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Networks of Conflict and Cooperation

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Abstract

Conflict and cooperation do not result from isolated individual actions. In settings such as insurgency, interstate conflict, protest mobilization, and informal governance, actors are highly interdependent. The study of networks aims to identify what the relevant interdependencies are and, crucially, how they shape conflict and cooperation outcomes. Although this is a relatively new research area, its early results convincingly establish that networks matter. Social networks provide information, transmit peer pressure, and structure interactions in ways that help groups overcome social dilemmas. With much research documenting the importance of particular outcomes in particular areas, the next major step will be putting the pieces together. Which connections between actors matter in which circumstances and how? The groundwork has been well laid for this large future research endeavor.

INTRODUCTION

Conflict and cooperation are not the results of isolated individual actions. Recruits to an armed insurgency pay attention to the actions of other potential recruits. War between two states depends in part on formal alliances and trade relationships to third party states. Protesters come together when they know where to go and why, when they expect enough others to join them, and, in at least some cases, when they expect their peers to judge them favorably for doing so. Whole communities can live peacefully when they know that group members are committed to sanctioning misbehavior that they hear about.

The study of networks in the domains of conflict and cooperation attempts to identify what the relevant interdependencies among key actors are and how they operate. The approach begins by establishing what counts as a relevant connection between actors. Does the protest behavior of one affect another because they are friends? Good friends? People who met once? Does a state account for another state in its international dealings because they trade a little? Trade a lot? Are formal allies? Once the researcher has made these choices, the full web of actors and their relevant connections, known as links or ties, comprise a network.

Research in this area aims to demonstrate that the network under examination is in fact relevant to conflict or cooperation outcomes, determine what exactly the links in the network are doing to bear on these outcomes, and establish how the arrangement of links—the network structure—matters. None of these aims is easy to accomplish. Theory quickly approaches intractability; experiments would ideally manipulate whole real-world networks, which is logistically challenging and ethically problematic; and empirical work faces onerous data requirements, with no help from the law of large numbers since observations are by definition dependent.

Despite these challenges, the body of research on networks of conflict and cooperation is substantial and growing rapidly. For the specific outcomes reviewed in this article, the first-order question of whether the network matters has been answered with a resounding yes. Interdependencies among actors are relevant to conflict and cooperation, and ignoring them would leave our understanding incomplete. The next step is establishing the mechanisms by which the network matters and how the arrangement of connections within the network matters. Research has just begun to scratch the surface of these issues, but results so far are promising.

This article reviews research pertaining to four broad conflict or cooperation outcomes. I begin with cooperative outcomes, since some conflict literature treats engaging in conflict as a problem of cooperation among participants. The first outcome is overcoming collective action problems, with a focus on protests. This literature has exploded in recent years thanks to the availability of online social media data. I detail the key results from both theory and empirical work and discuss issues with online network data sources.

The second outcome can be broadly characterized as informal governance. It includes the promotion of peaceful behavior, norm compliance, and public goods provision within communities. This literature relies heavily on the information-transmission role of networks and on group sanctioning mechanisms, so I consider these topics in turn.

The third and fourth outcomes focus specifically on violence. The third reviews the various ways that social networks are thought to matter for intrastate conflict, from recruitment to battle tactics to settlements. The fourth focuses on interstate conflict and the ways that networks among states relate to war.

Of course, any review with a page limit is bound to be incomplete. These four outcomes do not exhaust the study of networks of conflict and cooperation. Rich literatures on cooperation among politicians (Montgomery & Nyhan 2017), between politicians and constituents (Cruz et al. 2017), among strategic actors plotting corruption (Ferrali 2020), across bureaucratic units (Berardo & Scholz 2010), as well as the literature on conflict that spills over from place to place (Metternich

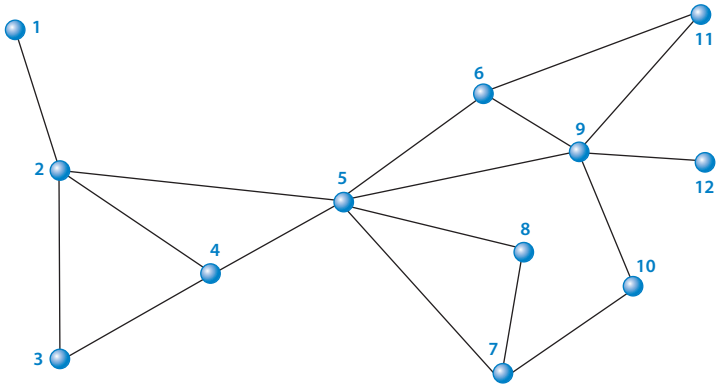

Figure 1

Example network with 12 nodes. The nodes and links could represent, for example, people and friendship, or people and shared club membership, or states and bilateral treaties. There are links between 17 pairs of the 12 actors in this network.

et al. 2017), are just a few that are omitted. I selected the four topics that are included because research on them is particularly active, they highlight a variety of methodologies for studying networks, they feature the key mechanisms thought to underlie the relationship between networks and cooperation in general, and they offer ample opportunities for high-impact future research. For each of the four outcomes, I point out some of the most pressing questions moving forward.

FOUNDATIONS OF NETWORKS RESEARCH

All of the literature reviewed here accounts for relationships between units and so makes use of networks as conceptual tools. A network is defined by a set of nodes (which units are of interest) and a set of links, also called ties (which units are connected to which other units). Much of this literature explores the consequences of different network features, such as how links are distributed across nodes or how links are arranged. While a primer on network features is beyond the scope of this article, I provide brief definitions of the key features in the glossary where they are relevant. The definitions refer to the example network shown in **Figure 1**.

All the research reviewed below makes the point that the outcomes of conflict and cooperation can be better understood by considering not only sets of actors but also the ways that the actors are connected to one another. Studying the nodes without the links misses an important part of the explanation for why the nodes may erupt into conflict or come together and coexist peacefully. These works make use of research methodology tailored specifically to studying networks. For an overview of empirical networks research in political science, see Victor et al. (2017). For more on empirical research design in this area, see Larson et al. (2020). For a thorough introduction to network structural features, see Jackson (2010, ch. 2).

NETWORKS AND COLLECTIVE ACTION

Social movements such as protests can be thought of as acts of cooperation. They occur when a sufficiently large number of people cooperate by showing up, undertaking the costs and potential risks of doing so instead of free-riding off the efforts of others. Sociologists have argued for decades that social networks are key to this process (McAdam 2003). People's willingness to participate may be a function of their links in a network. Social ties can transmit information, directly (such

as where the protest will be held) or indirectly (such as an impression of the number of others likely to attend), and can facilitate social pressure to reward participants and shame shirkers.

Seminal studies of collective action establish proof of concept: Networks indeed were relevant to real social movements. Recruitment to an insurgency in the Paris commune in 1871 relied on preexisting social networks (Gould 1991), people invited to participate in the 1964 Mississippi Freedom Summer project were more likely to accept if they had a friend who was also invited (McAdam 1986), and demonstrators in East Germany before the fall of the Berlin Wall had social connections to other demonstrators (Opp & Gern 1993).

Moving beyond proof of concept had to await the era of social media. Digging deeper into how networks matter for social movements requires rich data on the structure of networks. This entails a record of who participated as well as a detailed mapping of who is socially connected to whom. These data are not easy to acquire. In offline spaces, social movements rarely have participation rosters; even when they do, they even more rarely involve records of which participants were socially related to which others. Retrospective surveys can ask respondents about both participation and relationships at the time of the protest, but this method requires keen memories and is subject to bias.

While the social sciences waited for a data solution, theoretical models filled in some details about how we should expect networks to matter for social movements. Modeling the spread of information or motivation as a diffusion process and varying assumptions about how each person in the network becomes activated to join a movement, we gather the overwhelming takeaway: It's complicated. Whether more links, or individuals with more links, or links that are stronger make protest more likely depends heavily on other factors, including context and assumptions about when exactly a person is sufficiently motivated (Gould 1993, Marwell et al. 1988, Siegel 2009, Watts 2002). We do learn that when motivation to participate can be described by a complex contagion process, meaning that endorsement by multiple peers increases the likelihood of "catching" motivation, the presence of weak ties can impede protests (Centola & Macy 2007). The greater the level of clustering, the less likely a widespread protest will take off (for a review of the complex contagion literature, see Guilbeault et al. 2018). In contrast, we learn from the game theoretic model of Chwe (2000) that small, tight-knit subgroups within a network can cascade into a protest if they take cues from one another. Small groups of highly motivated participants can convince larger groups of slightly more hesitant participants, who can convince larger groups of even more hesitant participants, to turn out, producing a large protest.

Taken as a whole, these theories provide a stylized view of how networks might affect protests. A person's network ties (her network neighbors) matter because they serve as her sources of information about the protest and provide others with information about her. This information might be logistical details, insight into others' grievances, news that shapes the expected costs of participating, or the participation plans of others. Different people may be differently hesitant to protest for a variety of reasons (fear, apathy, lack of grievances, etc.). Distilling these reasons into a single value, we can say that a person's individual threshold for protesting is met if she believes that enough others are planning to protest. Since different people can reasonably have different thresholds, how individuals are distributed throughout a given network also matters. If high-threshold (highly hesitant) people are surrounded by only other high-threshold people, all will likely stay home. Whether low-threshold people motivate high-threshold people depends on whether the high-threshold people are linked to them.

Clustering: The extent to which nodes who have a neighbor in common are themselves linked, completing triangles in the network. In **Figure 1**, nodes 3 and 4 share common neighbor 2, and they are also linked to one another, creating a triangle. Clustering is calculated by taking the ratio of pairs of neighbors who are linked to the total number of pairs of neighbors in the network, here 15/44, or 0.34

Network neighbors: All nodes to which a node is directly linked in the network. In **Figure 1**, the neighbors of node 10 are 7 and 9

The Era of Social Media

Social media provide a vast new data source with network detail sufficiently fine grained to test some of these theories. Many modern protests are organized using online platforms in a way that

generates public data (Zeitzoff 2017). These data sources permit large-scale studies of any one protest, as well as comparisons across protests, for the first time. For instance, Steinert-Threlkeld et al. (2015) collect 14 million tweets sent during the Arab Spring by Twitter users in 16 countries, calculate a measure of how coordinated messages on Twitter are (by calculating the Gini coefficient of the number of hashtags used), compare the timing of this coordination to the timing of protests, and find a robust statistical relationship between yesterday's level of coordination and today's number of protests within each country. Since activity in online social media strongly coincides with activity in protests, using these media to study networks in protests was the sensible next step, bolstered by findings that social ties online are informative of social ties offline (Bisbee & Larson 2017).

Research using online social media data to study networks in protests has produced three main findings. First, those who participate in protests are in fact connected to other participants in their social networks. Using data from the protest following the 2015 *Charlie Hebdo* shooting and a technique that compared protesters (identified by geolocated tweets sent from the protest site) to similar nonprotesters (identified by a geolocated tweet sent sufficiently far from the protest site during the protest), Larson et al. (2019) show that protesters were substantially more connected to one another in terms of direct ties, indirect ties, reciprocated friendships, and clusters of friends than nonprotesters. This evidence is consistent with the motivation to attend spreading through the network.

Second, individuals in peripheral network positions (relatively low connectivity) actually have a large impact on whether a protest occurs. Their numbers are large enough that even if they do little, collectively they amplify messages widely enough to make them important to social movements (Barberá et al. 2015), and their participation may more credibly signal to others on the periphery that enough people plan to turn out to be motivating (Steinert-Threlkeld 2017).

Third, the structure of online networks is such that certain positions are better able to send information quickly to many others. In the follower network on Twitter, those who have more followers are in fact more influential in the reach of information (González-Bailón et al. 2011). Some also occupy bridge and bottleneck positions that afford the opportunity to share information spreading in one group with another group, though occupants of these positions do not make use of them very often (González-Bailón & Wang 2016).

Looking ahead, an exciting research agenda awaits. Protests are not all alike. Do different protests use networks differently to mobilize? Does this vary by the perception of risk or topic area? Do different uses of networks affect the success of protests? It also appears that there are many different mechanisms by which networks may facilitate protests. Do they all operate in every case, or are some more prevalent in some circumstances? Research that directly studies mechanisms at a large scale are rare (for an exception, see McClendon 2014). Furthermore, how will the network processes of future protests interact with the strategic attempts of outside actors who prefer to thwart protests? After all, whether repression works to suppress collective action depends on network structure (Siegel 2011), and leaders have a suite of tools at their disposal to disrupt networks, including the option to shut down the online network using internet blackouts (Gohdes 2015).

Peripheral: A node is relatively peripheral if it has few ties compared to the rest; some authors add the stipulation that it have low centrality. Nodes 1 and 12 would be considered peripheral in **Figure 1**

Bridge: A link that connects two otherwise separate communities. In **Figure 1**, the links between 1 and 2 and between 9 and 12 are bridges, since 1 and 12 would be separated from the community without them, though some authors do not count as bridges links whose absence would only separate a single node from the rest

Bottleneck: A node that connects two otherwise disjointed communities. Node 5 is a bottleneck in **Figure 1**

Future Issues: Collective Action

1. Which network mechanisms work for which kinds of protests? For instance, is the esteem of peers only relevant to protests that are expected to be nonviolent? Is logistical information ever sufficient?

2. How will protests evolve in response to increasing counterprotest information and tactics, especially on social media? Will networks begin to play a new role? Will these be visible in online data sources?

Density: The ratio of the total number of links present to the maximum that could be present given the number of nodes. The density of the network in **Figure 1** is $\frac{17}{66} = 0.26$

NETWORKS AND INFORMAL GOVERNANCE

Groups are often left to their own devices to govern themselves. This can be literally the case in weak states, and figuratively the case in instances of norms or cooperative behavior outside the scope of the law. Theory tends to approach informal governance by zeroing in on how groups can cooperate by jointly contributing to a public good (Bramoullé & Kranton 2007, Wolitzky 2013) or by getting along with one another (modeled as avoiding defection in the Prisoner's Dilemma; see Larson 2017a,c).

The study of cooperation among strategic, networked actors has its roots in game theoretic models of community enforcement (Kandori 1992). These asked: How can people be incentivized to behave appropriately when they interact with lots of different people, but no one person has the authority to keep order in any official way?

Early work quickly noted that decentralized schemes to keep one another behaving well would succeed only if people knew enough about how the others were behaving (Dixit 2003, Greif 1993, Lippert & Spagnolo 2011, Nava & Piccione 2014). In the extreme, if no one finds out that someone misbehaved, no one can do anything about it. People who expect no one to be able to do anything about their bad behavior misbehave. A key mechanism that this body of theory points to is information transmission—how people get information from one another, including about how people have behaved—which naturally lends itself to thinking in terms of networks.

If people in a group are part of a network where the ties serve as channels of information from one person to another, then the network can function to spread the word about people's behavior. Specifically, a network tie between two players provides each with information that the other has, and this information can inform the strategic decisions that facilitate cooperation. Most often, this information is about who did what in the past, which opens the possibility of punishing those who behaved uncooperatively. Networks then determine whether and how many people are informed when someone behaves badly.

For instance, Larson (2017c) considers a game theoretic model in which community members run into one another in daily life and any pair's interaction takes the form of a Prisoner's Dilemma. One person could injure or cheat the other for short-term gain, but the group would be better off if no one ever did so. The setting posited by Larson (2017c) is a weak state (and explores the case of frontier mining towns in 1850s United States), so centralized monitors or enforcers are unavailable. The community can enforce good behavior if people gossip about misbehavior in their social networks. When someone is wronged, she tells her network neighbors, who tell theirs, who tell theirs and so on, ideally until the number of people in the know is large enough to inflict a serious punishment. When the network of who gossips with whom is structured so that news of misbehavior spreads to a large number of others quickly, everyone expects to be punished by a sufficiently large number of other community members that they are deterred from misbehaving in the first place. Hence, networks that spread information about anyone else widely and quickly can enforce cooperation within a group.

This basic logic suggests that how links are arranged in a network affects how well groups can enforce cooperation because the arrangement of links affects who learns what when people share information. It may seem that networks with numerous links—those with high density—would be best, but in fact the arrangement of the links that are present can matter more. The

distribution of links matters because people in relatively isolated, peripheral positions have limited access to information, and information they send does not reach many people. The presence of such positions can result in the people occupying them misbehaving (Larson 2017a), or in the rest of the network effectively bullying them (Larson 2017c). This logic also suggests that bottlenecks in the network—positions that are essential to information in one region reaching another—can set up incentives for misbehavior (Larson 2017a) and lying without consequence (Lippert & Spagnolo 2011). The networks that best support cooperation have many links arranged so that no one person has too few (Larson 2017a).

Fragmented: A fragmented network has separate components. The network in **Figure 1** is not fragmented

This line of theory relies on two empirically testable assumptions. First, individuals are arranged into social networks that are at least sometimes used to spread word-of-mouth information. Second, individuals sometimes act on information they hear to sanction someone's misbehavior. This line of theory also produces a testable implication: Groups with certain network structures are expected to experience worse outcomes when trying to self-govern. Networks that have few links overall, that contain peripheral positions for some, and that are fragmented into distinct groups would be worse for enforcing cooperation. None of these three empirical propositions is easy to test, but the next sections review what a growing literature can say so far.

The Informational Role of Networks

Early studies of information spread through social networks largely relied on indirect methods of inferring that communication occurred along social ties. For instance, Duflo & Saez (2003) use an experiment that randomized invitations to a retirement plan fair and find indirect evidence that individuals within university departments talk with one another about retirement savings and upcoming events. Conley & Udry (2010) measure some social network ties among pineapple farmers in Ghana, and through a careful statistical analysis of planting behavior, the authors infer that farmers share information with one another about new technology.

Taking a more direct approach, Mobius et al. (2015) created an artificial opportunity for university students to reveal information seeking in their real networks (for a review of social learning, see Mobius & Rosenblat 2014). The authors created a treasure hunt game that entailed entering guesses to three cute questions about treasure. Each question had two possible answers, of which one answer was correct. Participants entered guesses in an online platform. Crucially, all participants were given initial suggested answers to the questions and were told that the majority of people received correct suggested answers. Respondents were asked to record whom they talked to about answers in the online portal, generating a record of who talked to whom. The researchers also had social network data against which they could compare names. The researchers find that although participants did reach out to their friends for information, they more often reached out to strangers. This finding warrants careful consideration, because it could be taken to imply that social networks are not particularly important sources of information—not if people are even more likely to try to learn things from strangers.

The exact setting of Mobius et al. (2015) is important for interpreting the results. The environment is an artificial one in which everyone knows that a stranger's information is just as valuable as a friend's. Friendship makes it no more likely that the organizers gave someone the correct suggested answers. Within the parameters of the game, that information matters only to help players make correct guesses. This setting should considerably drive down the value of friends as an information source. More realistic settings involve a lack of common knowledge that friends and nonfriends have equal access to the truth, the possibility of lying, a desire to vet information with someone trusted, risk in communicating about a topic, and so on, any of which would increase the value of a friend as a source of information.

Studies of less artificial settings indeed find that people rely heavily on their social ties for information when some of these features are at play (Banerjee et al. 2013), and people do privilege social contacts over strangers as sources. Larson & Lewis (2017) combine a mapping of network structure with a direct view of information transmission. The study seeded new information in two Ugandan villages that were similar on all observable dimensions except for ethnic composition—one was ethnically homogeneous, the other was more diverse. A few randomly chosen people in each village were told that in three days, an event would be held at which valuable blocks of soap would be given out in exchange for taking a survey. Through surveys at the event and after, the research team mapped the villages' social networks and tracked if and how villagers learned the information. Villagers who learned the information did so primarily through their social network and exclusively in person. Large differences in the reach of information across the two villages also corroborate the importance of network structure and the quality of ties for information transmission, discussed below.

Why would social contacts be sources of information that are preferred to those more socially distant? Why would friends be better sources than strangers, or even mere acquaintances? "Information" can mean many different things and is exchanged in a variety of circumstances. Some may be sterile fact-finding missions like that of Mobius et al. (2015). In others, senders may have incentives to withhold or misrepresent information, and receivers may distrust information or be endangered by learning it. In contexts with these features, not only may a social relationship lay the groundwork for a preferred information source, but some types of social relationships may be preferred to others. And of course, if information spreads because of incidental encounters (Minozzi et al. 2020), and these are more likely among friends, friends may again be responsible for a higher volume of information transmission.

Consider the setting of Ferrali et al. (2020), in which Ugandan villagers can adopt a new political communications technology to report on service delivery. Because any villager who adopts the technology would find it more valuable if others did as well (so that more of them can report in and improve service provision), a positive review from a stranger may be met with suspicion. Social ties, and in particular trusted ones, can more credibly communicate a positive review. Careful network maps and adoption behavior from 16 villages support the finding that when benefits are uncertain and a technology has positive externalities, friends can convince friends to adopt it if they trust one another. This study highlights the value of characterizing information in terms of how certain its benefits are and whether knowing it generates externalities. Viewed in these terms, Larson & Lewis (2020) find that when benefits are uncertain, no positive externalities are present, and information entails social risk, not all social ties transmit information equally. More studies of more contexts and information types will be helpful for filling out our understanding of the network process at play across the board.

These empirical findings are consistent with a literature pointing out that ties may vary in meaningful ways, including their strength (Granovetter 1973). Although Granovetter (1973) is primarily interested in the advantages of weak ties—those characterized by lower frequency of interaction and less intimacy—which stem from access to different information than one could access from strong ties, this work also points out that weak ties may transmit a reduced volume of information. For demand-driven processes of information acquisition, this means that too many weak ties may reduce a person's access to novelty overall (Aral & Van Alstyne 2011). For supply-driven processes of information sharing, weak ties may crowd out the use of strong ties (Larson 2017b). For both demand-driven and supply-driven cases, some ties are worse at spreading information [or, in the language of Aral & Van Alstyne (2011), have "lower bandwidth"] because of lower trust, infrequent encounters, less mutual intelligibility, and the like.

Ties that spread less information or that spread information less well can dramatically limit the speed and extent of the spread of information through a network. The agent-based model of Larson & Lewis (2017) shows that some social ties may have transmitted information relatively poorly in the Ugandan villages under study. If villagers were more hesitant to share information about the upcoming event with noncoethnics, making social ties between noncoethnics less likely to transmit information from an informed villager to a noncoethnic he or she encountered, then the presence of many cross-ethnic ties would substantially diminish the reach of information in the network. Indeed, information spread much more poorly in the diverse village than the homogeneous one. Perhaps not all social ties operate equally effectively at transmitting every piece of information.

If that is the case, the next large research agenda is pinning down which social ties transmit which kinds of information and when. Understanding the role of ties that span different identity groups falls under this agenda, with much ground left to be covered. When do networks of social interactions span identity groups? Where networks of social interactions do include cross-group ties, when does information flow freely along these ties? Given research showing that trust of in-group members tends to be higher than trust of out-group members (Robinson 2016), can any cross-group ties function as effectively as within-group ties for the spread of information? Is trust a qualitative feature of a tie that can be measured separately and that moderates its effectiveness at spreading information? What kinds of information spread incidentally, such that the type and quality of the tie are irrelevant?

Finally, the importance of networks for spreading information and fact that social ties can serve as trusted sources of information raise questions about the problem of misinformation. Does giving social contacts the benefit of the doubt mean that people will be more gullible when a social contact shares misinformation? Would certain network structures be more susceptible to buying into and widely spreading falsehoods? Most work in this area that has focused on the structure of networks has been theoretical, aimed at determining the optimal information campaign to counter misinformation, and largely finds that making this determination is exceedingly difficult (Budak et al. 2011, Tong et al. 2018). Recent empirical research has focused on misinformation campaigns in online social media, a domain where the prevalence of fake news is high (Lazer et al. 2018, Tucker et al. 2018). One study suggests that people are not seeing misinformation shared by friends at a very high rate on Facebook, at least not during the 2016 US presidential election (Guess et al. 2019). Experimental evidence suggests that people share fake news largely out of haste (Pennycook et al. 2020) and believe it largely out of a lack of deliberation (Bago et al. 2020). The questions remain: Are some network ties more conducive to hasty sharing? Are some network structures more susceptible to false information? And can strong ties be successfully used to actively vet information heard from third parties?

Using Social Networks to Sanction

The question of whether groups sanction misbehavior in response to information learned through their social networks is much more difficult to verify empirically. Operationalizing peer sanctioning is more challenging. Sanctioning can be subtle, down to a glance that conveys disapproval. Moreover, if a group is successfully applying social sanctioning to enforce cooperation, no instances of sanctioning should ever be observed; the threat that it *would* be used keeps everyone cooperating, and in equilibrium, no action is needed. Consequently, research verifying the second empirical assumption is scarcer.

One approach experimentally manipulates the perception that future sanctioning is possible. For instance, Gerber et al. (2008) use an experiment that randomized the content of mailings to registered US voters, with some promising to publicize their turnout to their households or

neighbors. Doing so would make it possible for household members or neighbors to sanction someone who did not vote. This possibility substantially increased turnout, suggesting that people do expect sanctioning from peers in their network.

Eubank & Kronick (2019) take a different approach to evaluating whether sanctioning drives behavior. The authors generate a social network of cellphone subscribers in Venezuela by using data on who calls whom. Since theories of how sanctioning enforces cooperation on a network imply that some network positions are more susceptible to peer sanction than others, the authors back out a measure of this susceptibility for every user. Comparing this measure with information on protest participation and petition signing, Eubank & Kronick (2019) show that indeed those who occupy network positions that are most susceptible to sanctioning are in fact more likely to cooperate (here, join the protest or sign the petition). Hence, expectations of peer sanctioning may have driven cooperative behavior.

Atwell & Nathan (2021) take yet another approach to empirically studying the network mechanisms leading to cooperation. In a field experiment in five communities in Ghana, participants played an anonymous public goods game. Individuals randomized to the control condition were asked for their contribution immediately. Treated individuals were asked for their contribution after a lag of 1–2 days, affording them the opportunity to communicate with one another (but without the possibility of sanctioning, since the players were anonymous). It would be during this time that fellow community members or leaders could in principle pressure others to contribute, and indeed the authors document instances of participants trying to convince others to contribute more in this interval. However, interestingly, these attempts were unsuccessful: The lag for communication did not increase contributions. Given the opportunity, people tried to talk one another into higher contributions, but without the ability to follow through with sanctioning undercontributors, this opportunity was ineffective. One interpretation of this set of results is that community members reached for their peer sanctioning strategy (saying things to try to make others increase their contributions), but since everyone knew that punishment was impossible, it was ineffective.

The headline result of Atwell & Nathan (2021) is that although participants in the public goods game were unable to sanction, and the opportunity to talk did not increase contributions, social network position was nonetheless strongly related to contributions. Individuals occupying more eigenvector central positions in their community's social network were much more generous in their contributions. Network position may relate to behavior even when the network does not operate to drive the behavior in any one instance. This finding is consistent with other work that suggests that networks may form in a way that favors connections between people who are inclined to behave cooperatively (Apicella et al. 2012) or who have more connections (Frey et al. 2019), perhaps as a result of strategic network formation at some point (Jackson & Wolinsky 1996, Raub et al. 2013).

This observation raises an important additional complication for the study of the network mechanisms driving cooperation. Any proposed mechanism may actively operate only some of the time, with the behavior carrying over into other times due to habit or heuristic. When a study finds that the mechanism is absent in one instance, is that evidence that the mechanism never operates? Careful theory should pin down not only what a mechanism might be, but also, ideally, when it would be observed to operate. Without this guidance from theory, tests of sometimes-present mechanisms may never falsify hypotheses.

Relationship Between Network Structure and Cooperation

The testable implication of theories of cooperation is not only that communities use networks to enforce cooperation through threat of sanctioning, but that how network ties are arranged

Eigenvector centrality: A measure of the importance of a node that increases in proportion to how many links it has as well as how many links its neighbors have. In **Figure 1**, node 5 has the highest eigenvector centrality, followed by node 9; node 1 has the lowest

relates to how successfully groups can accomplish this. Empirical tests of the latter require large amounts of rich network data that are costly to acquire. For network-level structural features, one community's network counts as a single observation, and small samples of nodes tend to be inadequate to reproduce all of any one network's features (for an inexpensive workaround that reproduces some features well, see Breza et al. 2020).

Degree: The number of neighbors a node has in the network. In **Figure 1**, the degree of node 6 is 3

Data limitations are less onerous for structural features at the level of the node. In a study of community organizations of Ugandan coffee producers, Baldassarri (2015) shows that greater centrality (in terms of degree, betweenness, and eigenvector) is associated with more cooperative behavior, here defined as the extent to which members sell their coffee through the organization and participate in the operations of the organization. The network analysis is complemented by a suite of lab-in-the-field games that suggest that reciprocity through repeated interactions is the most plausible mechanism, ruling out that the more central are simply more other-regarding or altruistic.

Another line of literature indirectly studies the network structural feature of fragmentation. Beginning with the observation that ethnic diversity in the developing world is positively associated with low levels of public goods provision (Miguel & Gugerty 2005), this line of research looks for evidence of network fragmentation with proxies such as measures of ethnic diversity or ethnic segregation in diverse areas (Kasara 2013). Ethnic groups are thought to have networks among coethnics that can spread information quickly and be used to find one another easily (Habyarimana et al. 2009). An inference commonly made in this literature is that since coethnics reasonably would have more ties to one another than to noncoethnics, the presence of multiple ethnic groups in a single area probably indicates a fragmented network (Fearon & Laitin 1996, Miguel & Gugerty 2005).

To the extent that empirical research has been designed to directly test whether ethnic heterogeneity in fact does relate to network fragmentation, results are mixed. Larson & Lewis's (2017) comparison of two villages finds that the social network in the ethnically diverse village is not at all fragmented, with many noncoethnics reporting spending time with one another, sharing meals with one another, and so on. However, that village's network functions as if it is fragmented, spreading new, sensitive information much more poorly than the homogeneous village's network. Larson & Lewis (2018) find that in areas with high ethnic diversity, highly sensitive information—in their study, information about new rebel groups operating nearby—spread separately in separate subcommunities and produced conflicting information. There again, at least for the spread of sensitive information that one probably prefers to pass along only to a trusted contact, networks functioned as if they were fragmented.

This once again raises the issue that whether a network is fragmented depends on which network we are talking about (and empirically, which network we have measured). The network that describes casual contact and incidental information spread may be very unfragmented in a diverse area (Larson & Lewis 2017); the network that would pass along information that could get you killed if it got into the wrong hands might nonetheless be fragmented. Only certain ties may be in operation to spread this kind of information. Knowing which links matter must come before attempts to describe a network's shape. For this reason, the field of empirical network analysis is wide open. Researchers have only scratched the surface of the daunting task of sorting out which ties get used to spread what and when.

Future Issues: Informal Governance

1. Which network ties successfully transmit information in different contexts and for different types of information?

2. How does peer pressure to behave cooperatively work on a network? When should we expect to observe sanctioning? When should we expect that the effect of a network is no longer active, but is simply baked in as habitual behavior?
3. Can policy interventions alter the structure of real social networks in ways that durably improve cooperation?

NETWORKS AND INTRASTATE CONFLICT

The study of intrastate conflict has identified many ways that networks relate to conflict outcomes. The way fighting groups are organized internally, the way multiple challengers interact with one another, and the networks of civilian groups from which fighting groups recruit all appear to shape the likelihood and duration of conflict.

Networks Within and Among Fighting Groups

Studies of networks within fighting groups aim to unpack the black box of a government challenger. Although thinking of a civil war in terms of a unitary challenger to a state is convenient, in reality, subnational conflict is messy. Focusing on the networks that organize challengers is one way to systematically account for some of the internal workings of a challenging organization.

First and foremost, exactly how poorly the unitary actor assumption describes a challenger bears on how well the challenger can organize its fighting and successfully bargain in crisis. The more fragmented the group, the more likely it is to experience civil war onset (Cunningham 2013). The extent to which the challenger is fragmented, and the precise way that different challengers relate to one another, can affect how well the different challenging units are able to work together. Just as some networks create difficulties incentivizing the provision of public goods (Bramoullé & Kranton 2007), some networks of government challengers create difficulties incentivizing the joint exertion of effort in taking on the government. Metternich et al. (2013) conceptualize a network among challengers where ties indicate closeness in social space, which means recruitment and support bases are similar. Actors who are too close in this space may prefer to free-ride off of one another, since the gains of one's effort will likely benefit the other. Actors more distantly related in this space have a greater incentive to individually contribute regardless of the effort of others, since gains made by one would not be as beneficial to the other.

That challenges can be messy also affects how conflict unfolds. In a push to move beyond a conflict dyad approach—an effort also addressed below as it pertains to interstate conflict—Dorff et al. (2020) show that a dynamic fighting network where nodes are armed groups and links are battles at a particular time helps to reveal how violence progresses. How two actors fight may depend on whether one fought some third party in the past, or whether a third party will enter in the future. A key takeaway from this work is just how much one will misunderstand by focusing only on the onset or volume of conflict within a civil war. Complexity in government challenges deserves a careful look.

Naidu et al. (2017) consider government challengers of a different form, prospective coup participants. Drawing on the logic of collective action on networks, here elites are connected to other elites in a network, and elite levels of effort in a coup are strategic complements within the network. One elite's participation makes a network neighbor's participation more valuable, and successful coups generate rents for the participants. These assumptions imply that elites who are more central are more likely to participate. This appears to have been the case for Haitian elites participating in the 1991 coup; more central families in the family network were more likely to participate, and those that did got richer.

To the extent that network data on insurgent groups and coups are hard to come by, the data limitations plaguing the study of terrorist groups are all the more severe. Theoretical work suggests that the arrangement of links in an organization's structure—how individuals receive information from others and how branches interact with other branches—affects its resilience to attack by an adversary (Dodds et al. 2003, Enders & Jindapon 2010, Goyal & Vigier 2014). Theory also suggests that organizational structure is likely dynamic and responds to countermeasures in order to maximize its chance of survival (Enders & Su 2007, Kenney et al. 2017). What records there are of joint credit claiming and joint preparations suggest that some terrorist organizations cooperate with other organizations, and those that do tend to be more lethal (Asal & Rethemeyer 2008) and survive longer (Phillips 2014).

Civilian Networks

In a direct analog to recruitment into protest movements, scholars have found evidence of networks playing a role in recruitment into armed groups. Biographical information on thousands of Kurdish militants combined with interviews of relatives of insurgents suggest that social ties to members of an insurgency make a person more likely to join (Tezcur 2015). Armed groups working on recruiting also make use of local networks to glean information that they use to better screen recruits for motivation and quality (Forney 2015).

Civilian networks also matter even when they are not directly tapped for recruitment. In the earliest stages of an armed rebellion, nascent rebel groups are small, fragile groups that will not survive if the government learns too much about them (Lewis 2020). Larson & Lewis (2018) show that civilians living near the location of nascent rebel groups' initial operations are their biggest threat: If these civilians offer information to the government, rebel groups never become viable challengers. Civilians are more likely to keep the rebels' secrets when their trusted social networks are unfragmented with short paths, so that they can quickly coordinate the messages they are hearing and quickly learn about enough other civilians who plan to keep quiet when the government tries to buy information. This research also shows that, at least in Uganda, favorable networks are facilitated by ethnic homogeneity.

At a much later stage in armed rebellion, civilian networks continue to play a role. Examining communist insurgency in the Philippines, Rubin (2020) shows that whether rebels attempt to control territory depends on how well communities in the territory can collectively act, which depends on their networks. In places where the state has a strong presence, provides services, and the communities have networks favorable to collectively acting, rebels refrain from seeking territorial control.

Network ties also appear to be effective at convincing others to participate in the perpetration of violence, even genocide. Using interviews and surveys, McDoom (2014) shows that participation in the violence during Rwanda's 1994 genocide was partly determined by existing social networks. Perpetrators had more network ties, and were themselves a more interconnected group. Being related as kin or neighbors especially strongly predicts participation, perhaps because such ties facilitate social pressure to behave a certain way, even when that way is committing genocidal collective violence. More than just shaping recruitment into the organization, preexisting social networks also appear to shape the character of fighting organizations once they form. Parkinson (2013) shows that in 1980s Lebanon, the role that people take on inside a fighting organization is related to their social networks in day-to-day life before joining.

Lyall (2010) also provides indirect evidence that civilian networks can be weaponized during insurgency. This work focuses on a "sweep," a multi-day armed counterinsurgency operation that involves house-by-house identification checks and restrictions on movement in an area. Insurgent

attacks in Chechnya varied depending on the identity of the military unit that had conducted a sweep previously. When pro-Russian Chechens conducted the sweeps, later attacks originating in the area were 40% fewer than when Russians conducted them. This is consistent with the logic of Habyarimana et al. (2009), who concluded that coethnicity provides an advantage, perhaps here by allowing people to tap into local networks of information in order to perform a more effective sweep.

Weighted degree: The count of links that a node has, where each link's contribution to the total is scaled by its "weight." In **Figure 1**, node 6's (unweighted) degree is 3. If the link between 5 and 6 had a weight of 1.5 while the other two links had weight 1, node 6's weighted degree would be 3.5

Future Issues: Intrastate Conflict

1. Networks within armed groups, networks among armed groups, and networks of nearby civilians all appear to affect intrastate conflict but tend to be studied independently. How do these network forces interact?
2. Networks among actors matter at different stages of rebellion. Do the same network structures that support initial rebel group viability also support success in later recruitment, on the battlefield, and in postconflict negotiations?
3. Networks can be used to coordinate cooperation for peace and apparently also to coordinate cooperation to perpetrate violence. Are the dynamics and relevant ties the same in both, or are there distinguishing features?

NETWORKS AND INTERSTATE CONFLICT

The study of interstate conflict has long accounted for the fact that any one state's likelihood of war depends on at least one other state: its adversary. It takes two to go to war. The study of networks in interstate conflict accounts for other states in addition. Past experience with fighting other states, current conflict with other states, mediation by third parties, and costs incurred from severing relations with third parties all suggest that a networks approach may help explain interstate conflict.

The typical approach to studying interstate conflict in a networks setting takes states as nodes and defines links in terms of a kind of interaction between pairs of states. For instance, links can stand for trade agreements or active trade routes. These studies allow researchers to ask not only whether trade within a pair of countries affects their war propensity, but also whether trade with other states affects two states' war propensity. For instance, Kinne (2012) considers a trade network that counts a link if one state trades with another. The links are directed, indicating the flow of goods, and weighted by the volume of trade as a proportion of GDP. Kinne (2012) shows that states with high weighted degree centrality are substantially less likely to initiate militarized disputes. In other words, states that trade a lot with many states are less aggressive with all states. This is not the familiar claim that states that trade with one another are less likely to go to war with one another. The claim is that one state's network position is related to its aggressiveness, which means that a state's interactions with third party states may matter.

Likewise, Lupu & Traag (2013) show that states can be meaningfully represented as participants of (possibly informal) trading communities, and coparticipation relates to conflict. Specifically, community detection methods reveal sets of states that trade with one another more than with other states, and war between states classified as trading in the same community is very rare. Here, too, the argument refers to third parties. Trade between two states matters in a way that is contingent on the patterns of trade among other states.

Network Structure and International Conflict

Trade is not the only interaction that has been used to define networks among states. Other types of interactions can be represented by links in networks, where the structure of these networks

correlates with conflict. For instance, co-membership in formal organizations is another possible network link that may relate to incentives that drive conflict. States that are indirectly connected in the intergovernmental organization (IGO) network are less likely to go to war with each other, perhaps because third parties in this network can mediate (Dorussen & Ward 2008). States with a similar degree in this network (that have a similar number of states with whom they share IGO membership) are less likely to go to war with one another, although too many states with the same degree may be an unstable situation that leads to conflict (Hafner-Burton & Montgomery 2006). Hafner-Burton & Montgomery explain that these patterns may appear because degree captures something like prestige, and having too many states at the same level of prestige creates pressure to reduce the number in order to maintain prestige among the few that remain. When states consider forming a new bilateral cooperation agreement, the strategic value of any new agreement is affected by the structure of existing agreements (Kinne 2013).

Another approach is more agnostic about the interaction that defines the ties; it focuses on whether the interactions are positive or negative. This line of reasoning assumes that a network can contain links that indicate relationships that are positive or negative—for instance, ties can indicate friendship or enmity (for a review of the literature on negative ties, see Harrigan et al. 2020). Applied to states in the international system, the idea is that states can have some relations that are warm and others that are less so. Negative links are not a problem in themselves; the problem occurs when the distribution of negative and positive relations is imbalanced (for a game-theoretic foundation of structural balance, see Hiller 2017). Imbalance occurs when the logic of "friends of my friends are my friends" and "enemies of my friends are my enemies" is violated. For instance, a state with an enemy to whom an ally is allied would be an instance of imbalance. Maoz et al. (2007) show that across a variety of network types, imbalance in the international system is correlated with conflict.

The study of interstate conflict and networks opens up many big questions for future research. These works and others point to empirically intriguing relationships between network features and conflict outcomes and offer rationales for how the network features could be contributing to the outcomes. Of course, pinning down causes of interstate conflict is exceptionally difficult. Can we be sure that the network is doing the work? The observed patterns are consistent with an affirmative answer. They are also consistent with some other factor that causes the network to look the way it does and conflict between nodes to occur where it does. For instance, maybe states that are highly central in the trade network have many trading partners because of some attribute that also makes them less war prone. Taking a deeper dive into the mechanisms that drive conflict will be important for putting all these pieces together.

This area of research raises questions about how states form relationships in the first place. There is work that considers whether current features of a network drive changes to it over time. For instance, consider a network where any two states are linked if they have a bilateral defense cooperation agreement. Viewed over time, this network changes shape and size, and the way it changes seems to depend on the network at any given time. In particular, the network formation process follows a pattern of preferential attachment, where nodes with many links are more likely to add links in the future (Kinne 2018). This makes sense, since states with numerous agreements have already convinced many other states that they are trustworthy. The network also tends toward triadic closure (that is, if A is linked to both B and C, a link is more likely to form between B and C to complete the triad), perhaps because having a mutual defense cooperation agreement partner generates information that may help states overcome commitment issues in forging an agreement (Kinne 2018). How the network of states changes, how changes are shaped by expectations of future conflict, and what consequences this pattern has for interstate conflict are all promising areas for continued research.

Future Issues: Interstate Conflict

1. How do all the various interstate networks interact with one another?
2. Which interstate networks matter most for conflict outcomes?
3. Are the networks responsible for conflict outcomes, or do links in them capture something else that carries the causal weight?
4. How do international networks form? Do endogenous expectations about conflict affect the addition of new links?

CONCLUSION

Research in the area of networks of conflict and cooperation has made great strides. Well beyond the point of proof of concept, carefully accounting for networks has undisputed value for the study of collective action, informal governance, civil conflict, and interstate relations, to name just four large research areas.

Thinking of networks research as a series of stages, for any one topic area, we would expect research on (*a*) whether networks matter, (*b*) which network matters for which outcome, (*c*) whether the structure of those networks matters, (*d*) why the network does what it does (the mechanisms), and (*e*) what circumstances mediate the role of networks. The only stage a researcher may find crowded is *a*. Filling out our knowledge at the other stages will require substantial effort by future researchers. The good news is that the way has been paved, the value is likely to be high, and there is nearly limitless room for additional contributions.

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Errata

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