that the German elite has maintained since 1945.[38]

The Leverage of Network Brokers

Simple access captures only one dimension of network power. Power may also increase when a node possesses exclusive ties to otherwise marginalized or weakly connected nodes or groups of nodes, such as China in Figure 1. States or other international actors in this type of position can gain influence as brokers; social capital can be turned into social power by a node that bridges structural holes in

35. Beckfield 2003, 404.
36. Beckfield 2008.
37. One difficulty with using a reciprocal measure such as eigenvector centrality or Bonacich power centrality is the (ultimately empirical) question of precisely how much the centrality of other actors matters (the selection of the beta weight for Bonacich power), and whether being connected to strong others (beta > 0) or weak others (beta < 0) increases centrality.
38. Germany's networked position is discussed in Katzenstein 1997, particularly the chapters by Katzenstein and Bulmer.

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the network.[39] A node that acts as a bridge or broker can gain influence through its centrality (defined as betweenness), because it may provide the only link to the larger network. In Figure 1 (as in the real world), it is difficult to form ties between Iran or North Korea and the United States. In this respect, brokerage power or prospective leverage is the mirror image of access: in the former, power flows from connection with those that are less central; in the latter, influence is a product of connecting to other highly central nodes.[40] Brokerage power is especially common in networks that exhibit "small-world" characteristics: that is, dense local connectivity combined with short global paths.[41]

The structure of imperial systems offers a prominent example of the power awarded to a network broker. Most accounts of empire emphasize bilateral relations between the imperial metropole and its peripheral possessions as the core of empire's definition. Network theory suggests an equally important characteristic: power claimed by the metropole because of the weakness of network ties among nodes on the periphery.[42] The metropole creates bargaining power vis-à-vis its colonial possessions, not only through its intrinsic military or economic capabilities, but also by its ability to construct and maintain exclusive or near-exclusive links to societies on the periphery.

Exit Options and Network Power

A final form of network power is based not on a node's centrality in the network, but on its ability to exit or de-link. This form of power highlights similarities between networks and markets. If bargaining power is the power of nodes that serve as brokers and social power inheres to highly connected nodes, the power of exit is often wielded by less embedded nodes at the margins of networks. Strategic efforts within the network to exploit bargaining power may result in threats of exit by those who are its targets. The existence of outside options, therefore, becomes critical in assessing network power of this kind. Iran and North Korea's positions in Figure 1 mirror their real-world situations: while both are on the margin and therefore may have exit options, North Korea's options for exit are limited because of its tremendous reli-

39. Burt 2000. Bonacich 1987, 1170–71, also notes the distinction between conventional centrality (connectedness) and connection to those with few options.

40. Gould 1989 captures these distinctions in elite political conflict, where the power of the broker expands with the barriers to communication of two hostile factions or groups. He also notes a potential conflict between conventional power, in the form of mobilizing resources, and such bargaining leverage. The former can put at risk the credibility of the "honest broker." Another historical example of bargaining power awarded by the role of broker is that of the Medicis in Renaissance Florence (Padgett and Ansell 1993), or by the liberals in Anglo-Irish politics in the early twentieth century (Goddard 2006).

41. The small-world problem was first codified in Milgram 1967 and given an important recent treatment in Watts and Strogatz 1998.

42. Nexon and Wright 2007 argue that this feature of empires distinguishes them from other, competing systems of power asymmetry, such as hegemony or unipolarity.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

ance on China, while Iran is less dependent. Decision rules for linking to networks also determine the credibility of exit threats: if nodes link preferentially to more connected nodes in a network, the threat of exit is less likely. If the social power of a node declines, however, exit threats become more credible.

Nodes that possess bargaining power will attempt to reduce the risk of exit, either through enhancing their appeal to network partners or by using coercion. Returning to the conventional imperial, hub-and-spoke network, for example, exit was constrained by coercion and by the absence of political "space" that was not colonized (exit from one empire risked capture by another). Although clandestine criminal and terrorist networks may also exert coercion to prevent exit, their behavior often suggests both competition for members among networks and high reputational costs associated with obstructing exit.

Network Power, Agency, and Fungibility

Two issues regarding network power are particularly important to international relations: whether actors can increase their power by enhancing and exploiting their network positions, and the fungibility of power—whether network power can be used to supplement or offset other forms of power.

Network analysis emphasizes structural explanations for international outcomes, rather than concentrating on the strategies of individual agents. As agents (nodes) comprehend the power that inheres in network structure, however, they may over time attempt to influence that structure. Pursuit of network power favors agent strategies that differ from those in conventional international politics. If the proposition that social power is based on network centrality is correct, then strategies of membership in international institutions may reflect more than simple calculations of interest in a particular organization or its benefits. The access that international institutions and agreements grant to larger networks may be as important as the content of the agreement itself. For example, the trade benefits of a bilateral agreement with the EU may be outweighed for a nonmember by access provided to the wider networks represented by the EU. Unilateralism, which sacrifices the social power of networks, becomes less attractive as networks become denser. If networks provide information that fosters learning, and if that learning can be biased in ways favorable to other agents in the network, international networks may also become targets of influence by governments and other actors. Thus the learning and socialization processes emphasized by constructivists may be manipulated and co-opted by powerful network actors.

The fungibility of network power and other forms of power in international relations is also worthy of investigation.[43] Social power based on network posi-

43. Bourdieu argued in his essay on the forms of capital that all three forms (economic, cultural, social) were fungible (1986). We are agnostic on this point with respect to forms of power, especially since the use of some forms (military, economic) may undermine other forms (social).

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tion may not closely track other measures of power, such as military capability or economic weight. In the network of preferential trade agreements (PTAs), the United States is a middling power; European states rank higher in the hierarchy of social power. Poorer and militarily less powerful states might offset their material disadvantages through the accumulation of social power.[44] An alternative view, however, notes that countries engaged in PTAs reinforce their position by becoming ever more attractive nodes in the network. Low-income countries (originally less connected through PTAs) are threatened with exclusion from the benefits of economic integration provided by these trade agreements.[45] These contrasting views of network effects illustrate one part of the rich research agenda generated by network analysis. Network power may offset other forms of power in international politics, but network power may also be self-reinforcing and ultimately deepen other inequalities in the international system. The perspective of network analysis suggests that countries skilled at building and exploiting their position in multiple networks (particularly midlevel, open, and connected powers) may gain in influence vis-à-vis poorer countries with less central network positions.

The New Wave of Network Analysis in International Relations

Network analysis has a long history in the behavioral sciences, although its incorporation into international relations has been slow and uneven. Theory formation regarding international networks has often been ad hoc, and the toolkit of network analysis has not received wide acceptance. Moreover, studies that have used the tools of network analysis have not always produced significant insights; a few have emphasized method over substance, and most have mapped but not explained some aspect of international politics, assuming rather than demonstrating the causal mechanisms through which networks actually constrain and enable their members. As attention to networks has grown in the field of international relations, however, a new wave of research has moved from description of networks in international politics toward more rigorous analysis of network structure and investigation of network formation and effects. The value of network analysis has already been demonstrated in more precise description of international networks, investigation of network effects on key international outcomes, tests of existing network theory in the context of international relations, and development of new sources of data.

44. Hafner-Burton and Montgomery 2009.
45. Manger, Pickup, and Snijders 2008.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

More Precise Description of Network Structure: Implications for Policy

More rigorous description of network structure has proven valuable in both scholarly and policy domains. Research on the dark networks behind arms trading and terrorism, for example, has illuminated network structures that point to political counterstrategies. Highly centralized around individual hubs, nuclear proliferation networks have difficulty transferring tacit knowledge. Ballistic missile networks, on the other hand, have multiple hubs due to an easier division of labor: knowledge about guidance systems, propulsion, and re-entry vehicles relies on less tacit knowledge and systems integration than does an understanding of nuclear warheads.[46] Networks involved in small-arms trading are much larger; the Illicit Arms Transfers dataset contains seventy-four states (thirty-seven of them African). A simple graph of the small arms trading network appears dense and difficult to attack, but network analysis shows that it follows a power-law distribution and contains only a few important brokers. Removal of these nodes may significantly disrupt the illicit arms trade.[47] Analyses of network structure suggest that concentration on hubs and brokers in such networks would be most productive in slowing arms proliferation.

Applying network analysis to terrorist networks also yields new policy prescriptions for dissolving those networks and demonstrates that early blanket assumptions about their form (cellular, nonhierarchical) and functioning (centralized decision making, decentralized execution) were too simple. Much of the early work on terrorist networks focused on mapping individual terrorist cells such as those who attacked the United States in 2001,[48] Bali in 2002,[49] and Madrid in 2004[50]; national networks[51]; or international networks or coalitions of networks such as the Salafist jihad.[52] Network analysis illuminates the operation of these networks and undermines commonly held beliefs.[53] Using network theory, Stohl and Stohl argue that current policy assumptions about terrorist networks may be incorrect.[54] Both Kahler and Kenney demonstrate the efficiency-robustness tradeoff described earlier: when centralization and hierarchy are adopted in terrorist networks, efficiency increases together with the risk of successful counterterrorist action.[55] Combining network analysis with strategic interaction, Enders and Su find that typical counterterrorist policies can increase the probability of a successful terrorist attack

46. Montgomery 2005 and 2008.
47. Kinsella 2006.
48. See Krebs 2002; and Brams, Mutlu, and Ramirez 2006.
49. Koschade 2006.
50. Rodríguez 2005.
51. Jordan and Horsburgh 2005.
52. Sageman 2004.
53. See Krebs 2002; Brams, Mutlu, and Ramirez 2006; Rodríguez 2005; Koschade 2006; Jordan and Horsburgh 2005; and Sageman 2004.
54. Stohl and Stohl 2007.
55. See Kahler 2009a; and Kenney 2007.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

if rational terrorists strategically respond to those policies (such as infiltration) by reducing density of ties and planning less complex attacks.[56] Pedahuzur and Perliger find that local activists make decisions in Palestinian suicide networks, contradicting the prevailing view that suicide attacks result from strategic organizational decision making.[57]

Analysts of transnational activist networks and nongovernmental organizations (NGOs) have only begun to apply network analysis to power relationships, issue adoption, and effectiveness in these organizations. Carpenter argues that issues crossing network boundaries are less likely to be adopted by the human rights community. Lake and Wong contend that the hierarchical structure of Amnesty International and its narrow focus have shaped norm adoption and the international human rights agenda.[58] Brewington, Davis, and Murdie demonstrate that the international human rights NGO network is hierarchical. Within that network, more central NGOs undertake more advocacy.[59] Moore, Eng, and Daniel relate network centrality among sixty-five NGOs to their effectiveness in flood operations in Mozambique.[60] Apart from this handful of studies, however, network analysis has not yet made significant contributions to the study of TANs and NGOs. Difficulty in developing suitable data is one constraint on the application of network analysis to this important sector of international politics.

From Structure to Outcomes: Network Effects in International Relations

Network analysis of international institutions has provided hypotheses regarding network effects, as well as initial tests of those posited effects. Alternative, network-based measures of membership in international institutions has produced new insights into key concepts, such as international inequality. For instance, Hafner-Burton and Montgomery find that, although material inequality (measured by gross domestic product and military capabilities) has increased among states since 1950, these material asymmetries may be offset by decreasing inequality in the distribution of social capital, measured by degree centrality of states in PTA networks.[61] Beckfield also finds steadily decreasing inequality of IGO ties over time among states. Despite increasing equality by some measures, regional fragmentation and exclusion still exist. Inequality in international NGO ties is as high

56. Enders and Su 2007.
57. Pedahzur and Perliger 2006.
58. See Carpenter 2007a and 2007b; and Lake and Wong 2009.
59. Brewington, Davis, and Murdie 2009. Those with more incoming ties and fewer outgoing ties had increased activities.
60. Moore, Eng, and Daniel 2003, 307. All three types of centrality used (degree, eigenvector, and flow betweenness) increased effectiveness.
61. Hafner-Burton and Montgomery 2009.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

as the level of world income inequality because rich, core, Western states and societies have grown more dominant in the NGO field.[62] Kim and Barnett find growing regionalization of communications IGOs, with most of the centrality in the network concentrated in Western industrialized nations, while Manger suggests that trade agreements have a strong tendency to produce relatively closed regional subgroups, and that low-income countries are excluded from these networks.[63]

Some studies move beyond descriptive mapping of network ties produced by IGOs to argue that the structure of these IGO networks, by shaping the distribution of power and information, may affect the frequency of international conflict in ways that state-centric analyses ignore. These investigations incorporate both the tools of network analysis and theories regarding information transmission or the effects of centrality and group identity on aggression and conflict. Most assume rather than demonstrate the causal mechanisms that link social networks to behavior. Hafner-Burton and Montgomery use network analysis to link interstate military conflict and the relative power positions created by networks of IGO membership.[64] They argue that network position alters the distribution of power, making certain strategies more practical or rational. Militarized disputes (MIDs) increase as the number of states in each structurally equivalent cluster grows; in-group favoritism and large disparities in centrality reduce MIDs. Dorussen and Ward claim that membership in IGOs creates network ties between states that allow them either individually or collectively to intervene more effectively in MIDs.[65] They also suggest that the network as a whole provides communication channels that may substitute for direct diplomatic ties. In these cases and others, network analysis has led to re-evaluation of claims that the Kantian tripod—shared IGOs, trade, and democracy—decreases conflict.[66]

Testing Network Theory in International Relations

Network concepts and theories do not always translate well to the domain of international relations, forcing modification of their use in other fields. Maoz and colleagues employ network methods to measure direct and indirect links between states in order to test whether structural balance holds in international relations. They find evidence that common enemies produce alliances and indirect enemies often fight, as structural balance theory predicts. Violations of structural balance produce higher levels of conflict.[67] Corbetta also finds that states are more likely to

62. Beckfield 2003.
63. Manger, Pickup, and Snijders 2008.
64. Hafner-Burton and Montgomery 2006.
65. Dorussen and Ward 2008.
66. Ward, Siverson, and Cao 2007. On the Kantian tripod, see Oneal and Russett 1999.
67. Maoz et al. 2007.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

join disputes with states that share a higher degree of homophily (of polity and civilization) and structural equivalence (of alliance, trade, and IGO portfolios).[68]

Networks can also affect other networks, an outcome that requires special methods of analysis. In the domain of international political economy, for instance, Ingram, Robinson, and Busch show that trade between two countries increases substantially when their IGO ties increase, even if those ties result from international social and cultural organizations. Connections through more institutionalized organizations have greater network effects, verifying that ties through one network can effect ties in another network.[69] Lewer and Van den Burg demonstrate that states sharing membership in the same religious network trade more with each other. Their finding is problematic, however, since network ties between religiously similar states are assumed, rather than demonstrated.[70] Ward and Hoff argue that conflict does not affect the trade network. Residual importer and exporter effects are significant, however, contrary to the standard assumptions of the gravity model of trade.[71]

Because existing network concepts may not fit the domain of international relations, scholars have created new network measures and theories specifically adapted to the field. For example, Maoz examines the effects of two new measures, network polarization and interdependence, on conflict.[72] He finds that alliance polarization and strategic interdependence increase the amount of systemic conflict, while trade polarization and economic interdependence have a dampening effect on conflict in the international system. The need for new system-wide measures at this stage of development is unclear. Theories that attempt to explain the level of conflict in the entire system with a single variable are inherently problematic; existing measures that can be applied to networks (such as centralization) may perform the same task.

Data for Network Analysis

The third wave of network analysis in international relations is driven in part by the desire to exploit available data; however, these data also impose constraints on analysis. For example, mutual membership in international institutions is one of the most widely used network variables, with data extending from 1816 through 2000.[73] Membership reflects affiliations rather than direct network ties, however. Although mutual membership in international institutions may lead to more opportunities for mutual interaction, socialization, and information transfer, it does not

68. Corbetta 2007.
69. Ingram, Robinson, and Busch 2005.
70. Lewer and Van den Berg 2007.
71. Ward and Hoff 2007.
72. Maoz 2006.
73. Pevehouse, Nordstrom, and Warnke 2003.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

necessarily lead to positive ties, as is often assumed in international relations.[74] IGOs are not created equal in their ability to sustain a transgovernmental network. Group of Eight (G8) meetings of heads of state, for instance, are more likely to produce social ties, information transfer, and socialization effects that can shape important events in international relations than are meetings of midlevel bureaucrats in the African Groundnut Council.[75] Moreover, government representatives involved in IGOs may not have significant influence in their domestic political and bureaucratic networks. Membership data are also problematic, since international institutions rarely die or lose members.[76] In contrast to the dynamic emphasis of network analysis, IGO membership may offer a static view of world politics. Just as these institutions are viewed as congealed power, international network analysts must regard them, to some extent, as congealed ties.[77]

For network analysts, directly measured ties are the most valuable and least problematic data. Recent efforts have expanded the number of international datasets with directly measured ties. However, only two such datasets cover enough years and countries to be reliable in charting changes and growth over time between states: those for diplomatic recognition and trade. Diplomatic recognition data is perhaps the most valuable, as it is available for a long period of time (1817 through 2005), is directed rather than symmetrical (A's recognition of B may be different than B's recognition of A), and even measures the strength of recognition (at the levels of *chargé d'affaires*, minister, and ambassador).[78] Data on diplomatic ties has been seldom used in network analysis, however, even though some researchers have used it as a unit characteristic.[79]

Trade provides a second body of data that is often used for network analysis. Although trade data are only available from 1948 to the present, they are directed and valued (as opposed to binary). The data are recorded for every year (a significant strength) but are incomplete. Substantial efforts have been made to fill in the missing data, but researchers often make assumptions about the available data and draw incorrect conclusions.[80] When the tools of network analysis can be applied to international relations data, network datasets are too often treated as if they are complete, accurate, and easily comparable to other network data. The results can be troubling. Superficial comparisons between a "world trade web" and other networks have displayed little or no grounding in either network theory or international political economy.[81] Work of this kind does not promote integration of

74. See Oneal and Russett 1999; and Pevehouse and Russett 2006.
75. We thank Dan Nexon for pointing this out.
76. Ingram 2006.
77. For a discussion of different international network measures and the advantages of the IGO data, see Hafner-Burton and Montgomery 2006, fn. 7.
78. Bayer 2006.
79. See Boehmer, Gartzke, and Nordstrom 2004; and Jo and Gartzke 2007.
80. Gleditsch 2002.
81. See, for example, Li, Ying Jin, and Chen 2003; Garlaschelli and Loffredo 2005; Duan 2008; and Fagiolo, Reyes, and Schiavo 2008.

https://doi.org/10.1017/S0020818309090195 Published online by Cambridge University Press

network analysis with the theoretical and empirical concerns of international relations.

Network Analysis: Useful Import or Another Fad?

Despite the promise of these recent applications of network analysis to international relations, the brief and unhappy history of other imports provides a cautionary note. Although network analysis has demonstrated its application across a wide variety of disciplines, its use in other fields has been carefully tempered by merging its methods with existing bodies of theory in each discipline. Even then, network analysis has not been uniformly successful; its history is littered with examples of failed imports. In the 1960s, anthropologists turned to network analysis for help in analyzing kinship networks and other core problems of their field. After that first effort at incorporation, Boissevain (a practitioner) warned that network analysis had not realized its full potential because of "an overelaboration of technique and data and an accumulation of trivial results."[82] His warning was prescient: the use of network methods in anthropology declined over the succeeding decades and has only recently been revived. Despite its apparent utility in addressing core questions of anthropology, network analysis failed to become a central part of the discipline.[83] The same was true of the first two waves of network analysis in international relations, due in part to the same problem: too many measurements of structure accompanied by too few tests of either network or international relations theory.

Lost in Translation: Shortcomings in Existing Applications of Network Analysis to International Relations

A consensus on the importance of networks exists in international relations. Effective incorporation of network analysis into the field will require great care, however. Currently, international relations research too often deploys network concepts and theories that are inappropriate or grounded in unproven assumptions. Selective extension of existing theory and findings to international relations may also be misleading. In translating network analysis to international relations, scholars have made theoretical leaps, equating homophily with positive ties and structural equivalence with affinity; yet either or both may lead to competition instead of cooperation. Some of the new literature often assumes that networks result from shared characteristics, such as common democracy, ethnic groups, or religion.[84]

82. Boissevain 1979, 393.
83. On the decline and revival of network analysis in anthropology, see White and Johansen 2004, 2–6.
84. See Maoz 2001; Maoz et al. 2005; and Lewer and Van den Berg 2007.

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While homophily is an important mechanism in creating ties, the mere existence of common characteristics does not always spur ties. For people, as for most types of actors, sharing one particular trait or characteristic, such as height, race, or gender, does not automatically prompt a network tie or positive interaction. Instead, arguments about homophily and ties must be carefully grounded in theories of interaction. Similarly, structural equivalence has been used as a measure of common identity.[85] Yet structural equivalence does not predict that nodes in similar positions act in positive ways toward each other. Network similarity can lead to cooperation, but it can also lead to competition for resources.

In other instances, scholars have bent network analysis to conform to existing methodologies in international relations. Networks have been reduced to static properties of individual nodes; a relational view that emphasizes dynamic analysis has been lost. Network analysis challenges many standard statistical assumptions commonly used in international relations. In particular, it threatens the assumption of independence required for standard dyadic statistical treatments in the international relations conflict literature (that is, network theory argues that observation of interaction between A and B is dependent on observations between A and C, B and C, and other network nodes). Fortunately, the tools of network analysis allow for estimation of unobserved (latent) network dependence—taking into account the likelihood of interaction given underlying network structures. These methods are similar to those used to correct for spatial correlation, although they correct for network dependencies, rather than measuring them as quantities of interest.[86] These tools have already been used to challenge traditional wisdom on the determinants of trade as well as parts of the Kantian tripod.[87]

The underlying causes of network ties beyond monadic attributes and dyadic relationships can also be modeled using stochastic agent-based models. These models simultaneously measure the effects of agent characteristics, dyadic covariates, and particular network mechanisms on network formation over time.[88] These models have been used to demonstrate that transitivity is a crucial factor in the formation of PTAs: recent agreements are more likely between two countries (by an order of magnitude) when both have signed an agreement with a third country.[89] Still, common assumptions about the completeness of observations are highly problematic for network analysis: most international network datasets provide aggregate information about states or institutions; most international relations theories rely on micro-theories of causality that these datasets cannot illuminate. Accurate and complete data on some subjects that are highly suitable for network analysis, such as criminal networks, are difficult to obtain.

85. See Maoz et al. 2006; and Hafner-Burton and Montgomery 2006 and 2008.
86. See Gleditsch and Ward 2001; Hoff, Raftery, and Handcock 2002; Hoff and Ward 2004; and Krivitsky and Handcock 2008.
87. See Ward and Hoff 2007; and Ward, Siverson, and Cao 2007.
88. See Snijders 2005; and Snijders, van de Bunt, and Steglich in press.
89. Manger, Pickup, and Snijders 2008.

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Although many of the concepts embedded in network analysis appear to fit well with existing structural approaches to international relations, that fit has yet to be empirically demonstrated. Network analysis will be most useful in international relations when it is carefully married to existing theoretical and conceptual approaches and then helps to expand their scope.

With this aim in mind, we offer a three-part agenda for applying network analysis to international relations: Import the toolkit to deepen research on international networks; test existing network theories in the domain of international relations; and test international relations theory using the tools of network analysis.

Importing the Toolkit: Networks as Organizations

Perhaps the simplest strategy for using network analysis is to use its toolkit for a more rigorous description of networks that are already of interest to international relations researchers. Although international relations has produced a rich literature on networks as forms of governance, the structural features of network analysis have rarely been applied to these networks. Applying network analysis can solve three shortcomings in this literature. First, it is difficult to arrive at a satisfying definition of a network organization or mode of governance. Podolny and Page have defined a network organization (as opposed to a network structure) as "any collection of actors ($N \geq 2$) that pursue repeated, enduring exchange relations with one another and, at the same time, lack a legitimate organizational authority to arbitrate and resolve disputes that may arise during the exchange." They suggest that, in contrast to market relationships, those in a network are enduring; in contrast to recognized dispute settlement authority that exits in hierarchies, no such authority resides with any single member of a network.[90] Although their definition provides empirical indicators for identifying network organizations, many organizations are hybrids, combining constituents that are networked with those that resemble hierarchies or markets. Other efforts to distinguish networks from hierarchies emphasize such characteristics as flatness, decentralization, and reciprocity, but do not provide robust methods of determining them.[91] Rather than assuming such characteristics, network analysis allows for measurement of the number of levels of hierarchy, the extent of centralization of a network, and the amount of reciprocity.

A second weakness of research on networks as organizations is the lopsided belief that networks enjoy advantages over their institutional rivals, particularly hierarchical state bureaucracies or formal IGOs. Networks have been promoted for "their general virtues of speed, flexibility, inclusiveness, ability to cut across

90. Podolny and Page 1998, 59.

91. For example, "fluidity" (Lin 2001, 38); "relative flatness, decentralization and delegation of decision making authority, and loose lateral ties among dispersed groups and individuals" (Zanini and Edwards 2001, 33); or "voluntary, reciprocal, and horizontal patterns of communication and exchange" (Keck and Sikkink 1998, 8).

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different jurisdictions, and sustained focus on a specific set of problems."[92] Terrorist networks, for example, have been portrayed as presenting a novel challenge to national security agencies.[93] Networked governance has been touted as a solution for a multilateralism that is too often slow-moving and inefficient. The disadvantages of networks, or, more usefully, the circumstances under which networks demonstrate less capability than other institutional forms when measured by actor influence or governance outcome, are less frequently examined.[94] If networks were uniformly superior to the organizational alternatives, presumably we would have witnessed a widespread demise of states and an erosion of bureaucratic organization. Network analysis allows for more precise assessments of the efficiency and robustness of these different organizational forms.

Finally, comparisons of networked organizations with other types of institutions have too often overlooked variation among these organizations. Although network analysis has been applied successfully to some networks of interest (especially dark networks), it has seldom been used to investigate either transnational activist networks or transgovernmental networks. Simply tracking the membership of such networks, at the individual and governmental level, would be an important first step toward understanding their structure and the potential effects of structure on cooperative outcomes. These networks—central actors in international relations for some time—are promising arenas in which to move from precise measurement and description of networks to investigation of behavior and performance.

Importing Both Theory and Toolkit: Structure and Outcome in International Relations

Some researchers have taken the next logical step: importing hypotheses drawn from network analysis that can be tested on networks in international relations. However, such imports require much more caution than the simple use of network analysis tools. First, extrapolating from individuals to international actors is not straightforward. The content of network links is stipulated much more easily in sociological studies of networks made up of individuals. For example, measurement of friendship or peer group networks relies explicitly on self-designation or other replicable information.[95] Also, the content of links in international networks is too often left implicit.

Too many attempts that relate international relations networks (typically of governments) to outcomes rely on findings from networks of individuals, failing to demonstrate that the same mechanisms operate at a different level of analysis. For

92. Slaughter 2004, 167.

93. Arquilla and Ronfeldt 2001. For a skeptical view of these prescriptions, see Kenney 2007, 188–202.

94. Mette Eilstrup-Sangiovanni 2009 has outlined the circumstances under which IGOs and networks are likely to be more successful in international governance.

95. See, for example, Giordano 1995 and 2003.

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example, Ingram, Robinson, and Busch[96] argue that membership in social and cultural IGOs has a significant effect on trade patterns. The authors move too quickly from the level of IGOs to that of citizens, however, without specifying mechanisms of influence or demonstrating how IGO networks could influence the behavior of citizens.[97]

Even in studies of networked individuals, microfoundations for personal and collective influence are often indeterminate. In a recent, striking demonstration of the influence of social networks on smoking cessation, the plausible "psychosocial mechanisms" that produced the measured effects "could not be distinguished on the basis of [their] data."[98] Of course, having several plausible routes for network influence is superior to having none. Recent research on networks in international relations has devoted even less attention to the microfoundations of network influence, even though the content of network links affects the influence that networks have on their members and, through those members, on international outcomes such as conflict or inequality. For example, scholars grappling with the influence of network structures on conflict have not agreed on the particular aspects of international networks that have the greatest effects.[99] Such studies often share the methodological shortcomings enumerated above. Dorussen and Ward, for example, claim that information conduits in networks affect propensity for conflict; Hafner-Burton and Montgomery argue for the distribution of social power.[100] Neither offers any clear evidence for their favored causal path.

The processes that connect network structure to network effects (and international outcomes) require exploration of the similarities and differences between networks of individuals, on the one hand, and networks of governments or NGOs on the other. States in anarchy may not respond to network constraints in the same way as individuals operating under hierarchy (such as workers in an electric company).[101] While network theory propositions can be usefully imported, mechanisms must be carefully translated and justified when changing levels of analysis, units, or systemic conditions.

Testing International Relations Theories with Network Analysis

Although a transfer of the microprocesses of social network analysis to international relations is often problematic, international macroprocesses and structures will benefit from investigation using the tools of network analysis. Such an

96. Ingram, Robinson, and Busch 2005.
97. Ibid., 830.
98. Christakis and Fowler 2008, 2256.
99. See Maoz 2001 and 2006; Hafner-Burton and Montgomery 2006 and 2008; Kim and Barnett 2007; Corbetta 2007; and Dorussen and Ward 2008.
100. See Dorussen and Ward 2008; and Hafner-Burton and Montgomery 2006 and 2008.
101. One of the first social network studies involved relationships in the Hawthorne electric works; see Roethlisberger, Dickson, and Wright 1939, 493–510.

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application, however, will require adaptation of both international relations and network analysis. Maoz has argued that network analysis provides a means for reviving the near-dormant systemic level of analysis in international relations.[102] As we have described, assessments of power in international relations could be transformed by network analysis, which proposes new bases for international influence independent of the capabilities of individual states. To successfully import network theories, however, network research in international relations must assess the effects of network position on the behavior of actors. It must also distinguish between network resources that could be translated into power, such as social capital, and actual power relationships. International diffusion is another significant international macroprocess that would benefit from network analysis.[103] The paths of diffusion often appear puzzling: countries appear to adopt common practices or policies because of affinities that seem to have no relationship to those policies (shared religious belief, for example). Network analysis provides a means for sorting the diverse mechanisms that are involved in diffusion.[104] Finally, network analysis could contribute to research on the behavior of democracies in international politics. Just as democracies display distinct conflict and alliance behavior, democratic institutions are likely to influence both engagement with international networks and the effects of those networks on domestic politics.

Conclusion

The effort to apply social network analysis to international relations also raises an important theoretical issue within the field: does international relations represent a society and, if it does, how is that society constituted? The English School, world polity theorists, and others who have endorsed a sociological turn in international relations have argued that "society" is more than a metaphor for the international system.[105] Recent studies on socialization by international institutions have accepted parallels between other social mechanisms and those at work between nation-states and their governments.[106] Network analysis could both provide an empirical basis from which to test such claims and a means for investigating the ways in which international society differs from a society of individuals. In each of these cases, network analysis sheds new light and offers new understanding of familiar

102. See Maoz et al. 2005; and Maoz 2006.

103. For a recent study of the international diffusion of markets and democracy, see Simmons, Dobbin, and Garrett 2008.

104. For an application of network analysis to the diffusion of bilateral investment treaties, see Elkins, Guzman, and Simmons 2006; for an application to the diffusion of constitutional forms, see Elkins 2009.

105. See Bull 1977; Buzan, Jones, and Little 1993; Meyer et al. 1997; Ruggie 1998; Wendt 1999; and Jackson and Nexon 1999.

106. See Checkel 2001; and Johnston 2001 and 2008.

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features of international relations. At the same time, network analysis must be adapted to fit the specific needs and problems of the field.

As with past imports into international relations, network analysis carries both great promise and substantial risk. Precise measurement of network structure in organizations such as TANs or dark networks can produce testable propositions about their behavior and survival. The hypotheses and findings of network analysis in other disciplines deserve careful attention for possible application to international relations. At the same time, casual transfer of findings from social networks of individuals must be scrutinized thoroughly. The level of analysis problem in international relations does not disappear in a networked world: are networks of individuals, governments, or other units the subject of investigation? Finally, if these obstacles can be overcome, network analysis provides a means for re-examining core concepts, such as power, diffusion, and socialization. At its grandest, network analysis may give some empirical purchase on the notion of an international society. All of this promise is predicated, of course, on the construction of datasets that are daunting in their novelty and scale. Observers may disagree on the balance of risks and rewards from the import of this new set of tools and theories into the field. We will not be able to assess that balance fully, however, without a deeper engagement with network analysis on the part of those in international relations.

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