RELATIONALLY CHALLENGED

PUTTING THE SOCIAL BACK INTO NETWORK ANALYSIS

Alexander H. Montgomery
Professor of Political Science, Reed College, Portland, OR
alexmontgomery.com

ABSTRACT

Social network analysis (SNA) is increasingly incorporated into the study of International Relations, This incorporation has been partial, focused primarily on methods, and separated from theoretical underpinnings. Scholars have treated nodes as autonomous, asocial agents; assumed that ties exist from common characteristics or affiliations; and reinvented existing theories while stripping them of their social context. This chapter surveys the use of SNA in International Relations scholarship and assesses its potential for reincorporating social relations in theory and practice. In theory, SNA is fully compatible with relationalism, although care must be taken to understand agents as socially situated and constructed. In practice, SNA has been implemented at odds with relational sensibilities. Scholars impute networks from common characteristics or affiliations (assumed to be static and concrete rather than dynamic and contingent) instead of using direct ties; new measures are created without reference to existing theories or tools; and network characteristics are reduced to units of analysis compatible with methodological individualism. Yet, some studies are beginning to carefully and slowly adopt the full analytic structure of SNA, including underlying theories.

KEYWORDS

Social network analysis, relationalism, ontology, methodology

Cite: Alexander H. Montgomery, "Relationally Challenged: Putting the Social Back into Network Analysis," *The Oxford Handbook of International Political Sociology,* edited by Stacie E. Goddard, George Lawson, and Ole Jacob Sending, Chapter 3, Oxford University Press, Oxford, UK, 2025.

INTRODUCTION

Social network analysis (SNA) has recently been re-imported into the study of international relations as well as the study of politics more generally (Hafner-Burton, Kahler, and Montgomery 2009; Victor, Montgomery, and Lubell 2017b; Lazer 2011). SNA is a well-established set of social theories coupled to quantitative and qualitative tools developed primarily in sociology over the past 50 years to map and analyze the structural characteristics of networks. It is a part of the broader network analysis (NA) family of approaches, parts of which do not involve social theory or mechanisms. Early SNA work and some contemporary work in international relations (IR) and related fields demonstrate the approach's power and potential to contribute to international political sociology (IPS), primarily via deeply relationalist theories and methodologies as well as through treating intersubjectivity and history seriously. Qualitative and small-n approaches in particular have demonstrated how network approaches reflect these sensibilities, even contributing back to the broader SNA literature through novel theoretical contributions derived from their analyses. Such approaches—by virtue of not relying on large-n network data—tend to center relations, social theory, and history. By contrast, while some quantitative SNA approaches have helped to inject relational as well as intersubjective and historical elements into IR in general and statistical studies of IR in particular, in many cases the use of such methodologies has been individualistic, asocial, ahistoric, or all three.

The power of quantitative SNA to contribute to IPS breaks down when scholars treat networks as individually possessed, static, and concrete substances rather than social, dynamic, and historically contingent relations; when new measures are created without reference to theories or tools; and when network characteristics are reduced to single-variable systemic, simple dyadic, or even monadic analyses compatible with methodological individualism. Tools are being applied in a particularly widespread breakout of "instrumentitis" that is most prevalent among a group of current and former physicists, leading to shallow analyses that disregard the social nature of the data or ignore highly problematic nonrandomly missing observations.

Yet some studies are beginning to carefully and slowly adopt the full analytic structure of social network analysis (SNA), including engaging with underlying social theories and their relational underpinnings. Moreover, quantitative methodologies have now (mostly) caught up with theory and are able to simultaneously account for multiple network mechanisms and the historical evolution of networks over time. While this new trend towards adoption of SNA as a whole rather than piecemeal is largely in line with IPS, certain tensions and incompatibilities still exist.

When political science scholarship refers to networks, it typically envisions them as unitary actors, a form of organization that differs significantly from hierarchies and markets (Powell 1990). The post-9/11 popularity of treating networks as an organizational form has spawned tautologies ("it takes a network to defeat a network," McChrystal 2011, 69) as well as a whole cottage industry of books that claim to use network analysis but treat "networks" as black boxes with binary (for example, "flat" versus "hierarchical") characteristics whose sole effect is to bestow influence upon individuals (e.g., Szwarcberg 2015; Patel 2022).[1] By contrast, SNA treats networks as complex social structures defined by a set or sets of ties (such as friendship, enmity, common membership, or transactions) that connect nodes (e.g., individuals, groups, corporations, or states). As such, network analysis can be usefully applied not only to agents that are traditionally referred to as networks (e.g., transnational advocacy networks, clandestine transnational actors, and networked governance) but to any kind of social structure involving relational ties. Indeed, rather than assuming or asserting that organizations have particular structures, SNA can be used to assess and classify complex admixtures of hierarchical, network, and market relations, since no organization is purely only one of these forms. For example, hierarchical organizations inherently rely on informal networks to function (Krackhardt and Hanson 1993), and networks of human rights international non-governmental organizations are much more centralized than typically assumed (Murdie 2014).

SNA, or at least its tools, can be applied to phenomena that are not strictly social as well; however, many of the theories and mechanisms are grounded in social theory, and may (and often do) suffer when removed from a social context. Standard primers to SNA theory and method (Scott 2017) and a comprehensive, if aging, methodological text (Wasserman and Faust 1994) are widely used in both pedagogy and research; the latest trends in methods are periodically released as updates (Carrington, Scott, and Wasserman 2005; Knoke and Yang 2008; Scott and Carrington 2011).

SNA approaches are not exclusively large-n quantitative—important texts concentrate on mapping small but empirically important networks (e.g., Krebs 2002; Spindel 2018; Perliger and Pedahzur 2011; Montgomery 2005), or leverage particular social network concepts to illustrate how certain groups gain or maintain power (e.g., Padgett and Ansell 1993; Padgett 2016; Goddard 2009; 2018; MacDonald 2014; 2018; Nexon and Wright 2007; Obert and Padgett 2012) or elucidate the relationship between networks and repertoires of resistance and violence (e.g., Staniland 2012; 2014; Wood 2008; Gade 2020; Mazur 2021; Parkinson 2013; 2016; 2023; Hundman and Parkinson 2019; Hundman 2016; Hadden 2015; Metternich et al. 2013). Some large-n work in this vein has managed to center relations, social theory, and history (e.g., Dorff 2017; Mazur 2019). These pieces, in turn, have contributed back to social theory and network analysis more broadly. However, quantitative SNA in IR is my main focus here since the pathologies associated with importing SNA are most prevalent and damaging in

[1] If the word "organization" can be substituted for the word "network" throughout a piece without any loss of meaning, it's not network analysis.

quantitative approaches, which represent the vast majority of network research in IR.

Below, I first recount a brief history of the use of quantitative network analysis in IR. I then discuss how network analysis relates to relationalism in the abstract, followed by examples of contemporary work that diverge from relational sensibilities both inside and outside IR. I end by reviewing recent promising developments in methodology and outline guidance for future work.

HISTORY: THE SNA (RE)TURN IN IR?

SNA itself has a lengthy and often-forgotten tradition in IR, a particularly apt irony given its potential to take history seriously. Early pioneers worked on examining the emergent structure of the international system between states resulting from ties derived from trade, international governmental organization (IGO) membership, diplomatic exchanges, and diplomatic visits (Savage and Deutsch 1960; Brams 1966; 1969; Skjelsbaek 1972; Christopherson 1976). Brams' piece is particularly remarkable, since it investigated three types of data that are still some of the primary sources for international social network analysis today: trade, IGO membership, and diplomatic exchanges. Moreover, it uses some of the same general approaches commonly used today, including rudimentary community detection. The membership of these groups in this early analysis indicated the strength of geography and colonization in determining the structure of international exchanges. Nevertheless, these early pieces mostly observed the structure of the networks rather than using network analysis to test structural theories or predict outcomes of interest.

The next wave of researchers in this particular branch of SNA focused their tools on testing theories of dependency, imperialism, development inequality, and world-systems theory. Some used blockmodeling (simplifying complicated networks into exclusive "blocks," groups of states who have stronger ties to each other than to states in other blocks) to determine the socioeconomic structure of the international system, first dividing the world into groups that shared ties to each other (or to other blocks), then measuring the inequalities across or within such block (Snyder and Kick 1979; Breiger 1981; Nemeth and Smith 1985; Faber 1987; Peacock, Hoover, and Killian 1988; Smith and White 1992; Van Rossem 1996); this research continues today, primarily in sociology (Kick and Davis 2001; Beckfield 2003; Mahutga 2006; Hafner-Burton and Montgomery 2009), although there has been a resurgence of interest due to the development of advanced community detection (Lupu and Traag 2013; Greenhill and Lupu 2017; R. E. Kim 2013; Gomez and Parigi 2015; Haim 2016). Others have used the world city system, rather than states, as their object of analysis (Smith and Timberlake 2001; Alderson and Beckfield 2004; Choi, Barnett, and Chon 2006; Lee 2013), while still others concentrated on the determinants of international trade from network characteristics such as structural autonomy or embeddedness in the IGO network (Sacks, Ventresca, and Uzzi

2001; Ingram, Robinson, and Busch 2005). The main methodological text for social network analysis even included a trade network as one of the five sample networks (Wasserman and Faust 1994). Yet much of this research was published in sociological or multidisciplinary journals rather than political science or international relations ones. Indeed, citation maps of political networks reveals a divided field, with American Politics, Public Policy, and International Relations bridged by sociological works (Victor, Montgomery, and Lubell 2017a). This points to a possible cause of the lack of recognition of this work in mainstream political science despite its quantitative cachet: the accompanying social theories either never gained much of a foothold or subsequently receded in popularity in political science and international relations. Moreover, a longstanding preference for linear and mechanical causation combined with a contemporary infatuation with causal identification in political science is at odds with most network approaches. Networks are an ideal way to engage with complexity and systems, both of which are anathema to linear models; network analysts are comfortable with a wide set of approaches to causality (Fowler et al. 2011; Rogowski and Sinclair 2017) that do not fit well with many political scientists' notions of reality as a set of simplistic interactions (AKA "general linear reality," see Abbott 1988).

Ironically, some of this early work fits much more closely with the relationalist project then most of the contemporary literature. In part, this is due to the nature of relationalism: while some aspects of the project are new to IR (in particular, treating relations as prior to entities), intellectually it has a great deal in common with work in the 1960s and 1970s by scholars such as Karl Deutsch, who emphasized social structures such as security communities rather than individual motives in IR. It is no accident that Deutsch is one of the few political scientists highlighted in Linton Freeman's history of the development of social network analysis (Deutsch 1957; Freeman 2004). Moreover, the proper use of these tools can help to break down rigid assumptions regarding pre-existing structures; for example, while world-systems theory is holist in its assumptions about core-periphery structures, SNA can bring a relationalist sensibility by testing whether these assumptions are correct, potentially uncovering more complex social structures between a larger number of groups.

THEORY: OVERLAPS AND DISJUNCTURES BETWEEN NETWORK ANALYSIS AND RELATIONALISM

As the "relational turn" in international politics groups together a number of different approaches that share certain sensibilities but differ on methodological approaches, the compatibility between network analysis and relationalism depends upon how narrowly or broadly relationalism itself is defined. Here I adopt the guideline that "Relationalist modes of inquiry hold that relations should be treated, either analytically or ontologically, as prior to either individual agents or aggregate structures." (Nexon 2010, 100) While social network analysis is a mode of inquiry that can potentially treat relations as analytically prior to individual agents, incompatibilities arise when attempting to move from methodology to ontology in the quantitative context.

This is partially a difference between theory and practice. In theory, there is no need to make methodological or ontological assumptions about the existence of individual nodes at a particular level of analysis. Nodes could be determined from a network analysis of relations at a lower or higher level, from observations of interactions at a set of sites or events, or with bootstrapping by following connections from a small number of carefully chosen root nodes. For example, it may be unnecessary to assume the existence of states in the international system in order to conduct an analysis of links between such states, since the existence of states as nodes can be discovered from analysis of flows at a lower level of material objects or people between and within states. Using the "First Encounter between alien peoples" counterfactual (Wendt 1999, 108), simply by observing the motion of individuals and things, it would be possible to come up with a list of geographically discrete entities within which more movement occurs within than across those entities, which would probably correspond fairly well to many, but not all, states. Consequently, it would be possible to infer the existence of many nodes without assuming them in the first place.

To take the counterfactual a bit further, such an analysis would also diverge in important ways from the traditional list of states in, for example, the correlates of war (COW) data set (Correlates of War Project 2011). Micro-states that are highly dependent upon their neighbors would likely be combined into regional units; European Union countries would be more difficult to discern than, for example, Latin American countries. The COW state membership data set itself is actually defined in terms of relational data: prior to 1920, existence is defined in part by recognition from Britain and France, using the "assume root nodes" method, and from 1920, is defined in part by membership in the League of Nations or the United Nations, using the "use nodes at a higher level of analysis" method.[2] Yet the problem with any of these approaches is that some kinds of individual nodes have to be assumed in order to carry out this bootstrapping exercise from either a lower or higher level. While this is not a unique problem of network analysis vis-à-vis relationalism (almost all relational analyses need to assume some kind of objects that relations happen between for methodological purposes), the necessity of treating some nodes as ontologically primitive for the purposes of quantification highlights the problem in this particular context. A "polycentric" approach can potentially counter this by observing interactions at sites or events, while including all nodes at multiple levels of analysis. Observations at a typical

[2] I thank Tanisha Fazal for bringing this to my attention as the cause of some discontinuities in state membership.

United Nations General Assembly would certainly reproduce the international state system, whereas the 2015 Paris UNFCCC Conference of Parties would produce not only states but also a variety of non-state actors as nodes. At the very least, this kind of approach can de-center states and allow the most "important" actors to emerge from the events rather than from ontological assumptions (See, for example, Paterson et al. 2013).

SNA is also problematic at the methodological level for relational approaches, although this is purely because of practice rather than theory. Analytically, social network analysis allows for, but does not restrict practitioners to, treatment of relations as the objects of inquiry. However, users in IR often quickly move from calculation of a relational property of nodes such as centrality to treating these measurements ontologically as monadic attributes of the nodes. This is closely related to the tendency of methodological individualism to decay into ontological individualism, moving from "for the purposes of my analysis I will treat states as unitary actors" to "states are unitary actors." Consequently, in fields like international relations that have been recently dominated by such approaches, the implementation of social network analysis has often resulted in network concepts being applied to traditional levels of analysis such as individual states or the system as a whole rather than remaining analytically relational. Moreover, social network theories are often discarded along the way in favor of pre-existing IR theories (many of which are individualist) and therefore are potentially a poor fit for the methodologies.

Assumptions, Assumptions

In recent years, SNA has been (re)discovered by mainstream political scientists (Victor, Montgomery, and Lubell 2017a; Hafner-Burton, Kahler, and Montgomery 2009; Lazer 2011). At the same time, the measures used have become more decoupled from network theory as well as relationalism. Instead of treating SNA as an integrated methodology with dense connections between theories and tools, it is being used as a set of standalone tools. While the use of blockmodeling to determine inequality and core-periphery structures was a natural union between method and theory, an overlap that arose "...from the interest of each approach in identifying nations' positions on the basis of their overall location in multiple world networks," (Breiger 1981, 375) new efforts are frequently an attempt to marry old IR concepts to network methods rather than to adapt existing theories that relate network structures to outcomes of interest. This amounts to a shotgun wedding: while there is a great deal of interest in the couple and their forthcoming offspring, the depth and longevity of the relationship as well as the amount of care that will be provided for their children is somewhat in doubt. Uses in IR have often involved imputing networks from similarities between actors rather than measurement of actual ties (thereby assuming that shared monadic attributes constitute relations), creating new measures without a theoretical basis, and concentrating on monads, dyads, or systemic characteristics conducive to individualist or holist approaches rather than relationalist ones.

Ideally, scholars would analyze direct networks (such as trade and diplomatic relations) in which the data represents relational ties or affiliation networks such as mutual membership in IGOs or alliances. Instead, some scholars have been imputing networks from shared characteristics or attributes such as common democracy, ethnic groups, or religion (e.g., Maoz 2001; Maoz et al. 2005; Lewer and Van den Berg 2007). This assumes that nodes with those particular attributes form ties without considering complicating interactions with other attributes (shared or not) or demonstrating that sharing those attributes would lead to ties. While homophily (the tendency of units with similar characteristics to form ties) is considered to be an important mechanism in creating ties, assuming ties from homophily without demonstrating that the mechanism is operating involves heroic assumptions. Sharing one particular identity does not imply that individuals will automatically act towards each other in a positive way (indeed, they may act negatively); due to the multiple, overlapping, and contingent identities that are possible for any two actors, arguments about homophily and ties must be carefully contextualized. Indeed, heterophily can also be an important mechanism for creating ties: e.g., due to comparative advantage, countries trade unlike things rather than like things.

Moreover, for the particular processes that many IR scholars are interested in (such as conflict), it is networks that are generated as the result of interactions, not networks generated from individual attributes, that seem to be important (Hafner-Burton and Montgomery 2006). For example, the democratic peace appears to be a network phenomenon rather than a dyadic one (Campbell, Cranmer, and Desmarais 2018). The distinction is important: dyadic approaches treat each dyadic observation as independent of all other dyads, whereas network approaches explicitly seek to measure the multiple different processes through which the observation of one dyad is dependent on the simultaneous observation (or non-observation) of others. Modifying Emmanuel Adler's phrase (1997, 347), the 'democratic peace' cries for a social network explanation. Current attempts tend to treat common democracy as a binary dyadic attribute, rather than as a possible group membership contingent on history, intersubjectivity, salience, or the cultural content of ties (McLean 2016). Some steps have been taken in this direction; for example, network approaches have demonstrated that there is evidence that it is the democratic IGOs rather than the states in the democratic IGO–state network that are socializing states to be less conflictual (Montgomery 2016). Other results are contested, with some arguing that democracy itself spreads through all IGOs (Torfason and Ingram 2010), while others find that it only spreads through defensive alliances (Cranmer, Desmarais, and Campbell 2019). Still, much is lacking in the way of narrowing down through what relational processes democracies come to see each other as being in a commonly identified group (or not).

In addition to the imputation of networks from similarities, new measures are being created that align much more closely with existing international relations notions rather than with social network concepts. There is nothing inherently wrong with this; indeed, this is a key area in which IR can contribute towards the development of network analysis (Hafner-Burton, Kahler, and Montgomery 2009). For example, new systemic measures have been invented, such as network polarization, a measure of how much state networks overlap (Maoz et al. 2005; Maoz 2006). This variable is used in the same way that, e.g., the notion of a hegemonic defense burden is used: as a single variable that attempts to predict the general conflict propensity of the entire international system (Oneal and Russett 1999). There is a solid theoretical basis in IR for the idea that polarization might cause conflict: in particular, if military alliances are polarized (and, possibly more importantly, rigid), conflicts may be more likely to occur due to a lack of flexibility in the system to adjust to changes. However, this mechanism must be demonstrated (just like any other cross-applied theory) to function in observed networks such as trade or assumed networks such as shared religion or language. Moreover, treating a system's structure in a uniform way is contrary to both relationalist approaches and social network analysis, which treat structure as a "lumpy" and heterogeneous influence that has radically different effects on different groups and nodes depending upon their positions in the system.

Apart from systemic characteristics, initial (re)uses in IR have tended to use the tools of network analysis to measure qualities of states or dyads rather than groups. IR scholars remain focused firmly on states as individual actors, a 'substantialist' rather than a 'relationalist' approach to IR (Jackson and Nexon 1999). Network characteristics are often calculated for monads (various measures of centrality) or dyads (strength of ties, common membership), then used as if they represented static properties that stand on their own rather than contingent ties that have to be created and recreated constantly by agents. Measures that are usually used as intermediate steps on the way to discussing group membership and group properties, such as structural distance, have been used to determine the similarity of networks of two actors in an attempt to predict conflict. This reduces the complex notion of structural position to a generic sameness, substituting the distance measure for other measures of sameness already used in IR (Maoz et al. 2006; Signorino and Ritter 1999). It also assumes that structural equivalence, which posits that similarity of position leads to *similar behavior in general* (Hafner-Burton and Montgomery 2006; 2009), would also predict that nodes in similar positions will act *towards each other* in particular ways, usually positively. Yet theories of cooperation (at least with respect to position) require a measure of groupness, not a measure of sameness; even if A and B are close, the entire population needs to be examined to determine whether A and B are *relatively* close, and therefore inhabit similar ecological niches. It will also depend on the particular roles are coupled to these similar structural positions; for example, do two states that have ties to their former colonizer compete or cooperate? The answer depends on context: are they competing for, say, limited trade quotas, or are they pressed into a united front against exploitation to overcome the malign influence of the *tertius gaudens* (Simmel 1950)? Not only positionality but intersubjectivity and history matter here: have they coevolved over time to engage in practices that cement their relationship as competitors or cooperators? Finally, the use of the distance between two states as a raw "sameness" variable doesn't allow for testing of hypotheses about the relationship between the number of group members and their tendency to conflict (Hafner-Burton and Montgomery 2006). Such uses are, nonetheless, embedded in existing IR theory. This is, in part, the problem, since many IR theories reduce complex logics to monadic, dyadic, or systemic hypotheses in the race to shave one's theories ever more parsimoniously with Ockham's razor.

The Rise of the (Ex-)Physicists

These critiques of quantitative SNA work in IR have to do with a lack of demonstrating mechanisms or incompatibility with relationalism rather than the total abandonment of the origins of the data by physicists who are using network analysis to analyze what they term the "World Trade Web,"(Li, Ying Jin, and Chen 2003; Garlaschelli and Loffredo 2005; Duan 2008; Fagiolo, Reyes, and Schiavo 2008; de Andrade and Rêgo 2018)—all published, weirdly enough, in Physica A. This odd neologism is apparently an attempt to draw an analogy to the "World Wide Web" in order to justify the use of the same tools that other current or former physicists have been using to great acclaim and even greater citation counts (Watts and Strogatz 1998; Watts 1999; 2003; Barabási and Albert 1999; Barabási 2002). This is a second departure from relationalist approaches, since any underlying intersubjectivity and history captured in the data is stripped out, leaving a set of relations without any real content or context. While the separation of form from content was an early foundation of sociological work in networks (Simmel 1908), the gains from this abstraction have been almost entirely on the micro network scale (e.g., triads, cycles, strength of weak ties). When moving to the macro scale and asserting that there are underlying similarities between networks that (ostensibly) have similar network structures, new "findings" are the result of surface-level analysis without any deeper insights.

These articles and books have the virtue of popularizing and bringing attention to network analysis; yet the 'discovery' of ubiquitous power-law distributions in networks is similar to the recent political science '(re)discovery' of SNA: they largely take a very narrow and ahistorical view of network analysis (Downey 2004; Urry 2004; Crossley 2005; Scott 2009). It is somewhat of a surprise that so much has been made of the commonality of power-law distributions; such distributions arise because the mechanisms that underlie the distribution produce mathematically similar outcomes, not because they are somehow the same phenomenon. Two characteristics that both have power-law distributions do not really have any more similarity than those that are both normally distributed. Indeed, early research on power laws found the distributions to be “more normal than Normal” and “rather common and unsurprising” (Fox Keller 2005, 1063) While similar tools can be used to study phenomena with common mathematical representations, lack of careful attention to the context, content, and meaning of the networks in question can lead to apparent superficial similarities, which seems to be what has occurred as these physicists engaged in “the enthusiastic testing of those models on nearly every kind of network that researchers could imagine (and for which they could locate machine-readable data on the structure).” (Downey 2004, 164). A better phenomenological description of instrumentitis would be difficult to find. It is unclear what the added value is of this work, other than throwing increasing computing power at enhanced datasets, to the contributions that had already been made by the original pioneers in random graph theory, small worlds theory, and the strength of weak ties (Erdös and Rényi 1959; 1960; Milgram 1967; Travers and Milgram 1969; Granovetter 1973; 1983).

The new “network science”[3] mania in physics, like the older “chaos theory,”[4] while capturing the popular imagination, ultimately boils down to two things: networks can be “scale-free” (meaning that degree distributions follow a power law: a few nodes have most of the ties, while there is a long tail of nodes with few ties) or a “randomly clustered” (clumps of highly-connected groups have few ties to other groups) small world, or sometimes both. The requirements to be one or other are not high. However, when actual power-law fits as opposed to speculative graphs were done, only 7 of the 24 discrete-data networks and 10 of the 24 continuous-data networks used in these analyses were statistically significant at a generous p<0.1 cutoff (Clauset, Shalizi, and Newman 2009). Follow-on work found scale-free networks to be empirically rare: only 4% of the networks studied were convincingly scale-free, and no social network studied was more than weakly scale-free (Broido and Clauset 2019). As for small worlds, as one text puts it, “Any network can be a small-world network so long as it has some way of embodying order and yet retains some small amount of disorder.’’’(Watts 2003, 99) Whether any real-world network does not meet this property is an exercise left to the reader. Watts claims that physicists “are almost perfectly suited to invading other people’s disciplines, being not only extremely clever but also generally much less fussy than most about the problems they choose to study.” (Watts 2003, 61)[5] Yet this is

[3] As with any other discipline that requires the modifier ‘science’ at the end of it to proclaim its scientific status, such claims should be subject to scrutiny: we need not refer to “physics science,” “chemistry science,” or “biology science.”

[4] Ultimately the last gasp of the old mechanistic-deterministic worldview: really, things interact in regular, predictable ways, we just can’t predict it because things are complicated. Complexity theory has since broken with this determinism.

[5] The author himself is entirely guilty of the same, but is trying to be conscientious about it.

precisely the problem: being less fussy about the problems means being less attentive to the data itself; this is less the problem of not seeing the forest for the trees and more seeing the forest as an inconvenient obstacle to the real treasure that lies underground where alleged polymaths carry out poorly-theorized data fracking.[6] Treating ties and nodes as static ignores the property that ties share with all structures: they are created, recreated, and destroyed in a dynamic fashion through performances by agents. Additionally, treating nodes and ties as homogenous ignores the historical trajectory that led to the formation, maintenance, and possibilities for future dissolution of these networks. Finally, they exclude the very real effects that power, domination, and inequality have on these processes, as well as the intentions of the actors and the meanings that these ties have for them.

Back to the Future?

More recent trends have indicated at least a partial movement back towards network concepts more compatible with a relationalist approach rather than substantialist ones; for example, indirect, third-party ties have become increasingly emphasized, although these are coupled with international relations theories about information more often than social theories of affect or social relations (Maoz et al. 2007; Dorussen and Ward 2008; Corbetta and Dixon 2005; Corbetta 2013; 2010; 2015; Corbetta and Grant 2012). Newer network methodologies that attempt to account for network processes have slowly been gaining more prominence, including latent space models (LSM) (Krivitsky and Handcock 2008), stochastic actor-oriented models (SAOMs) (Snijders, van de Bunt, and Steglich 2010), and exponential-family random graph models (ERGM) (For guides to model selection, see Cranmer et al. 2017; Desmarais and Cranmer 2017). For example, the latter can now account for many network mechanisms, including popularity effects, reciprocity, inertia, similarities, differences, cycles, and triads. Importantly, history can also now be taken into account in a fashion, since further extensions to the ERGM model have allowed for studying time-based network evolution (TERGM) (Leifeld, Cranmer, and Desmarais 2018) as well as generalized models that can handle valued ties (GERGM) (Desmarais and Cranmer 2012). SAOM such as SIENA (Simulation Investigation for Empirical Network Analysis) incorporate similar advancements, but follow a more individual-based rather than relational model, modeling “choices” made by individual nodes to proffer or accept a network tie. When SIENA was compared with TERGM, the relational ERGM approach often provided a better fit even in a dataset where the data generating process was thought to be individualistic, such as a friendship network in a Dutch school class observed across multiple times (Leifeld and Cranmer 2019). This suggests that other processes that are generally assumed to be the

[6] I thank Sarah Parkinson for this turn of phrase as well as extensive suggestions regarding qualitative network pieces in the literature review.

result of individual choices may be better modeled through intersubjective, relational processes instead.

Some new work is also following a more promising path, in part by using data that is more “network-like” in character and by integrating social network theory as well as tools. This is not to say that these forms of measuring or imputing ties are not potentially flawed as well. One of the most widely-used network variables, mutual membership in international institutions of various types (Russett, Oneal, and Davis 1998; Oneal and Russett 1999; K. Kim and Barnett 2000; J. H. Kim and Barnett 2007; Moore, Eng, and Daniel 2003; Maoz et al. 2006; H. Ward 2006; Dorussen and Ward 2008; Hafner-Burton and Montgomery 2006; 2008; 2009; Henke 2017), is an affiliation rather than a direct tie. While it can (usually) be assumed that mutual membership in institutions leads to more opportunities for mutual interaction and socialization (Johnston 2001), this does not necessarily lead to positive ties, and so should be used with some caution. One advantage of this data is that for IGOs, the data exists from 1815 through 1960 every five years, and from 1965 through 2014 for every year (Pevehouse et al. 2020). Another question is whether the tie strength imputed from such affiliations is a measure of some underlying affinity or whether it constitutes a tie in and of itself. Membership is also problematic because, unlike underlying ties, it tends to be ratcheted: international institutions rarely die or eject or otherwise lose members (Ingram 2006); consequently, just as some neoliberal institutionalists view these institutions as congealed power, network analysts must view these to some extent as congealed ties (Hafner-Burton and Montgomery 2006).

Directly-measured ties are, for network analysts and relationalists alike, the most valuable and least problematic (in terms of properly measuring ties) data. Recent efforts have expanded the number of international datasets with directly-measured ties; three stand out as existing for a sufficient number of years and countries as to be able to chart changes and growth over time: diplomatic recognition, arms proliferation, and international trade. Diplomatic recognition data is perhaps the most valuable, as it is available for a long period of time (1817 through 2005) (Bayer 2006), 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 (chargé d’affaires, minister, and ambassador). It is also one of the least used as a network indicator; while some studies have used it as a unit characteristic (Boehmer, Gartzke, and Nordstrom 2004; Jo and Gartzke 2007), until recently few have used this data as a network. The latest work has employed ERGMs and SAOMs to demonstrate the importance of reciprocity, sociality, popularity, transitivity, and homophily in diplomatic relations (Kinne 2014; Duque 2018). There are some weaknesses in this particular dataset; it is only recorded every five years, and it is very dense (in the sense that most countries have relations with many other countries), limiting its ability to be used for density-sensitive measures and concepts such as betweenness or brokerage.

Arms supply and proliferation data for small arms and light weapons (SALW), major conventional weapons (MCW), and weapons of mass destruction (WMD) show a great deal of potential for network analysis, but has so far been infrequently used apart from visualizations or standard dyadic models (Kinsella and Montgomery 2017). There are a few studies that have used ERGMs to account for network features of the global arms market in MCW using the SIPRI data, which is available from 1950 through the most recent calendar year, that demonstrate that while new trade relationships are initially driven by network effects and security, transfers persist based on receivers' military expenditures. Moreover, security considerations dominated during the Cold War and after 2001, with economic considerations only becoming significant during the 1990s (Willardson 2013; Thurner et al. 2019; Lebacher, Thurner, and Kauermann 2021).

Trade data is only available from 1948 to the present, although it is also directed and valued (as opposed to binary). Applying advanced network analysis tools to the dataset have yielded some surprising findings: for example, LSMs have shown that workhorse gravity models for trade do a poor job at fitting real-world data due to their lack of network effects such as reciprocity and clusterability (M. D. Ward, Ahlquist, and Rozenas 2013), and SAOM models have demonstrated that trade policies do not seem to diffuse with trade itself (Mohrenberg 2017). Trade data is recorded for every year (a significant strength), but suffers from missing values. While superb efforts have been made to fill in the missing data (Gleditsch 2002), it does mean that using the sets available in an unconscious manner is highly problematic.

RELATIONALISM AND SNA

There have been some recent promising developments in the use of SNA in IR. One area in which IR scholars have moved ahead is in analyzing how network structures affect behavior. While much of the sociological work involves mapping structures or analyzing inequality, the concern of many political scientists with how these networks affect behavior (whether of individuals, dyads, or groups) is a worthwhile goal for social network analysis. In particular, scholars have been grappling with how network structures (although often suffering from the problems enumerated above) affect conflict (Maoz 2001; 2006; Maoz et al. 2005; 2006; 2007; Maoz 2010; Hafner-Burton and Montgomery 2012; 2006; 2008; J. H. Kim and Barnett 2007; Corbetta 2013; Dorussen and Ward 2008; Montgomery 2016). There is currently little consensus among these pieces as to which particular aspects of international networks most affect conflict, and many of them suffer from the methodological shortcomings enumerated in this chapter. Nonetheless, there is a distinct trend to use theories and tools that are designed to operate in tandem on data that is appropriate to use for network analysis.

While these recent developments have moved SNA back towards appropriate data and theories and have applied them to outcomes of interest to IR scholars, it is unclear whether these developments also restore compatibility with relationalism. For example, finding that the centrality score of a state in a network increases the likelihood of that state initiating a conflict is only a partial movement towards a relational approach, since although it does use a network attribute to explain conflict, it still posits that conflict as being caused by an individual characteristic. A more relational approach, by contrast, would attempt to locate a locus for action in the interaction between two states, perhaps by looking at their relative centrality scores (e.g., Hafner-Burton and Montgomery 2006). Some types of centrality scores are more relational than others; for example, degree centrality simply sums over all direct incoming ties, whereas eigenvector centrality weights those incoming ties by the importance of each of the nodes from which the ties come. Consequently, the latter takes into account all of the ties in a connected group, rather than simply the direct ties, making for a relational analysis that incorporates an entire subsystem of relations rather than each node's immediate neighborhood.

Certain incompatibilities will likely always remain between relational approaches and SNA. In particular, there is an inherent problem with coding for quantitative analysis, in that it requires a freezing of meaning and a significant degree of abstraction, both of which are contrary to a thick relational approach. The bootstrapping problem for identification of nodes prevents a complete ontological commitment to treating relations as prior to entities as well. Finally, in practice, much of the data that is and will be used for SNA tends to be somewhat problematic from a relational ontology perspective, whether due to assumptions about the static nature of relations required to use the data as network ties, missing data, or using data that has been abstracted from its original meaning.

Overall, the revival of SNA in IR has been highly uneven; fitting SNA into IR has been mostly resulted in the theories associated with SNA getting short shrift rather than an expansion of IR theory beyond its traditional concerns with the monadic, dyadic, and systemic. This is rather unfortunate, as SNA has a great deal of promise for dealing with mid-level systemic analysis: what is called variously the "micro-structure" rather than the "macro-structure" (Wendt 1999, 12–13), the "…meso levels that are neither wholly micro nor macro" (Victor, Montgomery, and Lubell 2017a, 8), or (most simply) the interaction or transaction level of analysis, which is exactly where relationalism has the best chance of succeeding. Nevertheless, recent simultaneous moves towards analyses of conflict in IR and back towards the SNA theories that are tightly coupled with SNA tools demonstrate the so-far unrealized potential of SNA to contribute towards a relational IR.

BIBLIOGRAPHY

Abbott, Andrew. 1988. "Transcending General Linear Reality." *Sociological Theory* 6 (2): 169–86. https://doi.org/10.2307/202114.

Adler, Emmanuel. 1997. "Seizing the Middle Ground: Constructivism in World Politics." *European Journal of International Relations* 3 (3): 319–63. https://doi.org/10.1177/1354066197003003003.

Alderson, Arthur S., and Jason Beckfield. 2004. "Power and Position in the World City System." *American Journal of Sociology* 109 (4): 811–51. https://doi.org/10.1086/378930.

Barabási, Albert-László. 2002. *Linked: The New Science of Networks*. Cambridge, MA: Perseus Books Group.

Barabási, Albert-László, and Réka Albert. 1999. "Emergence of Scaling in Random Networks." *Science* 286 (5439): 509–12. https://doi.org/10.1126/science.286.5439.509.

Bayer, Reşat. 2006. *Diplomatic Exchange Data Set*. Diplomatic Exchange Data Set. Correlates of War Project.

Beckfield, Jason. 2003. "Inequality in the World Polity: The Structure of International Organization." *American Sociological Review* 68 (3): 401–24. https://doi.org/10.2307/1519730.

Boehmer, Charles, Erik Gartzke, and Tim Nordstrom. 2004. "Do Intergovernmental Organizations Promote Peace?" *World Politics* 57 (1): 1–38. https://doi.org/10.1353/wp.2005.0008.

Brams, Steven J. 1966. "Transaction Flows in the International System." *American Political Science Review* 60 (4): 880–98. https://doi.org/10.2307/1953763.

———. 1969. "The Structure of Influence Relationships in the International System." In *International Politics and Foreign Policy: A Reader in Research and Theory*, edited by James N. Rosenau, 2nd ed., 583–99. New York, NY: Free Press.

Breiger, Ronald L. 1981. "Structures of Economic Interdependence among Nations." In *Continuities in Structural Inquiry*, edited by Peter Michael Blau and Robert King Merton, 353–80. London, UK: SAGE Publications.

Broido, Anna D., and Aaron Clauset. 2019. "Scale-Free Networks Are Rare." *Nature Communications* 10 (1): 1017. https://doi.org/10.1038/s41467-019-08746-5.

Campbell, Benjamin, Skyler Cranmer, and Bruce Desmarais. 2018. "Triangulating War: Network Structure and the Democratic Peace." *arXiv:1809.04141 [Physics, Stat]*, September. http://arxiv.org/abs/1809.04141.

Carrington, Peter J., John Scott, and Stanley Wasserman. 2005. *Models and Methods in Social Network Analysis*. Structural Analysis in the Social Sciences. Cambridge, UK: Cambridge University Press.

Choi, Junho H., George A. Barnett, and Bum-Soo Chon. 2006. "Comparing World City

Networks: A Network Analysis of Internet Backbone and Air Transport Intercity Linkages." *Global Networks* 6 (1): 81–99. https://doi.org/10.1111/j.1471-0374.2006.00134.x.
Christopherson, Jon A. 1976. "Structural Analysis of Transaction Systems: Vertical Fusion or Network Complexity?" *Journal of Conflict Resolution* 20 (4): 637–62.
Clauset, Aaron, Cosma Rohilla Shalizi, and M. E. J. Newman. 2009. "Power-Law Distributions in Empirical Data." *SIAM Review* 51 (4): 661–703. https://doi.org/10.1137/070710111.
Corbetta, Renato. 2010. "Determinants of Third Parties' Intervention and Alignment Choices in Ongoing Conflicts, 1946–2001." *Foreign Policy Analysis* 6 (1): 61–85. https://doi.org/10.1111/j.1743-8594.2009.00102.x.
———. 2013. "Cooperative and Antagonistic Networks: Multidimensional Affinity and Intervention in Ongoing Conflicts, 1946–2001." *International Studies Quarterly* 57 (2): 370–384.
———. 2015. "Between Indifference and Coercion: Third-Party Intervention Techniques in Ongoing Disputes." *Conflict Management and Peace Science* 32 (1): 3–27. https://doi.org/10.1177/0738894214544879.
Corbetta, Renato, and William J. Dixon. 2005. "Danger beyond Dyads: Third-Party Participants in Militarized Interstate Disputes." *Conflict Management and Peace Science* 22 (1): 39–61. https://doi.org/10.1080/07388940590915318.
Corbetta, Renato, and Keith A. Grant. 2012. "Intervention in Conflicts from a Network Perspective." *Conflict Management and Peace Science* 29 (3): 314–40. https://doi.org/10.1177/0738894212443343.
Correlates of War Project. 2011. "State System Membership List, V20011."
Cranmer, Skyler J., Bruce A. Desmarais, and Benjamin W. Campbell. 2019. "The Contagion of Democracy through International Networks." *Social Networks*, October. https://doi.org/10.1016/j.socnet.2019.08.009.
Cranmer, Skyler J., Philip Leifeld, Scott D. McClurg, and Meredith Rolfe. 2017. "Navigating the Range of Statistical Tools for Inferential Network Analysis." *American Journal of Political Science* 61 (1): 237–51. https://doi.org/10.1111/ajps.12263.
Crossley, Nick. 2005. "Review Article: The New Social Physics and the Science of Small World Networks." *Sociological Review* 53 (2): 351–59. https://doi.org/10.1111/j.1467-954X.2005.00518_1.x.
de Andrade, Ricardo Lopes, and Leandro Chaves Rêgo. 2018. "The Use of Nodes Attributes in Social Network Analysis with an Application to an International Trade Network." *Physica A: Statistical Mechanics and Its Applications* 491 (February):249–70. https://doi.org/10.1016/j.physa.2017.08.126.
Desmarais, Bruce A., and Skyler J. Cranmer. 2012. "Statistical Inference for Valued-Edge Networks: The Generalized Exponential Random Graph Model." *PLOS ONE* 7

(1): e30136. https://doi.org/10.1371/journal.pone.0030136.
———. 2017. “Statistical Inference in Political Networks Research.” In *The Oxford Handbook of Political Networks*, edited by Jennifer Nicoll Victor, Alexander H. Montgomery, and Mark Lubell. Oxford University Press.
Deutsch, Karl Wolfgang. 1957. *Political Community and the North Atlantic Area; International Organization in the Light of Historical Experience*. Princeton, NJ: Princeton University Press.
Dorff, Cassy. 2017. “Violence, Kinship Networks, and Political Resilience: Evidence from Mexico.” *Journal of Peace Research* 54 (4): 558–73. https://doi.org/10.1177/0022343317691329.
Dorussen, Han, and Hugh Ward. 2008. “Intergovernmental Organizations and the Kantian Peace: A Network Perspective.” *Journal of Conflict Resolution* 52 (2): 189–212. https://doi.org/10.1177/0022002707313688.
Downey, Gregory. 2004. “Nodes, Links, and Phase Transitions: Popularizing ‘Network Science.’” *Technology and Culture* 45 (1): 162–67. https://doi.org/10.1353/tech.2004.0015.
Duan, Wen-Qi. 2008. “Estimating Trade Flow Based on Network Topology.” *Physica A: Statistical Mechanics and Its Applications* 387 (2–3): 519–27. https://doi.org/10.1016/j.physa.2007.09.018.
Duque, Marina G. 2018. “Recognizing International Status: A Relational Approach.” *International Studies Quarterly* 62 (3): 577–92. https://doi.org/10.1093/isq/sqy001.
Erdös, Paul, and Alfred Rényi. 1959. “On Random Graphs.” *Publicationes Mathematicae* 6:290–97.
———. 1960. “On the Evolution of Random Graphs.” *Publications of the Mathematical Institute of the Hungarian Academy of Sciences* 5:17–61.
Faber, Jan. 1987. “Measuring Cooperation, Conflict, and the Social Network of Nations.” *Journal of Conflict Resolution* 31 (3): 438–64. https://doi.org/10.1177/0022002787031003003.
Fagiolo, Giorgio, Javier Reyes, and Stefano Schiavo. 2008. “On the Topological Properties of the World Trade Web: A Weighted Network Analysis.” *Physica A: Statistical Mechanics and Its Applications* 387 (15): 3868–73. https://doi.org/10.1016/j.physa.2008.01.050.
Fowler, J. H., M. T. Heaney, D. W. Nickerson, J. F. Padgett, and B. Sinclair. 2011. “Causality in Political Networks.” *American Politics Research* 39 (2): 437–80. https://doi.org/10.1177/1532673X10396310.
Fox Keller, Evelyn. 2005. “Revisiting ‘Scale-Free’ Networks.” *BioEssays : News and Reviews in Molecular, Cellular and Developmental Biology* 27 (10): 1060–68. https://doi.org/10.1002/bies.20294.
Freeman, Linton C. 2004. *The Development of Social Network Analysis: A Study in the Sociology of Science*. Vancouver, BC: Empirical Press.

Gade, Emily Kalah. 2020. "Social Isolation and Repertoires of Resistance." *American Political Science Review* 114 (2): 309–25. https://doi.org/10.1017/S0003055420000015.
Garlaschelli, Diego, and Maria I. Loffredo. 2005. "Structure and Evolution of the World Trade Network." *Physica A: Statistical Mechanics and Its Applications* 355 (1): 138–44. https://doi.org/10.1016/j.physa.2005.02.075.
Gleditsch, Kristian Skrede. 2002. "Expanded Trade and GDP Data." *Journal of Conflict Resolution* 46 (5): 712–24. https://doi.org/10.1177/0022002702046005006.
Goddard, Stacie E. 2009. "Brokering Change: Networks and Entrepreneurs in International Politics." *International Theory* 1 (2): 249–81. https://doi.org/10.1017/S1752971909000128.
———. 2018. "Embedded Revisionism: Networks, Institutions, and Challenges to World Order." *International Organization*, May, 1–35. https://doi.org/10.1017/S0020818318000206.
Gomez, Charles J., and Paolo Parigi. 2015. "The Regionalization of Intergovernmental Organization Networks: A Non-Linear Process." *Social Networks* 43 (October):192–203. https://doi.org/10.1016/j.socnet.2015.03.007.
Granovetter, Mark S. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78 (6): 1360–80. https://doi.org/10.1086/225469.
———. 1983. "The Strength of Weak Ties: A Network Theory Revisited." *Sociological Theory* 1:201–33. https://doi.org/10.2307/202051.
Greenhill, Brian, and Yonatan Lupu. 2017. "Clubs of Clubs: Fragmentation in the Network of Intergovernmental Organizations." *International Studies Quarterly* 61 (1): 181–95. https://doi.org/10.1093/isq/sqx001.
Hadden, Jennifer. 2015. *Networks in Contention*. Cambridge University Press.
Hafner-Burton, Emilie M., Miles Kahler, and Alexander H. Montgomery. 2009. "Network Analysis for International Relations." *International Organization* 63 (3): 559–92. https://doi.org/10.1017/S0020818309090195.
Hafner-Burton, Emilie M., and Alexander H. Montgomery. 2006. "Power Positions: International Organizations, Social Networks, and Conflict." *Journal of Conflict Resolution* 50 (1): 3–27. https://doi.org/10.1177/0022002705281669.
———. 2008. "Power or Plenty: How Do International Trade Institutions Affect Economic Sanctions?" *Journal of Conflict Resolution* 52 (2): 213–42. https://doi.org/10.1177/0022002707313689.
———. 2009. "Globalization and the Social Power Politics of International Economic Networks." In *Networked Politics: Agency, Power, and Governance*, edited by Miles Kahler, 23–42. Ithaca, NY: Cornell University Press.
———. 2012. "War, Trade, and Distrust: Why Trade Agreements Don't Always Keep the Peace." *Conflict Management and Peace Science* 29 (3): 257–78. https://doi.org/10.1177/0738894212443342.
Haim, Dotan A. 2016. "Alliance Networks and Trade The Effect of Indirect Political

Alliances on Bilateral Trade Flows." *Journal of Peace Research* 53 (3): 472–90. https://doi.org/10.1177/0022343316630938.
Henke, Marina E. 2017. "The Politics of Diplomacy: How the United States Builds Multilateral Military Coalitions." *International Studies Quarterly* 61 (2): 410–24. https://doi.org/10.1093/isq/sqx017.
Hundman, Eric. 2016. "Networks and Loyalties: The Social Roots of Military Disobedience in the Sino-French War." Ph.D. dissertation, University of Chicago.
Hundman, Eric, and Sarah E. Parkinson. 2019. "Rogues, Degenerates, and Heroes: Disobedience as Politics in Military Organizations." *European Journal of International Relations*, February, 1354066118823891. https://doi.org/10.1177/1354066118823891.
Ingram, Paul. 2006. "Nasty, Brutish and Long: The Survival and Failure of Inter-Governmental Organizations, 1815-2000." In *Inproceedings*.
Ingram, Paul, Jeffrey Robinson, and Marc L. Busch. 2005. "The Intergovernmental Network of World Trade: IGO Connectedness, Governance and Embeddedness." *American Journal of Sociology* 111 (3): 824–58. https://doi.org/10.1086/497350.
Jackson, Patrick, and Daniel H. Nexon. 1999. "Relations before States: Substance, Process, and the Study of World Politics." *European Journal of International Relations* 5 (3): 291–333. https://doi.org/10.1177/1354066199005003002.
Jo, Dong-Joon, and Erik Gartzke. 2007. "Determinants of Nuclear Weapons Proliferation: A Quantitative Model." *Journal of Conflict Resolution* 51 (1): 167–94. https://doi.org/10.1177/0022002706296158.
Johnston, Alastair Iain. 2001. "Treating International Institutions as Social Environments." *International Studies Quarterly* 45 (4): 487–515. https://doi.org/10.1111/0020-8833.00212.
Kick, Edward L., and Byron L. Davis. 2001. "World-System Structure and Change: An Analysis of Global Networks and Economic Growth across Two Time Periods." *American Behavioral Scientist* 44 (10): 1561–78. https://doi.org/10.1177/00027640121958050.
Kim, Jang Hyun, and George A. Barnett. 2007. "A Structural Analysis of International Conflict: From a Communication Perspective." *International Interactions* 33 (2): 135–65. https://doi.org/10.1080/03050620701277764.
Kim, Kyungmo, and George A. Barnett. 2000. "The Structure of the International Telecommunications Regime in Transition: A Network Analysis of International Organizations." *International Interactions* 26 (1): 91–127. https://doi.org/10.1080/03050620008434962.
Kim, Rakhyun E. 2013. "The Emergent Network Structure of the Multilateral Environmental Agreement System." *Global Environmental Change* 23 (5): 980–91. https://doi.org/10.1016/j.gloenvcha.2013.07.006.
Kinne, Brandon J. 2014. "Dependent Diplomacy: Signaling, Strategy, and Prestige in the

Diplomatic Network." *International Studies Quarterly* 58 (2): 247–59. https://doi.org/10.1111/isqu.12047.
Kinsella, David, and Alexander H. Montgomery. 2017. "Arms Supply and Proliferation Networks." In *The Oxford Handbook of Political Networks*, edited by Jennifer Nicoll Victor, Alexander H. Montgomery, and Mark Lubell, 761–86. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190228217.013.33.
Knoke, David, and Song Yang. 2008. *Social Network Analysis*. Los Angeles: Sage Publications.
Krackhardt, David, and Jeffrey R. Hanson. 1993. "Informal Networks: The Company behind the Chart." *Harvard Business Review* 71 (4): 104–11. http://search.ebscohost.com/login.aspx?direct=true&AN=9402176614%20.
Krebs, Valdis E. 2002. "Mapping Networks of Terrorist Cells." *Connections* 24 (3): 43–52.
Krivitsky, Pavel N., and Mark S. Handcock. 2008. "Fitting Latent Cluster Models for Networks with Latentnet." *Journal of Statistical Software* 24 (5): 1–23.
Lazer, David. 2011. "Networks in Political Science: Back to the Future." *PS: Political Science & Politics* 44 (1): 61–68. http://journals.cambridge.org/abstract_S1049096510001873.
Lebacher, Michael, Paul W. Thurner, and Göran Kauermann. 2021. "A Dynamic Separable Network Model with Actor Heterogeneity: An Application to Global Weapons Transfers*." *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 184 (1): 201–26. https://doi.org/10.1111/rssa.12620.
Lee, Taedong. 2013. "Global Cities and Transnational Climate Change Networks." *Global Environmental Politics* 13 (1): 108–27. https://doi.org/10.1162/GLEP_a_00156.
Leifeld, Philip, and Skyler J. Cranmer. 2019. "A Theoretical and Empirical Comparison of the Temporal Exponential Random Graph Model and the Stochastic Actor-Oriented Model." *Network Science* 7 (1): 20–51. https://doi.org/10.1017/nws.2018.26.
Leifeld, Philip, Skyler J. Cranmer, and Bruce A. Desmarais. 2018. "Temporal Exponential Random Graph Models with Btergm: Estimation and Bootstrap Confidence Intervals." *Journal of Statistical Software* 83 (February):1–36. https://doi.org/10.18637/jss.v083.i06.
Lewer, Joshua J., and Hendrik Van den Berg. 2007. "Estimating the Institutional and Network Effects of Religious Cultures on International Trade." *Kyklos* 60 (2): 255–77. https://doi.org/10.1111/j.1467-6435.2007.00371.x.
Li, Xiang, Yu Ying Jin, and Guanrong Chen. 2003. "Complexity and Synchronization of the World Trade Web." *Physica A: Statistical Mechanics and Its Applications* 328 (1–2): 287–96. https://doi.org/10.1016/S0378-4371(03)00567-3.
Lupu, Yonatan, and Vincent A. Traag. 2013. "Trading Communities, the Networked Structure of International Relations, and the Kantian Peace." *Journal of Conflict Resolution* 57 (6): 1011–1042.

MacDonald, Paul K. 2014. *Networks of Domination: The Social Foundations of Peripheral Conquest in International Politics*. Oxford University Press.
———. 2018. "Embedded Authority: A Relational Network Approach to Hierarchy in World Politics." *Review of International Studies* 44 (1): 128–50. https://doi.org/10.1017/S0260210517000213.
Mahutga, Matthew C. 2006. "The Persistence of Structural Inequality? A Network Analysis of International Trade, 1965-2000." *Social Forces* 84 (4): 1863–89. https://doi.org/10.1353/sof.2006.0098.
Maoz, Zeev. 2001. "Democratic Networks: Connecting National, Dyadic, and Systemic Levels-of-Analysis in the Study of Democracy and War." In *War in a Changing World*, edited by Zeev Maoz and Azar Gat, 143–82. Ann Arbor, MI: University of Michigan Press.
———. 2006. "Network Polarization, Network Interdependence and International Conflict, 1816-2002." *Journal of Peace Research* 43 (4): 391–411. https://doi.org/10.1177/0022343306065720.
———. 2010. *Networks of Nations: The Formation, Evolution, and Effect of International Networks, 1816-2001*. New York, NY: Cambridge University Press.
Maoz, Zeev, Ranan D. Kuperman, Lesley G. Terris, and Ilan Talmud. 2006. "Structural Equivalence and International Conflict: A Social Networks Analysis." *Journal of Conflict Resolution* 50 (5): 664–89. https://doi.org/10.1177/0022002706291053.
Maoz, Zeev, Lesley G. Terris, Ranan D. Kuperman, and Ilan Talmud. 2005. "International Relations: A Network Approach." In *New Directions for International Relations: Confronting the Method-of-Analysis Problem*, edited by Alex Mintz and Bruce M. Russett, 35–64. Lanham, MD: Lexington Books.
———. 2007. "What Is the Enemy of My Enemy? Causes and Consequences of Imbalanced International Relations, 1816-2001." *Journal of Politics* 69 (1): 100–115. https://doi.org/10.1111/j.1468-2508.2007.00497.x.
Mazur, Kevin. 2019. "State Networks and Intra-Ethnic Group Variation in the 2011 Syrian Uprising." *Comparative Political Studies* 52 (7): 995–1027. https://doi.org/10.1177/0010414018806536.
———. 2021. *Revolution in Syria: Identity, Networks, and Repression*. Cambridge University Press.
McChrystal, Stanley A. 2011. "Becoming the Enemy." *Foreign Policy*, no. 185, 66–70.
McLean, Paul. 2016. *Culture in Networks*. John Wiley & Sons.
Metternich, Nils W., Cassy Dorff, Max Gallop, Simon Weschle, and Michael D. Ward. 2013. "Antigovernment Networks in Civil Conflicts: How Network Structures Affect Conflictual Behavior." *American Journal of Political Science* 57 (4): 892–911. https://doi.org/10.1111/ajps.12039.
Milgram, Stanley. 1967. "The Small World Problem." *Psychology Today* 1 (1): 60–67.
Mohrenberg, Steffen. 2017. "Studying Policy Diffusion with Stochastic Actor-Oriented

Models." In *Networked Governance: New Research Perspectives*, edited by Betina Hollstein, Wenzel Matiaske, and Kai-Uwe Schnapp, 163–88. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-50386-8_10.

Montgomery, Alexander H. 2005. "Ringing in Proliferation: How to Dismantle an Atomic Bomb Network." *International Security* 30 (2): 153–87. https://doi.org/10.1162/016228805775124543.

———. 2016. "Centrality in Transnational Governance: How Networks of International Institutions Shape Power Processes." In *The New Power Politics: Networks and Transnational Security Governance*, edited by Deborah D. Avant and Oliver Westerwinter. Oxford University Press.

Moore, Spencer, Eugenia Eng, and Mark Daniel. 2003. "International NGOs and the Role of Network Centrality in Humanitarian Aid Operations: A Case Study of Coordination During the 2000 Mozambique Floods." *Disasters* 27 (4): 305–18. https://doi.org/10.1111/j.0361-3666.2003.00235.x.

Murdie, Amanda M. 2014. "The Ties That Bind: A Network Analysis of Human Rights International Nongovernmental Organizations." *British Journal of Political Science* 44 (1): 1–27. https://doi.org/10.1017/S0007123412000683.

Nemeth, Roger J., and David A. Smith. 1985. "International Trade and World System Structure: A Multiple-Network Analysis." *Review (Fernand Braudel Center)* VIII (4): 517–60.

Nexon, Daniel H. 2010. "Relationalism and New Systems Theory." In *New Systems Theories of World Politics*, edited by Mathias Albert, Lars-Erik Cederman, and Alexander Wendt, 99–126. Palgrave Macmillan.

Nexon, Daniel H., and Thomas Wright. 2007. "What's at Stake in the American Empire Debate." *American Political Science Review* 101 (2): 253–71. https://doi.org/10.1017/S0003055407070220.

Obert, Jonathan, and John F. Padgett. 2012. "Conflict Displacement and Dual Inclusion in the Construction of Germany." In *The Emergence of Organizations and Markets*, edited by John F. Padgett and Walter W. Powell, 235–65. Princeton, NJ: Princeton University Press. http://www.worldcat.org/oclc/835648589.

Oneal, John R., and Bruce M. Russett. 1999. "The Kantian Peace: The Pacific Benefits of Democracy, Interdependence, and International Organizations, 1885-1992." *World Politics* 52 (1): 1–37. https://doi.org/10.1017/S0043887100020013.

Padgett, John F. 2016. "The Emergence of Organizations and States." In *The Oxford Handbook of Political Networks*, edited by Jennifer Nicoll Victor, Alexander H. Montgomery, and Mark Lubell, 59–89. Oxford University Press.

Padgett, John F., and Christopher K. Ansell. 1993. "Robust Action and the Rise of the Medici, 1400-1434." *American Journal of Sociology* 98 (6): 1259–1319. https://doi.org/10.1086/230190.

Parkinson, Sarah E. 2013. "Organizing Rebellion: Rethinking High-Risk Mobilization

and Social Networks in War." *American Political Science Review* 107 (3): 418–32. https://doi.org/10.1017/S0003055413000208.
———. 2016. "Money Talks: Discourse, Networks, and Structure in Militant Organizations." *Perspectives on Politics* 14 (4): 976–94. https://doi.org/10.1017/S1537592716002875.
———. 2023. *Beyond the Lines: Social Networks and Palestinian Militant Organizations in Wartime Lebanon*. Cornell University Press.
Patel, David Siddhartha. 2022. *Order out of Chaos: Islam, Information, and the Rise and Fall of Social Orders in Iraq*. Cornell University Press.
Paterson, Matthew, Matthew Hoffmann, Michele Betsill, and Steven Bernstein. 2013. "The Micro Foundations of Policy Diffusion toward Complex Global Governance an Analysis of the Transnational Carbon Emission Trading Network." *Comparative Political Studies*, 0010414013509575.
Peacock, Walter Gillis, Greg A. Hoover, and Charles D. Killian. 1988. "Divergence and Convergence in International Development: A Decomposition Analysis of Inequality in the World System." *American Sociological Review* 53 (6): 838–52. https://doi.org/10.2307/2095894.
Perliger, Arie, and Ami Pedahzur. 2011. "Social Network Analysis in the Study of Terrorism and Political Violence." *PS: Political Science & Politics* 44 (1): 45–50. https://doi.org/10.1017/S1049096510001848.
Pevehouse, Jon CW, Timothy Nordstrom, Roseanne W McManus, and Anne Spencer Jamison. 2020. "Tracking Organizations in the World: The Correlates of War IGO Version 3.0 Datasets." *Journal of Peace Research* 57 (3): 492–503. https://doi.org/10.1177/0022343319881175.
Powell, Walter W. 1990. "Neither Market nor Hierarchy: Network Forms of Organization." *Research in Organizational Behavior* 12:295–336.
Rogowski, Jon C., and Betsy Sinclair. 2017. "Causal Inference in Political Networks." In *The Oxford Handbook of Political Networks*, edited by Jennifer Nicoll Victor, Alexander H. Montgomery, and Mark Lubell, 1:131–46. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190228217.013.6.
Russett, Bruce, John R. Oneal, and David R. Davis. 1998. "The Third Leg of the Kantian Tripod for Peace: International Organizations and Militarized Disputes, 1950-85." *International Organization* 52 (3): 441–67. https://doi.org/10.1162/002081898550626.
Sacks, Michael Alan, Marc J. Ventresca, and Brian Uzzi. 2001. "Global Institutions and Networks: Contingent Change in the Structure of World Trade Advantage, 1965-1980." *American Behavioral Scientist* 44 (10): 1579–1601. https://doi.org/10.1177/00027640121958069.
Savage, I. Richard, and Karl W. Deutsch. 1960. "A Statistical Model of the Gross Analysis of Transaction Flows." *Econometrica* 28 (3): 551–72. https://doi.org/10.2307/1910131.

Scott, John. 2009. "Social Physics and Its Critics." In *The Sage Handbook of Social Network Analysis*, edited by Peter Carrington and John Scott. Sage Publications.

———. 2017. *Social Network Analysis*. 4 edition. Thousand Oaks, CA: SAGE Publications Ltd.

Scott, John, and Peter J. Carrington, eds. 2011. *The SAGE Handbook of Social Network Analysis*. SAGE. https://doi.org/10.4135/9781446294413.

Signorino, Curtis S., and Jeffrey M. Ritter. 1999. "Tau-b or Not Tau-b: Measuring the Similarity of Foreign Policy Positions." *International Studies Quarterly* 43 (1): 115–44. https://doi.org/10.1111/0020-8833.00113.

Simmel, Georg. 1908. "The Problem of Sociology." In *On Individuality and Social Forms: Selected Writings*, 23–35. University of Chicago Press.

———. 1950. "The Triad." In *The Sociology of Georg Simmel*, 145–69. Simon and Schuster.

Skjelsbaek, Kjell. 1972. "Peace and the Structure of the International Organization Network." *Journal of Peace Research* 9 (4): 315–30. https://doi.org/10.1177/002234337200900403.

Smith, David A., and Michael F. Timberlake. 2001. "World City Networks and Hierarchies, 1977-1997: An Empirical Analysis of Global Air Travel Links." *American Behavioral Scientist* 44 (10): 1656–78. https://doi.org/10.1177/00027640121958104.

Smith, David A., and Douglas R. White. 1992. "Structure and Dynamics of the Global Economy: Network Analysis of International Trade 1965-1980." *Social Forces* 70 (4): 857–93. https://doi.org/10.2307/2580193.

Snijders, Tom A. B., Gerhard G. van de Bunt, and Christian E. G. Steglich. 2010. "Introduction to Stochastic Actor-Based Models for Network Dynamics." *Social Networks* 32 (1): 44–60. https://doi.org/10.1016/j.socnet.2009.02.004.

Snyder, David, and Edward L. Kick. 1979. "Structural Position in the World System and Economic Growth, 1955-1970: A Multiple-Network Analysis of Transnational Interactions." *American Journal of Sociology* 84 (5): 1096–1126. https://doi.org/10.1086/226902.

Spindel, Jennifer. 2018. "Beyond Military Power: The Symbolic Politics of Conventional Weapons Transfers." Ph.D. dissertation, University of Minnesota.

Staniland, Paul. 2012. "Organizing Insurgency: Networks, Resources, and Rebellion in South Asia." *International Security* 37 (1): 142–77. https://doi.org/10.1162/ISEC_a_00091.

———. 2014. *Networks of Rebellion: Explaining Insurgent Cohesion and Collapse*. 1 edition. Ithaca: Cornell University Press.

Szwarcberg, Mariela Laura. 2015. *Mobilizing Poor Voters: Machine Politics, Clientelism, and Social Networks in Argentina*. Cambridge, UK: Cambridge University Press.

Thurner, Paul W., Christian S. Schmid, Skyler J. Cranmer, and Göran Kauermann. 2019. "Network Interdependencies and the Evolution of the International Arms

Trade." *Journal of Conflict Resolution* 63 (7): 1736–64. https://doi.org/10.1177/0022002718801965.
Torfason, Magnus Thor, and Paul Ingram. 2010. "The Global Rise of Democracy: A Network Account." *American Sociological Review* 75 (3): 355–77. https://doi.org/10.1177/0003122410372230.
Travers, Jeffrey, and Stanley Milgram. 1969. "An Experimental Study of the Small World Problem." *Sociometry* 32 (4): 425–43. https://doi.org/10.2307/2786545.
Urry, John. 2004. "Small Worlds and the New 'Social Physics'." *Global Networks* 4 (2): 109–30. https://doi.org/10.1111/j.1471-0374.2004.00083.x.
Van Rossem, Ronan. 1996. "The World System Paradigm as General Theory of Development: A Cross-National Test." *American Sociological Review* 61 (3): 508–27. https://doi.org/10.2307/2096362.
Victor, Jennifer Nicoll, Alexander H. Montgomery, and Mark Lubell. 2017a. "Introduction." In *The Oxford Handbook of Political Networks*, edited by Jennifer Nicoll Victor, Alexander H. Montgomery, and Mark Lubell. Vol. 1. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190228217.013.1.
———. 2017b. *The Oxford Handbook of Political Networks*. Oxford University Press.
Ward, Hugh. 2006. "International Linkages and Environmental Sustainability: The Effectiveness of the Regime Network." *Journal of Peace Research* 43 (2): 149–66. https://doi.org/10.1177/0022343306061545.
Ward, Michael D., John S. Ahlquist, and Arturas Rozenas. 2013. "Gravity's Rainbow: A Dynamic Latent Space Model for the World Trade Network." *Network Science* 1 (1): 95–118. https://doi.org/10.1017/nws.2013.1.
Wasserman, Stanley, and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications*. Cambridge, UK: Cambridge University Press.
Watts, Duncan J. 1999. *Small Worlds: The Dynamics of Networks between Order and Randomness*. Princeton, NJ: Princeton University Press.
———. 2003. *Six Degrees: The Science of a Connected Age*. New York, NY: Norton.
Watts, Duncan J., and Steven H. Strogatz. 1998. "Collective Dynamics of 'Small-World' Networks." *Nature* 393 (6684): 440–42. https://doi.org/10.1038/30918.
Wendt, Alexander. 1999. "Social Theory of International Politics." In *Social Theory of International Politics*, 22–44. Cambridge Studies in International Relations. Cambridge, UK: Cambridge University Press.
Willardson, Spencer. 2013. "Under the Influence of Arms: The Foreign Policy Causes and Consequences of Arms Transfers." PhD Thesis, University of Iowa. http://ir.uiowa.edu/etd/2660.
Wood, Elisabeth Jean. 2008. "The Social Processes of Civil War: The Wartime Transformation of Social Networks." *Annual Review of Political Science* 11 (1): 539–61. https://doi.org/10.1146/annurev.polisci.8.082103.104832.