Social Networks 36 (2014) 5–22

Contents lists available at ScienceDirect

Social Networks

journal homepage: www.elsevier.com/locate/socnet

Reciprocity and the structural determinants of the international sanctions network

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ARTICLE INFO

Keywords:
Political networks
Sanctions
ERGM

ABSTRACT

The imposition of international economic sanctions is a strategic and often multilateral phenomenon of states attempting to coerce each other into altering their behavior by means of economic pain. The interlocking connections of states issuing sanctions and being sanctioned creates a network of interdependent relations and, we argue, the structure of dependencies endogenous to the network is a major determinant of the network's formation and persistence. We consider endogenous structures, both theoretically and empirically, with three foci: the tendency to sanction frequently, the tendency to be sanctioned frequently, and, most of all, reciprocity. The empirical support we find for each of these processes adds a new dimension to our existing knowledge of the sanctioning process, casts doubt upon some previous findings, and opens important avenues for future research.

1. Introduction

To what extent do dependencies *endogenous* to the web of interlocking international economic sanctions drive the development of the sanctions system? Economic sanctions are a complex and interdependent phenomenon in which a state or numerous states cut or threaten to cut regular economic relations with another state in order to obtain a policy change.[1] Yet such sanctions rarely occur in isolation. Consider the often-studied example of multilateral sanctions where some lead state organizes a coalition of sanctioning states in order to cut off a larger proportion of the target's trade. If such coordination is at play, as many studies have assumed (Martin, 1993; Drezner, 2000; Bapat and Morgan, 2009), then the sanctions by each of the senders against the target are not independent: the lead sender's sanctioning efforts rendered the other sanctions more likely. Such coordinated sanctioning behavior is, however, just one of the ways in which the onset of sanctions between two states can beget or prevent other sanctions. Despite the fact that a number of studies assume such interdependent processes occur, no analyses of sanctioning, of which we are aware, have developed specific theories about these interdependencies or analyzed them empirically.

Economic sanctions are commonly understood as episodes of political interaction between a sending state (or several) and a target state. The sender seeks to change a policy that is under the target's control by reducing, terminating, or threatening to reduce or terminate hitherto regular economic interactions. A sender may demand that the target discontinue policies it has in place (e.g., tariffs, weapons programs, ethnic favoritism) or take action to rectify a variety of problems (e.g., improve labor practices or respect human rights). Examples of threatened punishments include the cutting of foreign aid, imports, exports, freezing of the target's financial assets, or the imposition of travel bans on political leaders. The essence of sanctions is a demand for the target to change its actions and if that demand is unmet, the sender(s) may alter economic interactions with the target.[2]

We argue throughout this paper that the complex web of interlocking international economic sanctions forms a network and that viewing sanctions as a network phenomenon provides important insights into endogenous patterns, dynamics, and factors related to their onset and persistence. Sanctions relationships naturally form networks. The fact that states can issue sanctions to several states and receive sanctions from several states allows a complex set of relationships to emerge. Whereas previous work on sanctions has taken a strictly dyadic perspective, a network perspective allows endogenous, extra-dyadic, relationships, along with dyadic factors, to affect dyadic onset and persistence.

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[1] As is standard in the sanctions literature, we will call states that impose or threaten economic sanctions "senders" and those upon which they are imposed "targets."

[2] This view of sanctions excludes cases in which states impose tariff barriers *solely* to protect some ailing industry of theirs (i.e. without making a demand of the target).

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http://dx.doi.org/10.1016/j.socnet.2013.01.001

Our aim is to examine an element of the sanctioning process that is, thus far, unexplored in the literature: the extent to which the structure of dependencies *among* existing sanctions relationships affect the onset and persistence of international economic sanctions. We argue that the structure of interdependencies in general, and the effect of reciprocity in particular, play a substantial role in the establishment and continuation of sanctions. Economic sanctions are commonly thought to work by forcing costs on the target. To cope with these costs, the target may give into the sender's demand or try to offset costs by trading elsewhere; the latter strategy clearly involving dependencies outside the sender-target dyad. A third option is to counter the sanction with a sanction of its own, which may actually get the sanction removed without having to concede to the sender's demand. This third option also involves dependencies outside the directed dyad (the sanction from state i to state j is dependent on the sanction from state j to state i) and constitutes the major theoretical contribution of the present study. We develop theoretical expectations about counter-sanctioning and the temporal dynamics of this process, as well as activity and ignominy effects for senders and targets respectively.

Recent work finds that similar endogenous dependencies in other inter-state networks, such as reciprocity and transitivity in the alliance and conflict networks, play a substantial role in determining the conflictual and cooperative outcomes of relations between states (Cranmer and Desmarais, 2011; Cranmer et al., 2012b,a; Maoz et al., 2006; Maoz, 2006, 2010; Warren, 2010); suggesting that some of the same forces may be at play in the conflictual network of sanctioning. However, exploring the effects that endogenous dependencies have on the network is more than an opportunity to learn about the process by which sanctions begin and persist. Neglecting the possibility of endogenous effects in the sanctions network could produce twin perils: omission of such factors from consideration can lead to misspecified theories and empirical models that fail to account for network structure, when it in fact plays a role, can result in explanatory power being falsely attributed to covariates (Cranmer and Desmarais, 2011; Cranmer et al., 2012a).

We construct the sanctions network, in which a directed relationship exists if one state sanctions another, and analyze it with particular interest in its endogenous structure. We consider endogenous structures, both theoretically and empirically, with three foci in mind: activity, ignominy, and reciprocity. Our analysis finds that dependence structures endogenous to the network do indeed play a role in driving the onset and persistence of sanctions. Most notably, we find empirical support for reciprocity as an endogenous structure that does much to explain the network of sanctions as well as the process of sanctions onset. Our results offer strong support for our theory of reciprocity in sanctioning, including specific support for our expected temporal dynamics. We also find support for our activity and ignominy effects. Specifically, we find that ignominy, the tendency for some states to be targeted by many states, is gained at a decreasing rate while activity, the tendency of a state to sanction multiple other states, is gained at an increasing rate. We further show the danger of failing to account for dependencies when analyzing networks: we find that the effect of trade relationships on sanctioning is reversed from previous studies after including endogenous dependencies in the model, and the previously established effects of alliances, geographic distance, and joint democracy drop out of statistical significance.

2. Endogenous determinants of the sanctions network

A common feature of networks is that they are often driven, in large part, by the endogenous structure of connectivity within the network. As such, taking a network perspective on the system of economic sanctions and focusing on the endogenous factors that drive the system are one and the same: a perspective characterized by attention to effects that go beyond the basic, directed dyadic, unit of analysis. The distinction between a relational phenomena that can be treated as dyadic and one that must be thought of as a network hinges on whether the relationship between two actors can be affected by other contemporaneous relationships.[3] Sanctions, we argue, constitute a process that must be thought of as a network because the presence or absence of a sanction between two states can affect whether sanctions will exist between other pairs of states, thus rendering the edges of the network dependent on one another. For example, even though they were separate actions undertaken by different governments, the decisions of the United States and United Kingdom to sanction South Africa in the 1980s were highly interdependent.

An irony in the sanctions literature is that policy makers and sanctions scholars have long conceived of sanctions in a way that suggests a network structure, but it is only recently that the technology to model sanctions as a network has existed. For example, the way sanctions scholars have thought about multilateral sanctions makes a *prima facie* case that sanctions ought to be conceptualized as a network. When the modern conception of sanctions became prominent with the League of Nations, the idea of multilateral sanctions was driven by the notion that more sanctioning nations could impose more costs on the target by cutting off more previously beneficial trade and economic transactions. Following this original intuition, a sizable body of work focuses on whether multilateral sanctions are more effective than unilateral sanctions. Initially, and based on older data than we will use below, scholars were surprised that multilateral sanctions appeared not to be more likely to succeed than unilateral sanctions (Lam, 1990; Hufbauer et al., 2007). Scholars have considered numerous explanations for why multilateral sanctions may have lower success rates, each of which implies a network perspective. Drezner (2000) suggests that bargaining between senders makes it more difficult to compromise with the target so that sanctions persist without success. Also, he argues that particular issues might attract larger coalitions of senders so that the size and the target's resolve are confounded. Miers and Morgan (2002) and Bapat and Morgan (2009) propose that the senders may fail to coordinate over the demand they are making of the target so targets can play senders' incongruent demands against each other. However, these inter-sender coordination issues seem remedied when the sanctions are carried out through an international organization.

All three arguments above suggest strategic interaction among the senders and between the senders and the targets. From each of these arguments it follows that the sanctions (or their absence) are systematically affected by other senders' sanctioning activities. When a state rationally coordinates with others in order to get a target to change its policy, then, by definition, there exists non-ignorable dependencies between the states that are involved in a given sanctions regime. Therefore, it is appropriate to consider economic sanctions from a network perspective, which to our knowledge has not yet been done. We aim to fill this gap by using the endogenous focus of the network perspective to examine three endogenous factors, as well as their temporal dynamics, that should influence the onset and persistence of sanctions.

[3] We make this distinction because relationships that are independent from one another can form networks, but the independence of the relationships ensures that there are no dependencies endogenous to the network, thus allowing the relationships to be analyzed as dyads without producing bias.

2.1. Reciprocity

Reciprocation of existing sanctions is the primary endogenous process that we consider. When a state *i* counters a sanction by state *j* through a sanction of its own, then, by definition, each of the sanctions are dependent. To our knowledge, this topic has not been addressed theoretically or empirically by sanction scholars, even though the idea of retaliatory sanctioning is prominent in several well-known anecdotal cases.[4]

For intuition about how the retaliatory sanctioning process may function, consider the following three examples. First, in 1973, then Egyptian President Sadat sought the removal of a ban on military weapons imposed by the Soviet Union. The arms embargo was a serious setback for Egypt because approximately 90% of its military equipment was Soviet made and that equipment was deteriorating.[5] In the fall of 1977, as talks between the Soviet Union and Egypt were stalling, Sadat proclaimed that Egypt was going to stop payments on its considerable debt to the Soviet Union and cease selling cotton in retaliation for the arms embargo.[6] The retaliation quickly brought about renewed talks and a resumption of arms sales to Egypt.

Second, in July of 1940, the United States imposed sanctions on Japan over its joining the Axis alliance with Germany and Italy.[7] Specifically, the United States stopped the sale of scrap metal that Japan depended upon. Japan swiftly resorted to a series of retaliatory measures designed to interfere with the trade of U.S. goods in East Asia, block the transport of natural resources from the East Indies to the United States, and halt the purchase of U.S. cotton.[8] As it is well known, Japanese efforts to get the sanctions lifted failed and the dispute between the countries escalated to war in December of 1941.

Third, the United States and other countries imposed a new round of sanctions against Iran over its nuclear program in the summer of 2010.[9] As President Obama was signing the Iran Sanctions Act into law, Iranian President Ahmadinejad announced retaliatory measures against the United States and Western countries. He issued a ban on signature "western" products such as those by Coca Cola, IBM, and Intel.[10] Thus far, this retaliatory action has failed to lift the sanctions.

These anecdotes suggest that the strategy of countering one sanction with another should constitute a feature of the sanctions network: targets have an incentive to retaliate because retaliation raises the cost of the sanctions regime for the sender. If retaliatory processes are indeed integral to the phenomenon of sanctioning, then we expect that the imposition of a sanction increases the probability that the original sender becomes the target of a counter-sanction from the original target.

Consider the following logic underlying retaliatory sanctioning. As is standard in the sanctions literature, we see sanctions as instruments of foreign policy that are employed to bring about changes in the targeted countries' policies (Baldwin, 1985; Palmer and Morgan, 2006). The sender stops or reduces regular economic interactions such that some hitherto efficient relationship is no longer in play; that is the primary source of costs imposed on the target. More formally, the standard process of economic sanctions in the literature is thought of as a multi-stage interaction between two states, *i* and *j*.[11] State *i* demands some policy change from *j* and announces that sanctions might be imposed if *j* does not change its behavior. If *j* acquiesces to the demands, the interaction ends. If *j* refuses, then *i* may impose sanctions. If sanctioning occurs, then some economic transactions are reduced, which imposes costs on *i* as well as on *j*.

Besides acquiescing and changing its behavior, the target, *j*, can react to the threat or imposition of sanctions against it in a number of ways. First, the target may refuse to change its behavior and opt to endure the costs of the sanctions regime. This is an attractive option when the sanctions are not overly costly to the target. For example, the Soviet arms embargo against Egypt was not immediately costly to Egypt because its weaponry did not need maintenance when the sanctions were first imposed. Galtung (1967) points out that, at low levels of cost to the target, citizens may actually rally behind the government and economic costs may turn into political gains. Second, the target may satisfy its trading needs in an alternative manner (Early, 2009). If the sender places an export ban on the target, the target can consider trying to manufacture the good at home by restructuring its industries or it can seek other trading partners. In this case, the target is affected by the sanctions to the degree that alternative options are more costly.

A third option for states targeted by sanctions has not been addressed directly in the literature. Instead of acquiescing, bearing the costs of sanctions, or seeking new trading partners, the target may take action to encourage the removal of the sanction. The sender imposed sanctions in order to motivate the target to change some policy; retaliating, the target can impose sanctions and possibly impose costs on the sender sufficient to make it lift the sanctions. In other words, the target can impose a counter-sanction, levying costs on the sender that are linked to the sender's sanctioning of the target. By making the sender feel more economic pain than it had originally bargained for when it created the sanctions regime, the target may hope to render the original sanction too costly for the sender to maintain.

Our primary hypothesis is that, for a given pair of states *i* and *j*, a sanction by *i* against *j* makes a sanction by *j* against *i* more likely. This is an endogenous effect because it involves coordination among the ties sent in the sanctions network.

H_{1a}: Sanctions will tend to be reciprocated.

However, while we expect the endogenous reciprocation of sanctioning to drive the network's evolution, we can formulate specific expectations about the temporal dynamics of that reciprocation. Sanctions need not be reciprocated immediately for the retaliatory sanctioning to be effective.

There are three central reasons why sanctions might not be reciprocated immediately, even if the original target intends to counter-sanction. First, the reciprocation of sanctions may be delayed because the target does not suffer the economic pain of the sanctions immediately. In the example of Egypt and the Soviet Union discussed above, Egypt was not subject to much immediate

[4] A partial exception is Bayard and Elliott (1994). The book studies retaliation through economic sanctions by the United States in cases in which other states fail to reciprocate favorable trade practices by the United States. In the view of most sanctions scholars, this would not be seen as reciprocal sanctioning.

[5] Washington Post, "Egypt to Cancel Friendship Pact with the Soviets," March 15, 1977; The Guardian, "Sadat to cut Soviet link," March 15, 1977.

[6] Washington Post, "Egypt to Halt Military Debt Payment To Russia Because of Arms Embargo," October 27, 1977; New York Times, "Sadat puts off Payment on big Debts to Moscow," October 28, 1977.

[7] New York Times, "Japan is Aroused by U.S. Embargo," July 27, 1940.

[8] New York Times, "Japan is Aroused by U.S. Embargo," July 27, 1940; New York Times, "Americans charge curbs by Japanese," August 4, 1940; Washington Post, "Japan plans retaliation," September 27, 1940; Wall Street Journal, "Scrap Iron Embargo," September 27, 1940; New York Times, "Japanese retaliate for scrap embargo," September 29, 1940.

[9] U.S. Sanctioning of Iran dates back to 1979.

[10] Christian Science Monitor, "Iran sanctions kick in, and Ahmadinejad says he'll ban Coca-Cola," July 1, 2010.

[11] The basic setup presented here is also found in Smith (1995), Drezner (2003), Lacy and Niou (2004), and Whang (2010).

difficulty from the arms embargo. At the time the embargo began, Egypt's extensive Soviet-made arsenal was relatively new and in good repair with an existing stock of spare parts. The sanctions had little effect until the arsenal started to degrade and Egypt ran short of spare parts; then Egypt retaliated.

Second, bureaucratic and legal hurdles can lead to delayed counter-sanctioning. For example, getting approval from the WTO to retaliate in a trade dispute takes time as the WTO needs to agree to set up a dispute panel, which then must issue a ruling that the parties to the dispute can appeal. If appealed, the WTO issues its final ruling. Each of these steps can take considerable time during which the original sanction prevails and the counter-sanction is shelved. Many international institutions through which economic sanctions may be imposed have similarly complicated rules, so targets seeking to retaliate with the approval of international bodies, thought to be more effective mode of sanctioning in the first place (Bapat and Morgan, 2009), may not be able to do so immediately.

Third, targets may have an incentive to delay counter-sanctioning in order to avoid escalating a dispute into the military realm. Rapid retaliation for economic sanctions can increase the intensity of a thus-far peaceful dispute. Our example with Japan and the United States showed that economic sanctioning can be, if not a cause of war, at least a prelude to it. Often though, the sender and target are not so evenly matched as the United States and Japan were in the early 1940s: many senders are considerably more powerful than the targets. Targets may fear that rapid and aggressive counter-sanctioning may give the sender a reason to intervene militarily, which the sender may feel can be done at reasonably low cost if they have a sizable power advantage. Some delay in counter-sanctioning may strike a balance between overly aggressive and passive responses, while taking care to signal an intention not to escalate.

While all of the above are reasons to delay retaliatory sanctioning, they are also reasons to expect that, in most cases, it will not take decades to reciprocate a sanction if such reciprocation is to be done at all. The sanctions literature has often noted that economic actors in the target and sender countries adapt to the changed circumstances (Galtung, 1967). For example, firms may substitute goods or trading partners to cope with the effects of the sanctions (Kobayashi, 2011). Therefore as time elapses since the original sanction, the target's economically injured actors may have adapted so that the target's need to retaliate dissipates after a long period. Taken together, we expect the reciprocation of sanctions to be frequently delayed, but not by long time periods.

H_{1b}: Delayed reciprocity should be common, but delays should not be long.

2.2. Activity and ignominy

While reciprocity is the endogenous determinant of the sanctions network in which we are most interested, we do not expect it to be the only relevant endogenous predictor of the sanctions network. In addition to reciprocity, the occurrence of "activity" and "ignominy" effects are theoretically likely as well. We define the former as single states imposing multiple sanctions and the latter as a state being the target of multiple sanctions.

To some countries, economic sanctions are available as part of their foreign policy repertoire. Heinrich and Morgan (2012) argue that a great level of wealth is a necessary condition for states to use sanctions; for poorer states, sanctions are simply inefficient to use because they impose little pain on the target and much pain on the sender. They show that the probability of using any economic sanction increases above the 75th percentile of national wealth and that the frequency of the use of sanctions rises at an increasing rate. Sanctions become a tool in the foreign policy "toolbox" of the wealthiest states.

Our network perspective can shed additional light on this phenomenon. In particular, if sanctions are a part of the foreign policy repertoire, then states that can use sanctions should be expected to use them against multiple targets. This increased activity should not be an artifact of a single intense dispute, but should be a characteristic of a state's foreign policy. Our network model is able to capture this expectation (as opposed to monadic and dyadic analyses) and should reveal two things: that there are a large number of states that do not sanction at all and that those that do use sanctions also tend to sanction multiple targets. In network terms, we expect to see strong isolate and "out-star" (called such because the edges radiating from the sender to multiple targets forms a star shape when drawn) effects.

H_{2a}: A large number of states will be not be using sanctions (isolates).
H_{2b}: A state that is imposing sanctions against some states is more likely to sanction other states (out-stars).

We expect a similar phenomena with states that are the targets of sanctions. Outside of scholarly circles, it is widely believed that sanctions are more effective when imposed multilaterally. However, scholarly research has shown that this is only the case under certain circumstances, depending on the number of issues in dispute and whether an international organization is involved (Miers and Morgan, 2002; Bapat and Morgan, 2009). We are aware of no research has that has considered what gives rise to such multilateral sanctions in the first place.[12] We expect that sanctioning coalitions form depending on the issue involved, particularly when widely held international norms are violated. For example, after Alberto Fujimori's 1992 post-election coup in Peru, the U.S. spearheaded sanctions by the members of the Organization of American States as well as other countries. Similarly, human rights violations during the Apartheid years in South Africa saw numerous countries coordinate through the United Nations to impose economic sanctions against South Africa. In both cases, the efforts of one sanctioner made sanctions by other countries more likely and thus not independent of each other. When manifest in the network, this phenomenon should result in the formation of "in-stars:" many different states sanction a single state that has ruffled the feathers of the international community. In-stars are the exact opposite of out-stars and serve to capture "popularity" in a network (Cranmer and Desmarais, 2011); a dubious honor in the case of sanctions which we can safely call ignominy.

H_3: A small number of states will be highly ignominious (in-stars).

3. Empirical analysis

3.1. Data

For our empirical analysis, we construct the sanctions network from the Threat and Imposition of Economic Sanctions (TIES) data set (Morgan et al., 2009).[13] The TIES data contain 888 instances of threatened and imposed economic sanctions for the years 1972 through 2000. The data set contains information on sanctions cases in which at least one country threatened to terminate or reduce regular economic transactions with another country in order to affect

[12] Some ideas are offered by Drezner (2000), whereby sanctions that are more salient to the target attract larger coalitions of sanctioners.
[13] More information and the full dataset are available for download at http://www.unc.edu/ bapat/TIES.htm.

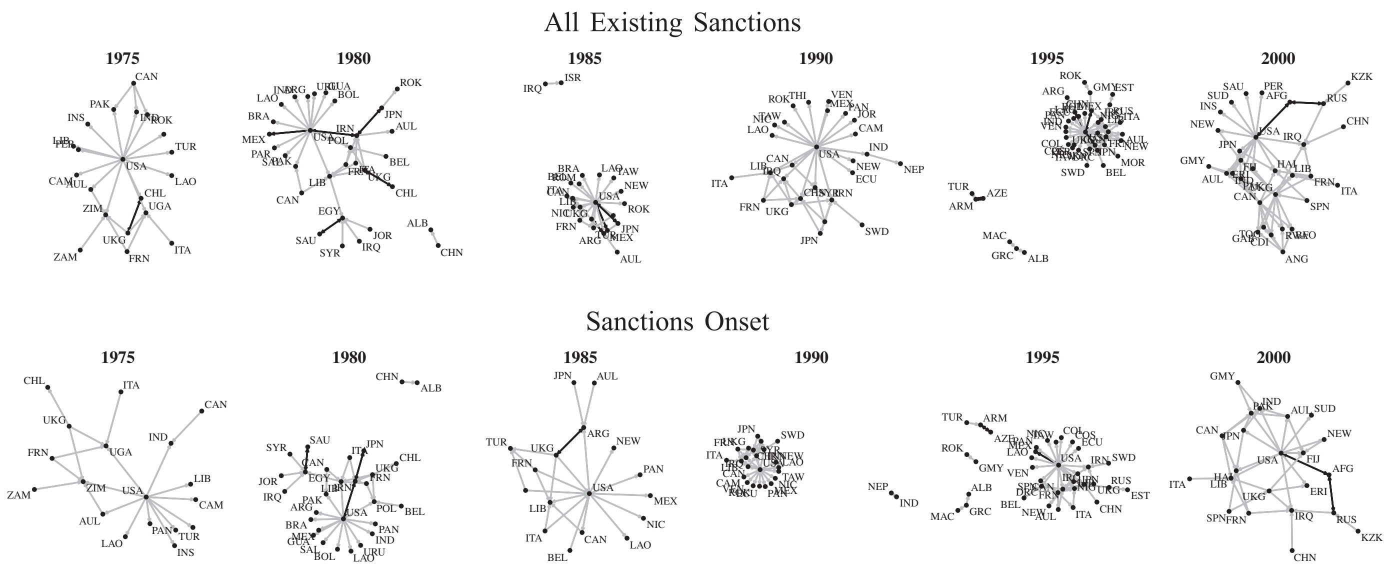

Fig. 1. The sanctions networks in five year intervals. The top row of plots shows the network of sanctions for 1975, 1980, 1985, 1990, 1995, and 2000. The bottom row of plots shows the same for the network of sanctions onset (new sanctions only). Nodes are labeled with the state's three letter abbreviation. Sanctioning relationships are indicated by gray arrows from the sender to the target. Those edges plotted in black are reciprocal sanctions.

policy change by the target state. Because the aim of sanctions, either threatened or imposed, is to make the target change some element of its policy, sanctions put into place solely for domestic reasons (without making a demand for the target to change behavior) are not considered economic sanctions and are not recorded in the data set.[14] Sanctions coded in the TIES data can take many forms, such as impeding trade through tariffs, prohibiting trade, reducing economic and military assistance, preventing foreign officials from traveling, and freezing the economic assets of the target country.

We consider two specifications of the sanctions network for each year between 1972 and 2000. We study, separately, the network in which a directed link exists between two states when *any* economic sanctions are present, as well as the network where only the onset of *new* sanctions is coded as a (directed) link. The complexity of the sanctions network and the non-independence of sanctioning relationships can be seen plainly in the illustrations of the network presented in Fig. 1. Also, we report basic descriptive statistics for the networks in Fig. 2 and the top five targets and senders for both networks in Table 1. It is striking that there are relatively few sanctions, with a maximum of around 80 in the network, which is approximately 0.36% of the $2 \times \binom{2}{150} = 22,350$ potential directed sanctions.

3.2. Methods

Our central hypothesis is that the international economic sanctions network will be characterized by reciprocity with certain temporal dynamics and our primary goal is to rigorously test these hypotheses (H_{1a} and H_{1b}). A second overall objective is to provide a first empirical look at the international sanctioning process from a network analytic perspective. As such, we utilize a method designed for statistical inference on network data that permits us to simultaneously (a) test our central hypotheses of reciprocity in the sanctions network, (b) incorporate other network effects into the model, and (c) control for exogenous covariates that have been previously identified by the literature.

We fit an exponential random graph model (ERGM) extended to a discrete time-series of networks based on the method introduced by Robins and Pattison (2001).[15] Robins and Pattison (2001) extend the (now) ubiquitous ERGM (Wasserman and Pattison, 1996) to account for first-order intertemporal dependence. This model was further extended by Hanneke et al. (2010) to account for higher-order intertemporal dependence and termed the "temporal exponential random graph model" (TERGM), a phrasing that we adopt. The TERGM allows us to simultaneously test numerous hypotheses about the processes underlying the sanctions network, including exogenous covariate effects as well as effects that are endogenous to the network, and to provide a generative model for the evolving sanctions network. The performance of ERG models depends heavily upon careful consideration of the fit of the ERG distribution to the data on hand (Cranmer and Desmarais, 2011). In order to better account for temporal variation in the network structure, we customize our methodology to relax the assumption that the TERGM parameters are constant over time. We use a combination of Bayesian change-point methods and the bootstrap maximum pseudolikelihood approach developed by Desmarais and Cranmer (2012) to smooth the ERG parameters over time. These methods are described in greater detail in Appendix A.

The process of specifying an ERG model consists of designing network statistics that capture the generative processes underlying the network. We denote the vector of network statistics by $\boldsymbol{\Gamma}$, and a single network statistic by Γ. The endogenous network effect that we use to test hypothesis H_{1a} about the role of reciprocity in the sanctioning process is

$$\Gamma_M(N^t) = \sum_{\forall\{i,j\}} N^t_{ij} N^t_{ji}, \qquad (1)$$

which counts the number of reciprocal dyads in the network at a specific point in time (N^t). Our expectation, given that we hypothesized reciprocity to constitute a feature of the network, is that the effect of Γ_M will be positive.

[14] Such symbolic use of economic sanctions is studied by Lindsay (1986) and Whang (2011).

[15] We have also run conditional uniform graph tests (Anderson et al., 1999) as univariate tests of our reciprocity hypothesis. These tests are supportive of our hypothesis, and available upon request addressed to the corresponding author.

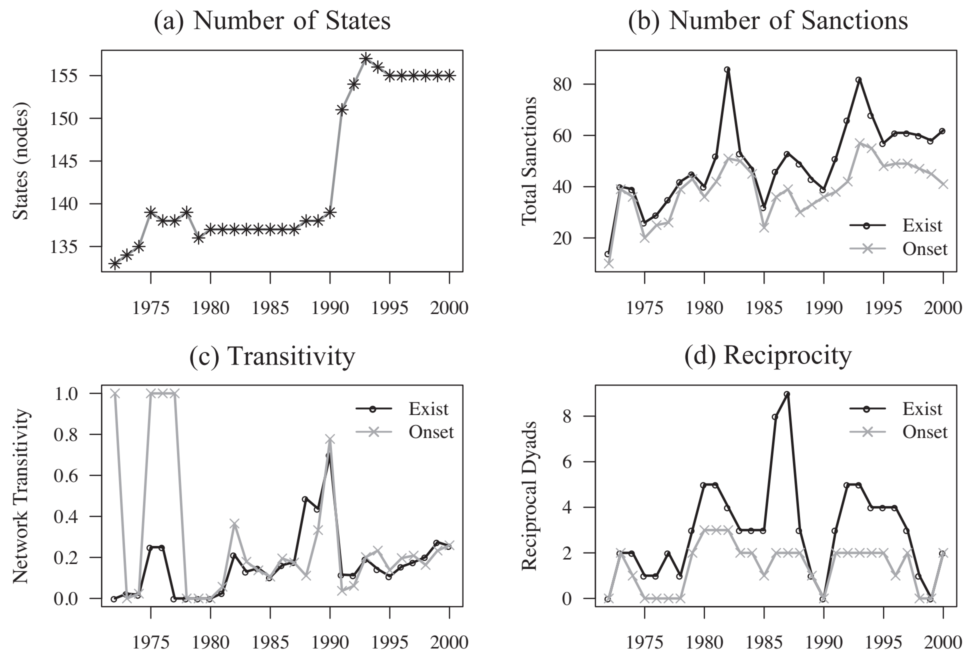

Fig. 2. Descriptive network statistics. Panel (a) gives the number of states (i.e., nodes) in the network and (b) gives the number of sanctions (i.e., edges) in the network. The graph transitivity (c) of the network is the proportion of potential transitive triads that are closed (i.e., are transitive triads). Panel (d) gives the number of reciprocal dyads, which are those with two edges.

Because we do not expect counter-sanctioning to occur immediately, as we argued in Hypothesis H_{1b}, we include two network statistics that capture the dynamic effects of sanctions and counter-sanctions. Our TERGM accounts for year-to-year dynamics in the sanctions network through the network statistics

$$\Gamma_A(N^t, N^{t-1}) = \sum_{\forall\{i,j\}} N_{ij}^t N_{ij}^{t-1} + (1-N_{ij}^t)(1-N_{ij}^{t-1}), \quad (2)$$

and

$$\Gamma_{LR}(N^t, N^{t-1}) = \sum_{\forall\{i,j\}} N_{ij}^t N_{ji}^{t-1} + N_{ji}^t N_{ij}^{t-1}, \quad (3)$$

which capture autoregressive memory in the edges and lagged reciprocity respectively.

We hypothesized above that (large) stars should be a feature of the sanctions network (H_{2b} pertains to out-stars and H_3 to in-stars). We expect that a first sanction against a state should make it more likely that more sanctions against others should follow, and that a sanction against a target should attract more senders. To test for ignominy and activity effects, we include statistics that count the number of in- and out two-stars (stars in which state k has edges with two other states i and j) as well as in- and out three-stars (stars in which state h has edges with i, j, and k). Robins et al. (2004) show that such star statistics allows the model to capture large stars which are small in number. The in and out-star statistics we include are:

$$\begin{aligned}
\Gamma_{2IS}(N^t) &= \sum_{\forall\{i,j\}} \sum_{\forall k \notin \{i,j\}} N_{jk}^t N_{ik}^t,\\
\Gamma_{3IS}(N^t) &= \sum_{\forall\{i,j,k\}} \sum_{\forall h \notin \{i,j,k\}} N_{jh}^t N_{ih}^t N_{kh}^t,\\
\Gamma_{2OS}(N^t) &= \sum_{\forall\{i,j\}} \sum_{\forall k \notin \{i,j\}} N_{kj}^t N_{ki}^t,\\
\Gamma_{3OS}(N^t) &= \sum_{\forall\{i,j,k\}} \sum_{\forall h \notin \{i,j,k\}} N_{hi}^t N_{hj}^t N_{hk}^t.
\end{aligned} \quad (4)$$

We include two other network effects. First, we account for the number of edges in the network (i.e. its density). This is important

Table 1
Frequent senders and targets in the sanctions network. Each column gives the top five targets and top five senders of sanctions over the five-year periods indicated by the column headers.

	Existing sanctions					Sanctions onset				
	76–80	81–85	86–90	91–95	96–00	76–80	81–85	86–90	91–95	96–00
Target										
1	LIB	USA	LIB	LIB	LIB	ZIM	LIB	LIB	LIB	LIB
2	ZIM	LIB	SYR	IRQ	IRQ	LIB	EGY	SYR	IRQ	IRQ
3	EGY	EGY	ARG	HAI	UKG	EGY	CAN	ARG	HAI	UKG
4	UGA	CAN	CAN	IRN	BUI	UGA	ARG	CHN	IRN	IND
5	IRN	ARG	IRN	USA	IND	IRN	USA	USA	USA	BUI
Senders										
1	USA	USA	USA	USA	USA	USA	USA	USA	USA	USA
2	UKG	UKG	UKG	CAN	UKG	UKG	UKG	UKG	CAN	UKG
3	FRN	FRN	CAN	UKG	CAN	FRN	FRN	CAN	UKG	FRN
4	CAN	ITA	GFR	FRN	FRN	CAN	ITA	GFR	FRN	CAN
5	ITA	GFR	FRN	GMY	GMY	ITA	GFdR	FRN	MEX	GMY

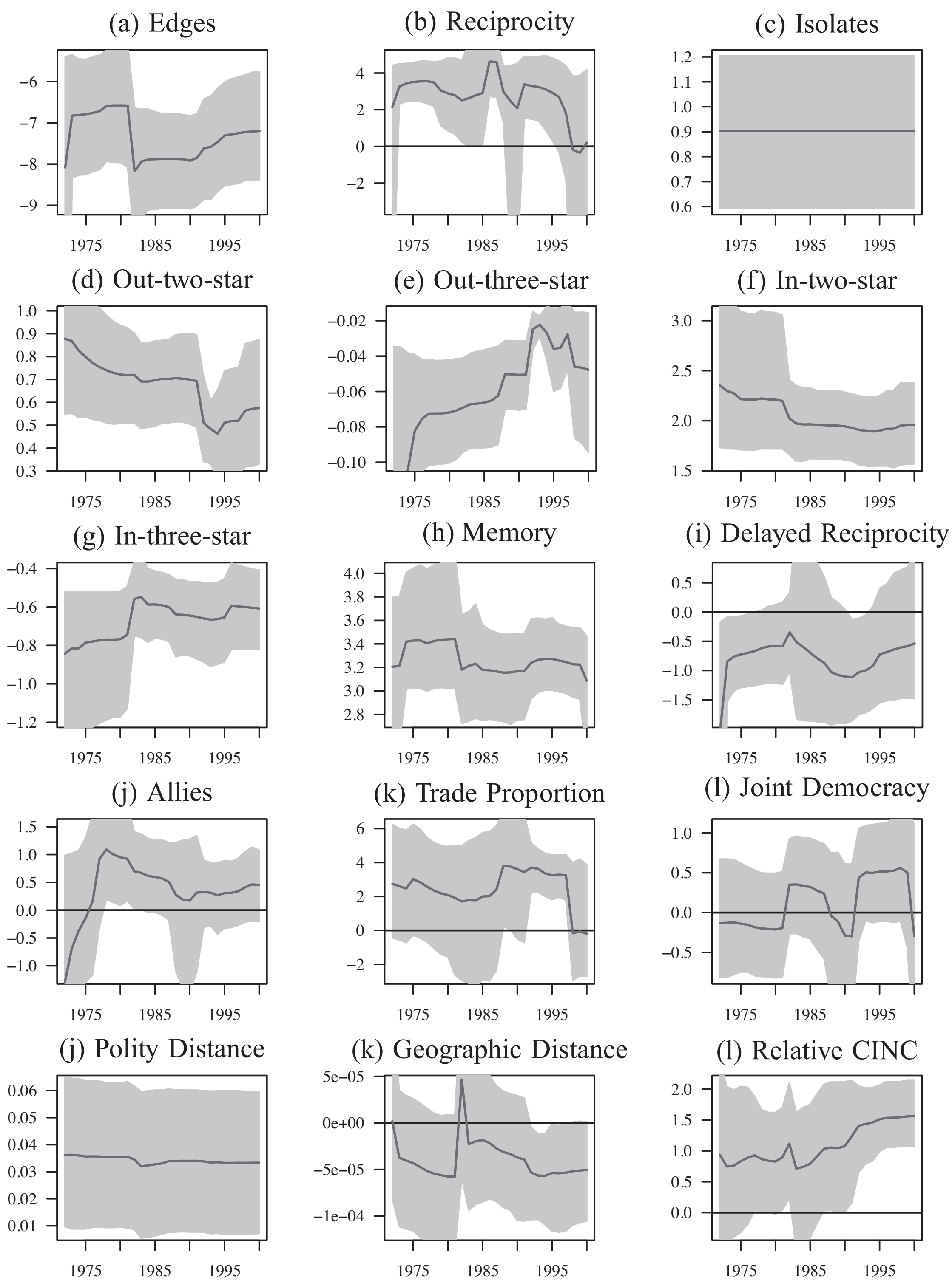

Fig. 3. Bootstrap smoothed TERGM results for the network of existing sanctions relationships. The dark gray line plots the magnitude (y-axis) of the smoothed coefficient over time (x-axis) while the light gray area spans the 95% bootstrap confidence interval.

as the number of sanctions rises throughout the dataset (see Fig. 2). Second, we include a statistic that accounts for the number of inactive states (isolates) in the system because we expect there to be many states that never use economic sanctions. Similarly, there are also many states that never provoke sanctions.

We also control for several exogenous covariates that the literature suggests should be drivers of sanctions onset and persistence. We include each of these covariates through a general statistic that captures the association between some covariate $\boldsymbol{X}$ and the network N:

$$\Gamma_{\boldsymbol{X}}(N) = \sum_{i=1}^{n} \sum_{\forall j \neq i} X_{ij}^{t} N_{ij}^{t}. \quad (5)$$

This statistic sums the values of the dyadic covariate X_{ij} when edges on that dyad, N_{ij}, exist.

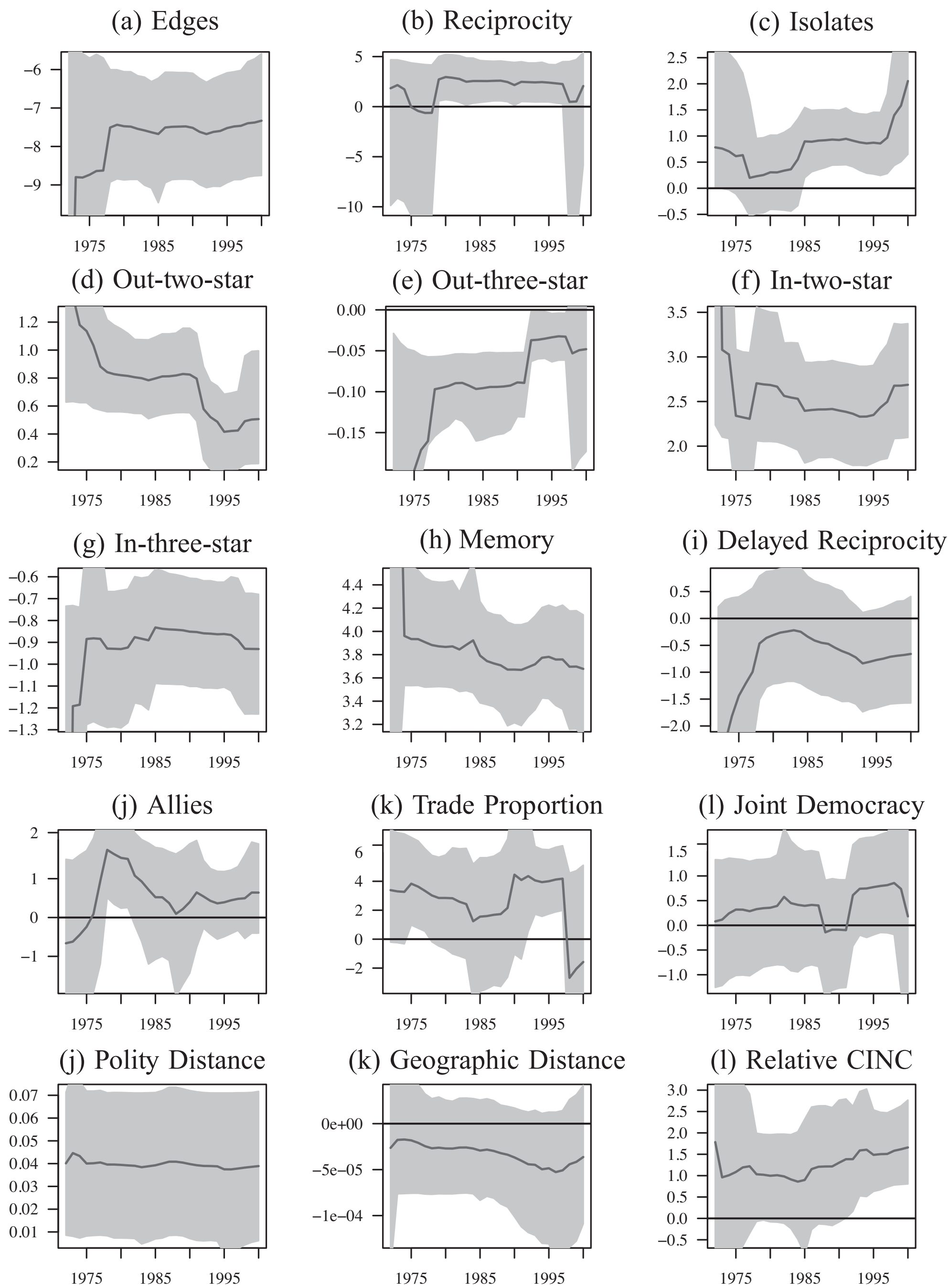

Fig. 4. Bootstrap smoothed TERGM results for the network of sanctions onset. The dark gray line plots the magnitude (y-axis) of the smoothed coefficient over time (x-axis) while the light gray area spans the 95% bootstrap confidence interval.

In such a manner, we control for the following variables. First, we control for military alliance relationships between any two states using data from the Alliance Treaty Obligations and Provisions (ATOP) dataset (Leeds et al., 2002). The literature suggests that allies tend to sanction each other more than non-allies (Lektzian and Souva, 2003; Hafner-Burton and Montgomery, 2008), but the opposite can be the case under identifiable conditions (Whang, 2010). Second, we control for trade relationships in the form of the proportion of the total trade activity of the two states in the dyad accounted for by trade between the two states in the dyad using the Expanded Trade and GDP data set (Gleditsch, 2002); if countries trade together, the sender should have more economic leverage over the target, but should also bear higher costs (potentially dissuading the sender from imposing sanctions). Hafner-Burton and Montgomery (2008) find that increased exports make sanctions more likely. Third, we control for the distance between state capitals using data from Gleditsch and Ward (2001) under the assumption that states far away from each other are less likely to sanction each other than states that are geographically proximate. Fourth, we include two controls for regime type. Using the Polity data (Marshall et al., 2009), we include an indicator for joint democracy with the idea that democratic dyads should be less likely to sanction one another (Lektzian and Souva, 2003, 2007; Hafner-Burton and Montgomery, 2008), and a variable measuring the difference in polity scores in the dyad, the idea being that greater differences in government types should result in a higher

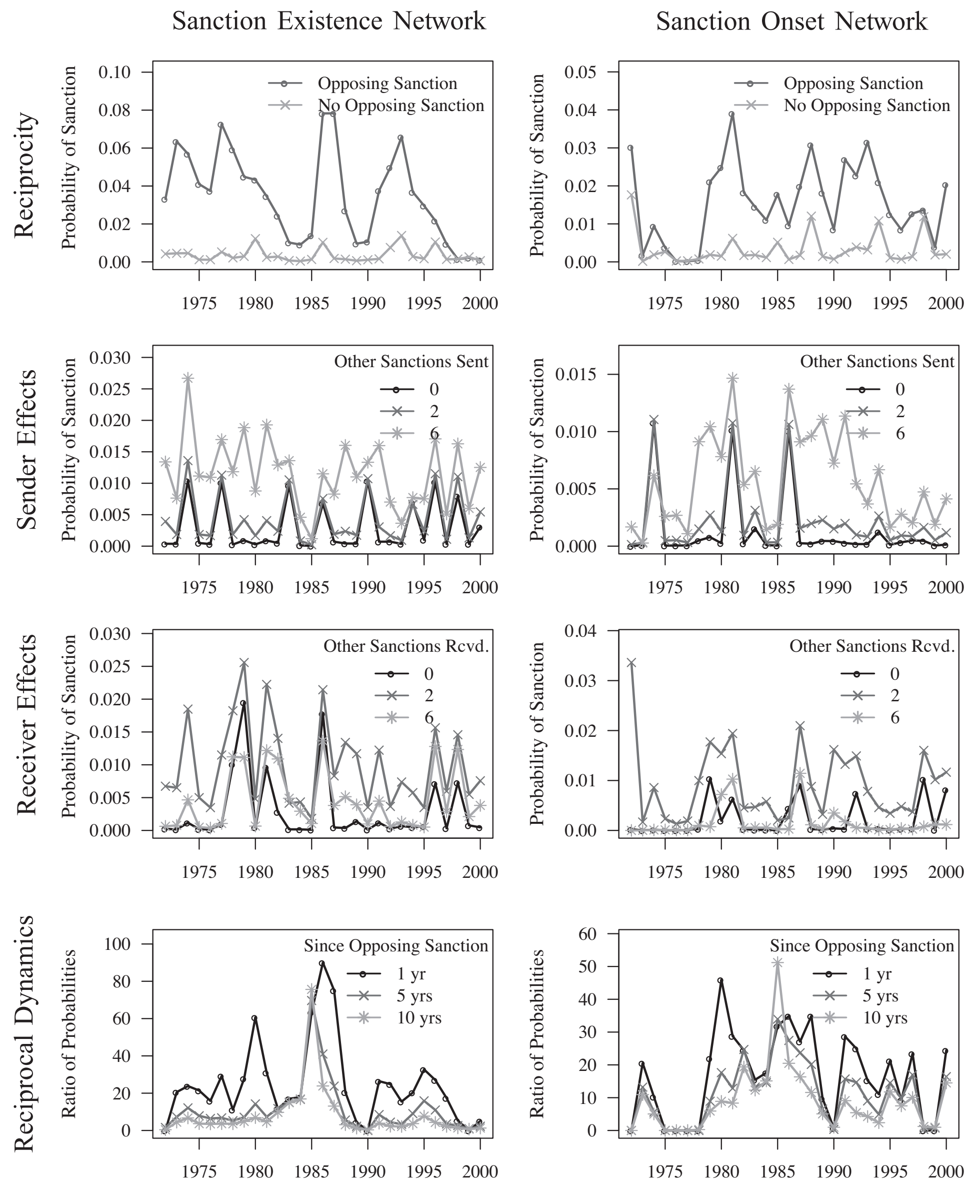

Fig. 5. Interpretation of TERGM results. The reciprocity effects depicted in the first row give the conditional probability of *i* sanctioning *j* given (a) that *j* sanctions *i* and (b) that *j* does not sanction *i*, averaged over 100 randomly selected dyads by year. The second and third rows give the conditional probability of a sanction from *i* to *j* given the number of other sanctions sent by *i* or received by *j*, respectively, averaged over 100 randomly selected senders and receivers. The plots in the last row give the ratio of the probability of a sanction from *i* to *j* in the future given a sanction from *j* to *i* in the current time over the probability of a sanction from *i* to *j* in the future given no sanction from *j* to *i* in the current time. These probabilities are computed using the average proportions over 100 simulated 10-year series from the time on the *x*-axis.

probability of sanctioning within that dyad (Hafner-Burton and Montgomery, 2008). Last, we estimate the effects of relative power between two countries relying on the commonly used Composite Index of National Capabilities (Singer et al., 1972). Lektzian and Sprecher (2007) find that greater relative capabilities make sanctions more likely if two states are involved in a crisis; Hafner-Burton and Montgomery (2008) report such effects in general. In contrast, Lektzian and Souva (2003) show that there is a negative effect of relative capabilities on the initiation of sanctions.

4. Results

Our results provide strong support for the importance of dynamic endogenous factors generally and reciprocity specifically. Also, as expected, the evidence for covariate effects is diminished for most covariates we include.

We present the results from our TERGM analyses for the sanctions network in Fig. 3 and for the sanctions onset network in Fig. 4. Before doing so, we should point that our estimated models accurately capture the underlying data. This is evident in our goodness of fit tests, presented in Appendix A. For both networks, we estimate a model including the endogenous parameters and exogenous control variables discussed above. We present the results graphically for each parameter, with a gray line plotting the magnitude (*y*-axis) of the smoothed coefficients over time (*x*-axis) and with gray bands capturing 95% confidence intervals. For each model, the results and confidence intervals are based on 1000 bootstrap iterations as described by Desmarais and Cranmer (2012). Any coefficient for which the

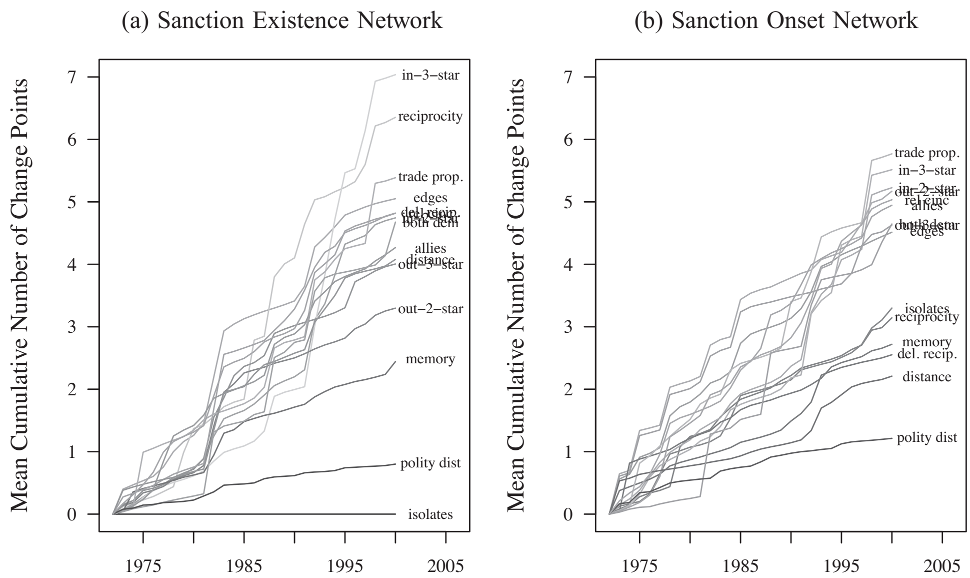

Fig. 6. The lines give the average number of change points over the 1000 regime series up to the time point on the *x*-axis.

confidence interval does not include zero is statistically significant.

4.1. Reciprocity

We first turn to examining our network property of primary interest: reciprocity. In Figs. 3 and 4, the coefficient estimates for the reciprocity parameter are positive for most of the years so that, in general, a sanction by one state makes it more likely for the target to respond with a sanction of its own in the same period. This supports H_{1a} in which we expected contemporaneous reciprocal effects.

In a complex model such as the TERGM, the magnitudes of these effects can be difficult to intuit. As such, we present more substantive interpretations of the endogenous effects, computed using the conditional probability methods developed by Desmarais et al. (n.d.), and present these in Fig. 5. Each of the eight plots gives interpretation measures by year. The interpretation measure in the year given on the *x*-axis is computed using the value of the smoothed TERGM parameter estimates in that year. The first row offers an interpretation of the reciprocity parameter. This gives the probability that *i* sanctions *j*, conditional upon the state of the rest of the network, excluding the dyad *ij*. Conditional probabilities are computed setting the edge from *i* to *j* to zero and then to one. Fig. 5 shows how the dynamics of counter-sanctioning varied historically. For essentially all years in our sample, the probability of a sanction from *i* to *j* in a given year increases substantially if *j* imposed a sanction against *i* in the same time period.

Even though retaliation within the same period is likely, the effects of a sanction are not expected to be fully realized contemporaneously. We expected that a sanction makes the initial target more likely to impose a sanction against the initial sender for some periods following the initial sanction (see H_{1b}). However, these temporal dynamics are more difficult to grasp from the model as they depend upon three of the TERGM parameters: *Memory*, *Reciprocity*, and *Delayed Reciprocity*. We use simulation to gain clarity of interpretation and graphically summarize the simulations in the bottom row of Fig. 5. In order to understand the dynamics of counter-sanctioning, we simulate the network ten years into the future, using the parameter estimates from the year on the *x*-axis in each panel. We then compute two separate probabilities at 1, 5 and 10 years into the future: the (empirical) probability of a sanction from *j* to *i* given that a sanction from *i* to *j* existed at the starting year of the simulation, and the same probability under the assumption that there was no sanction from *i* against *j* initially. We then plot the ratio of these probabilities over the course of the time series.

For the vast majority of the time series (i.e., the estimated TERG distributions), the probability of a sanction from *j* to *i* given that there was a sanction from *i* to *j* is at its relative highest just one year into the future; strong support for H_{1b}. Fairly swift counter-sanctions are most likely. However, this risk declines gradually within five and ten years into the future. Whereas the magnitude declines with time, it is still larger than one for most years, even five and ten years into the future. This indicates that, through the combination of memory and reciprocity effects, a sanction from *i* to *j* raises the likelihood of a sanction from *j* to *i* long into the future. This is the case for the onset-network (right panel) as well as for the existence-networks (left panel).

Our findings suggest that economic sanctions alter economic relations between two countries for quite some time. After an initial imposition of sanctions, the risk of further disruptions of economic relations because of sanctions remains elevated even a decade later.

4.2. Activity and ignominy

Our results with respect to the activity and ignominy hypotheses are in accordance with our expectations, but with an added nuance. We obtain consistently positive coefficients on in-two-stars and out-two-stars, but consistently negative ones on in-three-stars and out-three-stars (see Figs. 3 and 4). These results suggest that moderately connected states, both in and out, are fairly common whereas heavily connected states are uncommon. We expected to find this and it is the case for the TERGMs on both the existing sanctions and sanctions onset networks, thus providing strong support for hypotheses H_{2b} and H_3 respectively. In addition, the positive coefficients on the isolate statistics show that there tend to be states that are completely uninvolved in the sanctions system, as expected under hypothesis H_{2a}. Thus, we generally have many inactive potential sanctioners (positive isolates), some mildly active sanctioners (positive out-two-stars), and only a few highly active senders (negative out-three-stars). These results line up well with our theoretical expectations. The same pattern is also evident for target-specific sanctions clustering: some states are not targeted at all (positive isolates), some are sanctioned by a few senders (positive in-two-stars), but only a small few are sanctioned by a

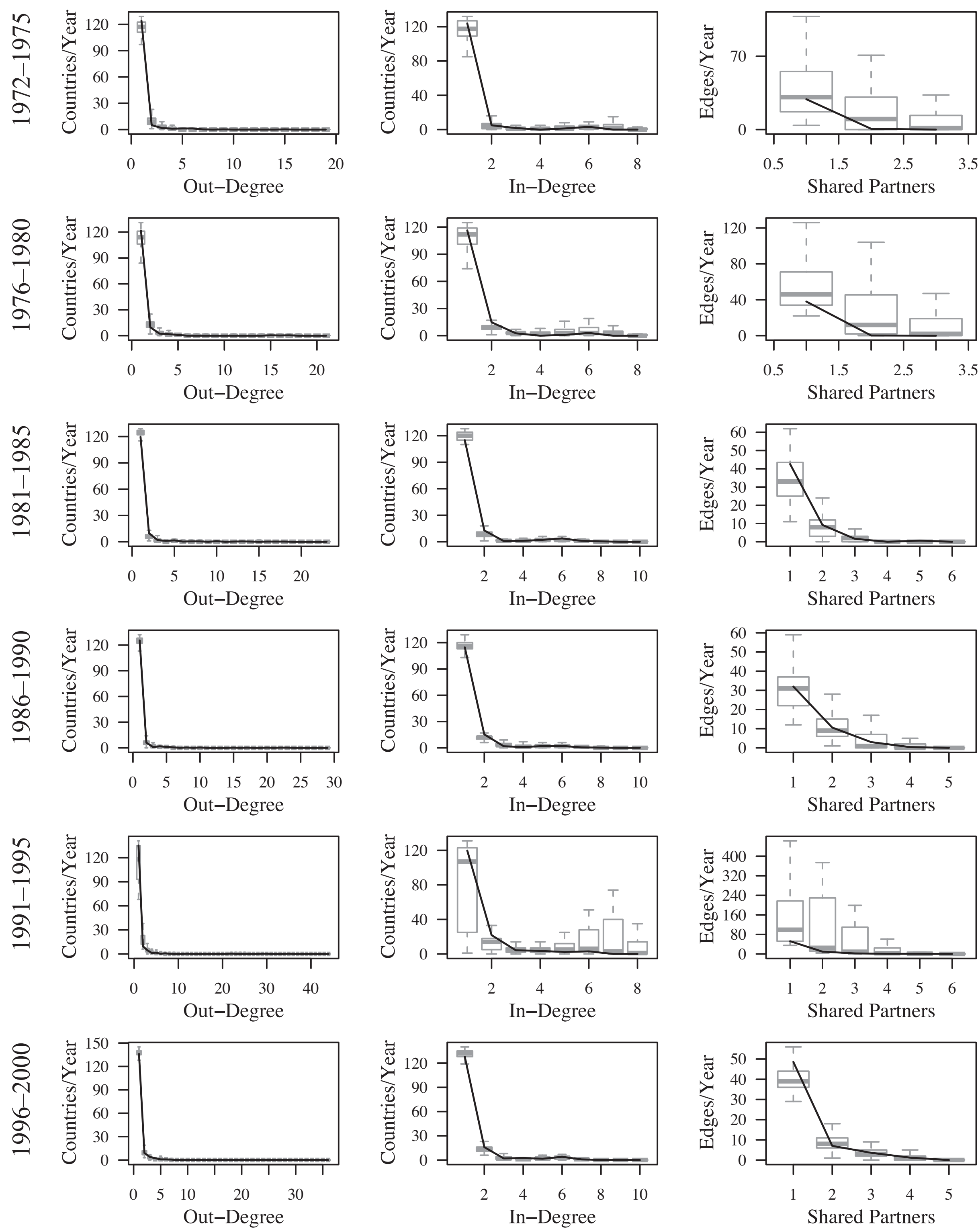

Fig. 7. Goodness of fit of smoothed TERGM models in the network of extant sanctions. Boxplots depict the distribution of statistics per year, from 1000 networks simulated for each year, over the intervals indicated by rows. Networks are simulated from the average bootstrap parameter estimates in each year. Black lines indicate the average statistic values in the simulations. Black lines close to the simulated median indicate good model fit.

great number of senders (negative in-three-stars). Smaller (possibly only bilateral) sanctions are common, but large sanctions (such as against in Iran recently or against South Africa under Apartheid) are rare. These results are, again, in line with our expectations.

The substantive magnitudes are most easily expressed through simulation. In the two middle rows of Fig. 5, we show how the probability of a sanction changes as we assume zero, two, and six sanctions that the sender is already imposing (row 2) and that the target (row 3) is already facing. Consider the target's perspective in row 3 of Fig. 5. When the target finds itself without a sanctions against it, the state faces a probability between zero and .01 that any other state is going to impose a sanction. Once there is some

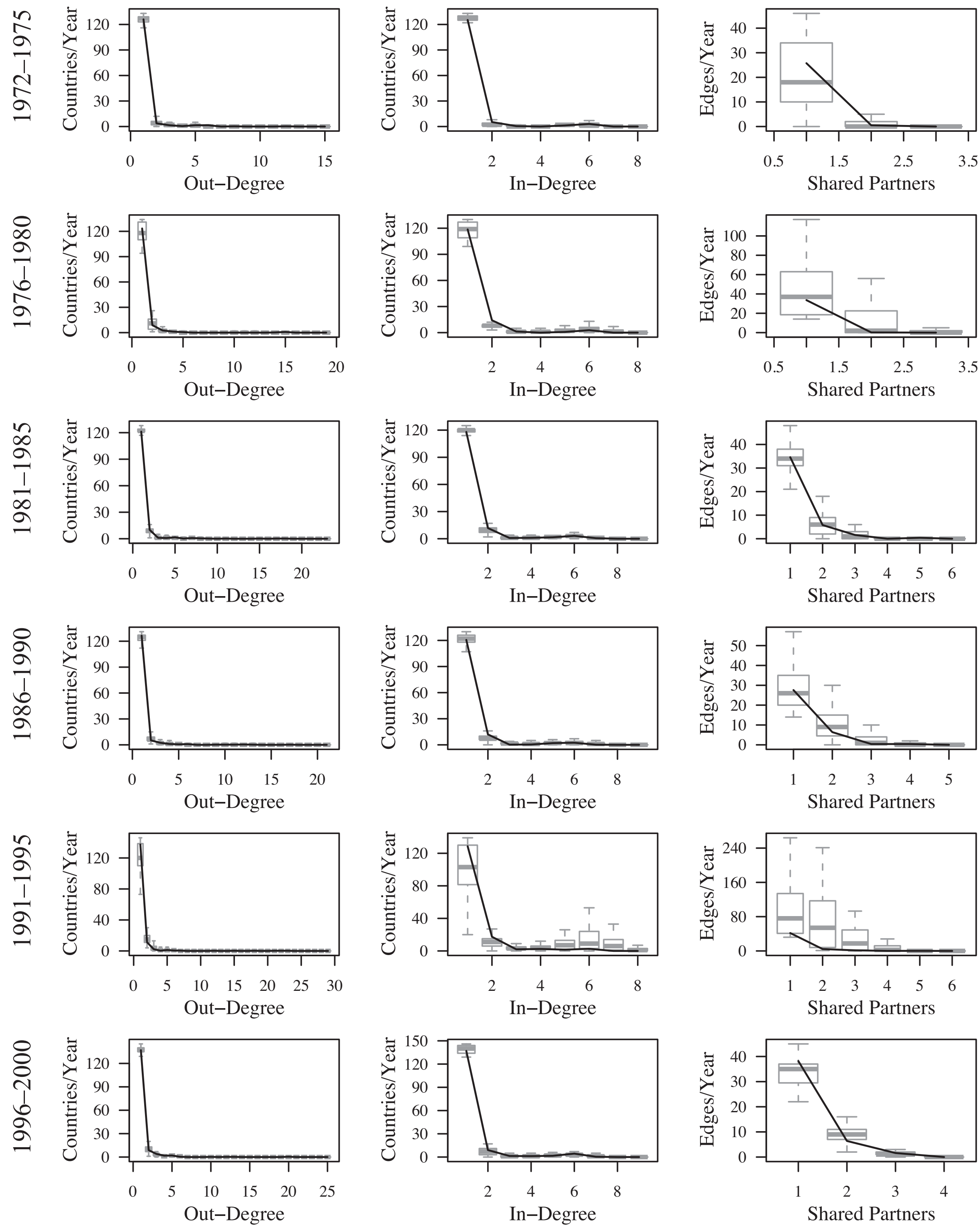

Fig. 8. Goodness of fit of smoothed TERGM models in the sanctions onset network. Boxplots depict the distribution of statistics per year, from 1000 networks simulated for each year, over the intervals indicated by rows. Networks are simulated from the average bootstrap parameter estimates in each year. Black lines indicate the average statistic values in the simulations. Black lines close to the simulated median indicate good model fit.

sanction in place against it, the probability of additional sanctions rises for most of the years in our data. Interestingly, the potential third sanction against a state is considerably more likely than the seventh. This suggests that sanctioning coalitions grow at a diminishing rate.

Turning now to the effects of a sender's other sanctions on the probability of imposing another one, we see in row 2 of Fig. 5 that the probability of imposing any sanction is very low but once a sanction has been imposed, there is an increasing rate to sanctioning activity. The unconditional probability of imposing a sanction

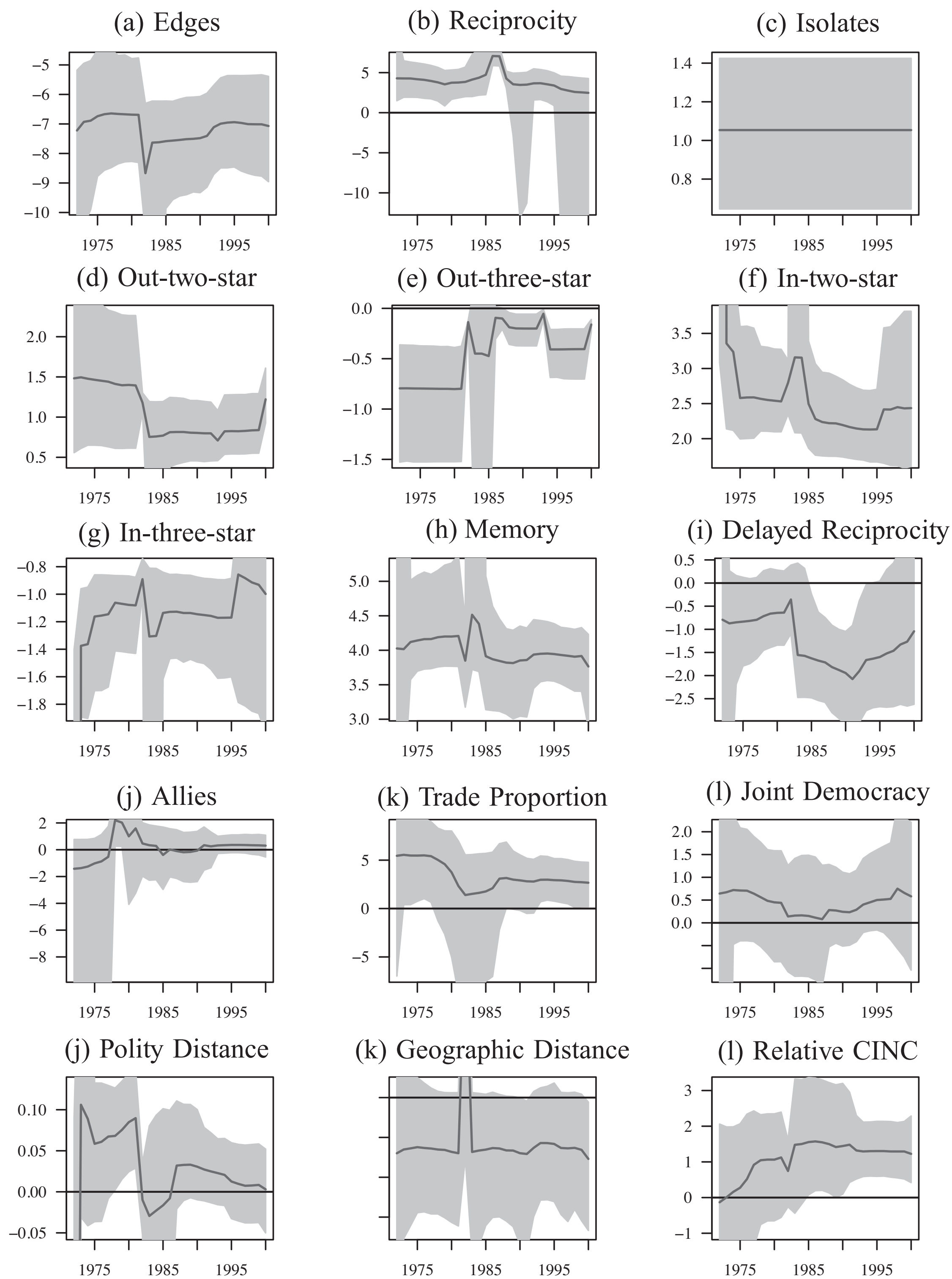

Fig. 9. Bootstrap smoothed TERGM results for the network of existing sanctions relationships. The gray line plots the magnitude (y-axis) of the smoothed coefficient over time (x-axis) while the light and dark gray bands capture the 95% and 99% confidence intervals respectively.

if a state has no sanctions in place is almost always very close to zero, highlighting that only a few states in the world ever use sanctions. However, the probability of a third sanction is slightly higher in most specifications than it is for the first. The effects become distinctly larger in most years for imposing a seventh sanction. While these results appear in both our existing sanctions and sanctions onset networks, the effects are more pronounced in the former.

By considering in- and out-stars as well as isolates, we find several new insights that provide an impetus for future research. First, we hypothesized the direction of the in-star effects but cannot claim to have formulated a comprehensive theory about the expected constellation of senders. To our knowledge, no comprehensive theoretical work exists that offers such predictions. Presumably, the inter-sender coalition dynamics are centrally

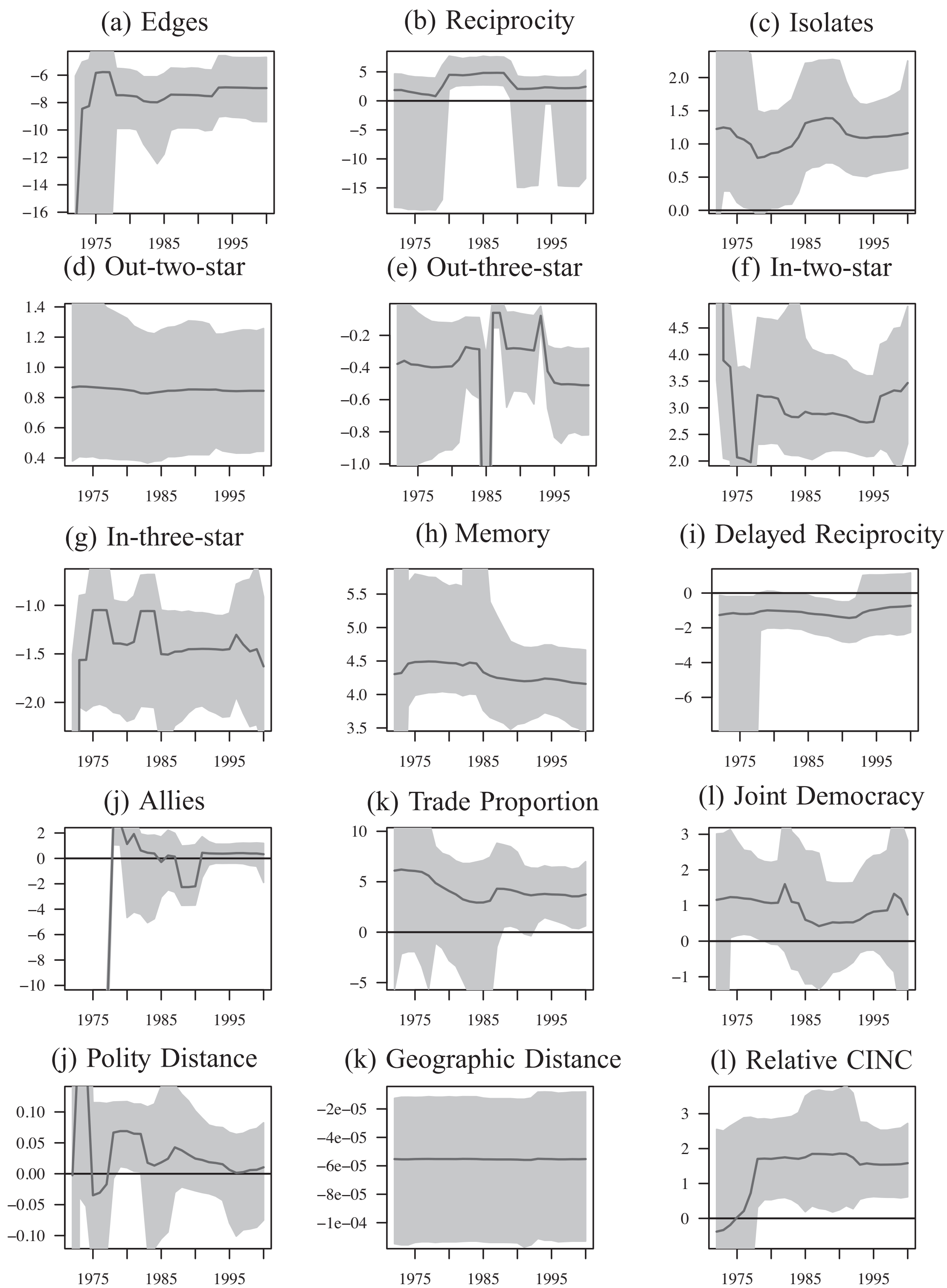

Fig. 10. Bootstrap smoothed TERGM results for the network of sanctions onset. The gray line plots the magnitude (y-axis) of the smoothed coefficient over time (x-axis) while the light and dark gray bands capture the 95% and 99% confidence intervals respectively.

important. Also, our finding that the size of the sender coalition grows at a diminishing rate is quite interesting. One may speculate that, if the benefits from sanctions are divisible among senders (perhaps in trade policy cases), then a growing number of senders should make it less beneficial for further states to join.

Second, our result about senders' sanctioning behavior (out-stars) provides an interesting nuance to the findings of Heinrich and Morgan (2012). They show that the rate of using sanctions increases at an increasing rate, but their monadic, sender-centric study does not distinguish between targets. Here, we see that the probability of sanction against a state that was hitherto not targeted increases as well. It is therefore not the case that the increasing rate of sanctioning is driven by some dispute that gave rise to initial sanctions, but that senders use sanctions widely once they have acquired the economic might necessary to use sanctions. If a state is using sanctions, then every other state in the world is at a greater risk of becoming a target.

4.3. Monadic and dyadic effects

We expected that accounting for network effects might diminish the effects of exogenous monadic and dyadic covariates, which were the main focus of most previous empirical work on sanctions. We see, in Figs. 3 and 4, that this is largely the case.

Most of our exogenous covariates, be they dyadic or monadic, are largely insignificant across time for both of our models. First, the presence of a military alliance between two countries does not affect whether there is a sanction between them (panel (j) in each figure). The alliance dummy variable, in both our models, produces an positive effect, but one that is not statistically significant in either of the sanctions networks under consideration. This is unsurprising as the literature has not produced a consistent finding for the effect of alliances on the onset of sanctions (Lektzian and Souva, 2003; Cox and Drury, 2006; Hafner-Burton and Montgomery, 2008; Whang, 2010).

Second, geographic distance also does not systematically explain the sanctions or their onset as its coefficients are insignificant in both TERGMs. There seems to be a negative effect of distance on whether there is a sanction in place (Fig. 3(k)), but it straddles insignificance; in the onset network (Fig. 4(k)), the estimates are centered around zero. These largely insignificant results comport with estimates by Lektzian and Souva (2003, 2007).

Third, neither joint democracy nor the difference in polity scores seem to systematically influence the probability of a sanction, as shown in panels (l) and (j) of Figs. 3 and 4. The insignificant results for joint democracy support earlier results from Hafner-Burton and Montgomery (2008), who showed that findings by Cox and Drury (2006) and as well as Lektzian and Souva (2003, 2007) – that joint democracy reduces the probability of sanctioning in a dyad – were confounded. Though the difference in polity scores appears to have a significant effect in Figs. 3 and 4, these findings are largely driven by the United States. In our Figs. 9 and 10, we report results from a robustness check in which we dropped the United States from the analysis: the effects of polity distance drop out of significance. This suggests the interesting caveat that polity distance has an effect for sanctions involving the United States, but not otherwise.

There are two variables that turn out statistically significant for a non-trivial portion of years in our sample: trade and the relative power between states. First, the proportion of trade between the sender and the target exerts a mostly insignificant effect on the probability of an ongoing or newly imposed sanction in the earlier years of our sample (panels (k)), but becomes mostly significant and positive for years since roughly 1990. These results lead us to reconsider those established elsewhere in the literature. Nooruddin (2002) provides evidence that, in a sample dominated by cases involving the United States, a higher proportion of trade with the United States decreases the probability that a state is going to be subject to a sanction. In a larger sample, Lektzian and Souva (2007) also provide evidence that relative trade dependence reduces the probability of sanctions onset. There are two differences between these earlier works and ours, namely that we use a dataset featuring many more non-U.S. sanctions and shorter sanction cases (TIES instead of a version of Hufbauer et al. (2007)), and that we account for endogenous dependencies. There is some evidence of a case-selection bias in earlier research. As a robustness check, we also estimated network models that exclude the United States. These estimates, which are reported in Figs. 9 and 10, show sizable and consistently statistically significant positive effects of trade proportions on sanctions. Since previous work, relying on a dataset heavily featuring the United States (Morgan et al., 2009), found negative effects, we can provide a tentative revision to previous conclusions about trade and sanctioning. In interactions involving the United States, trade moderates sanctioning tendencies whereas it promotes them when the United States is not involved. This might also explain why in our full sample, the coefficient estimates become largely positive after 1990 as roughly 15 new countries entered our sample (see Fig. 2(a)). Clearly however, these observations are tentative and a more detailed examination is beyond the scope of this study.[16]

Second, the relative CINC scores tend to be positive and statistically significant for all but the earlier years in our sample. It is interesting to note that relative CINC takes on a positive and consistently statistically significant effect around the time that the Cold War ends and major new IGOs, such as the WTO, emerge. Beyond that nuance, the result that higher relative CINC scores produce more sanctioning is intuitive.

Our results with respect to the exogenous determinants of economic sanctions suggest that previous work overstated the effects. In particular, the effects of several variables widely considered by the existing literature dropped out of statistical significance as we accounted for endogenous network effects. These findings give further credence to Cranmer and Desmarais's (2011) warning that failure to account for endogenous network dependencies in relational data can result in explanatory power being falsely attributed to covariates.

5. Concluding thoughts

We have argued that sanctions constitute a network phenomena that should be treated, both theoretically and empirically, as such. Through a number of endogenous processes, sanctions make other sanctions directly affect the likelihood of other sanctions. We have shown that theoretical consideration of the sanctions network can lead to new ideas about the role of endogenous structure in determining the evolution of the network over time and we have shown, through our empirical analysis, that these endogenous structures play a non-negligible role in the formation and explanation of the sanctions network.

We charted new theoretical territory with the consideration of the target's option to counter-sanction in order to raise costs to the sender(s) and thus potentially terminate the sanctions regime without changing its behavior or altering its trading partners. We found robust empirical support for this reciprocity effect through our TERGM analysis of both the network of sanctions onset and the network of ongoing sanctions: it seems reciprocity, both contemporaneously but also in delay, is a major determinant of the sanctions network. Having established that reciprocity is of key importance in the sanctioning process, more theoretical work is needed to understand how reciprocity affects the eventual success or failure of sanctions regimes.

We also found support and interesting nuances for our predictions about the clustering of sanctions. In- and out-stars, which we used to capture activity and ignominy, provide important insights into the sanctioners' behavior. Users of sanctions not only use them against one state, but tend to use them broadly at an increasing rate. With regard to senders' actions against specific targets, states tend to join other senders in sanctioning a target, but these coalitions grow at a diminishing rate. Small coalitions are therefore more likely than sole senders whereas large coalitions are the exception. We believe these insights provide points of departure for the little studied question of when and how inter-sender coordination and alignment occurs.

[16] This was also the time around which the World Trade Organization was founded. Perhaps the invention of the WTO allowed states to more efficiently leverage their trade portfolios for political concessions.

Acknowledgement

Many thanks to Navin Bapat, Yoshi Kobayashi, Zeev Maoz, and Cliff Morgan for helpful comments on an early draft.

Appendix A. Time-varying TERGM

In the TERGM with first-order intertemporal dependence, the probability of observing a particular instance of N^t given N^{t-1} is

$$\mathcal{P}(N^t|N^{t-1},\boldsymbol{\theta}) = \frac{1}{C(\boldsymbol{\theta}, N^{t-1})}\exp\{\boldsymbol{\theta}'\boldsymbol{\Gamma}(N^t, N^{t-1})\}, \qquad (6)$$

where $\boldsymbol{\theta} \in \mathbb{R}^p$ is the parameter vector to be estimated, $\boldsymbol{\Gamma} : N^t \to \mathbb{R}^p$ is a vector of network statistics that influence the probability of observing a particular instance of the network, and C is the normalizing constant that assures the sum over the support of N^t is unity. The probability of observing the series of $T-1$ networks given the initial network is

$$\mathcal{P}(N^2, N^3, \ldots, N^T|N^1,\boldsymbol{\theta}) = \prod_{t=2}^{T}\mathcal{P}(N^t|N^{t-1},\boldsymbol{\theta}). \qquad (7)$$

We specify $\boldsymbol{\Gamma}$ to account for endogenous features of the network – here reciprocity, activity, and ignominy – as well as temporal dynamics and exogenous covariates that have been previously found to influence sanctioning behavior.

A.1. Temporal heterogeneity in the TERGM

Eq. (7) shows that the same $\boldsymbol{\theta}$ parameterizes the ERG distribution for each year in the series. This embeds a strong assumption: that the process generating the sanctions network is constant over time, which we would like to relax. On the other hand, we do think that there will be autocorrelation as the network generating process changes, that the process generating the network at time t is related to the process at time $t-1$. Thus, we seek a method to allow the parameters of the TERGM to vary smoothly over time. Specifically, we make the assumption that the sanctions network goes through periods of stasis bounded by intermediate periods of rapid change (e.g., the collapse of the Soviet empire). However, we are uncertain about when, precisely, these periods of change occur.

We use a Bayesian change point analysis to estimate and average over our uncertainty regarding the regimes in the parameter vector. This approach allows us to partition the sequence of parameter values into a discrete number of continuous regimes with equal parameter values between the points at which regimes change, called change points. This method is well suited to our needs because it identifies, inductively, the number of stable regimes and the change points between them when both the number and locations of the change points are unknown. We use an approximation of the change point method proposed by Barry and Hartigan (1993) developed by Erdman and Emerson (2008), and implemented in the R package `bcp` (Erdman and Emerson, 2007).

Specifically, we fit a Gaussian change point model to the series corresponding to each element of $\boldsymbol{\Gamma}$ in the TERGM. The network statistics are, by construction, sufficient statistics for $\boldsymbol{\theta}$. Thus, considerable change in the network statistics indicates considerable change in $\boldsymbol{\theta}$. As a pre-processing step, we fit a Gaussian change point model to each network statistic time series using Markov chain Monte Carlo (MCMC). In each iteration of the algorithm, a $T-2$ length vector of Gaussian means is generated, such that the mean is constant between the change points in that iteration of the MCMC. We retain the last 1000 draws and encode them into regime series. A regime series is an indicator vector of length $T-2$, such that every value up to the first change point is 1, then after the first change point and up to the second change point is 2 (i.e., the second regime in the series) and so forth. We use these regime series to select the periods in which the TERGM parameters are constant.[17] The number of change points up to each year, for each statistic, in each network, is given in Fig. 6.

Desmarais and Cranmer (2012) develop a bootstrap resampling method that corrects the downward bias in coverage probabilities in the conventional standard errors for maximum pseudolikelihood estimators. This method works by resampling entire networks from the time series with replacement. In each of the 1000 bootstrap iterations, we use one of the regime series to identify periods in which the parameters are restricted to be the same value. By sampling a new regime series in each bootstrap iteration, we account for variability in the change-point model via the bootstrap re-sampling. Thus, time periods close to each other are more likely to be in the same regime than those far apart. By sampling over change point regimes, we account for our uncertainty regarding the change point locations and smooth the TERGM estimates over time.

Appendix B. Goodness of fit

We consider how well the models fit the data. Model fit diagnostics, presented in Figs. 7 and 8, indicate that our estimates accurately recover the structure of both sanctions networks over time. We use the fit to the in- and out-degree distributions as well as the shared partners distributions to diagnose the fit produced by our specification and pseudolikelihood estimation procedure. To do so, we simulated networks from the distribution described by the TERGM parameters at each time point. If the model fits well, we should not see the empirical features of the network depart markedly from the center of the distribution of feature values simulated from our model. Consider the fitted model to be the null expectation for the empirical value of the feature. If the model does not fit well, then the empirical feature will be in the tails of the feature distribution implied by the model. This is formalized as the notion of a predictive p-value, which can be used to diagnose the fit of models that imply probability distributions for the data (Desmarais, 2012). The fit to the degree distributions serves as a check regarding whether our model recovers the large stars in the network and the shared partners distribution can be used to diagnose whether we have misspecified the model by excluding triadic/transitive effects. Overall, the fit of the smoothed TERGM for both networks is strong. The only interval in which there is noticeable lack of fit is 1991–1995 (rows 5).[18] Since this period represents only approximately 17% of the data under study, we are hesitant to adjust the model to account for this discrepancy in the interest of avoiding over-fitting the data.

Appendix C. Robustness analysis

In this appendix, we report analyses that serve as robustness checks. Specifically, we replicate the analyses reported above excluding the U.S. We also replicate all analyses, without the time-varying component, on a network series constructed from six-month intervals. A theme throughout the robustness analyses is that the estimates are less stable over time because removing the U.S. and reducing the time interval over which we aggregate both

[17] Ideally, we would use a TERGM change point model, in which inference regarding the change points and $\boldsymbol{\theta}$ was conducted simultaneously. We are not aware of the theoretical development or implementation of such a model, and the derivation is beyond the scope of the current article.

[18] It remains to be studied what it is about this time-period that makes the TERGM fit inadequately. One reviewer suggested and we share this view that this might be associated with the creation of the World Trade Organization, which was a major institutional innovation and had profound impact on trade relations.

Table 2
TERGM estimates with the network defined on six-month intervals including all countries. Models include one estimate per network statistic, covering the entire time period. 1000 bootstrap iterations are used to construct the 95% confidence intervals. *Note*: All coefficients are different from zero at the two-tailed, 0.05 level of significance.

	Existing sanctions		Sanctions onset	
	Estimate	95% CI	Estimate	95% CI
Edges	−9.45	[−10.01, −9.03]	−10.46	[−11.03, −10.02]
Reciprocity	2.26	[1.90, 2.69]	2.11	[1.59, 2.78]
Isolates	1.23	[1.01, 1.41]	0.72	[0.51, 0.92]
Out-two-star	0.42	[0.39, 0.49]	0.62	[0.59, 0.70]
Out-three-star	−0.02	[−0.03, −0.02]	−0.04	[−0.05, −0.04]
In-two-star	2.30	[2.09, 2.59]	3.02	[2.78, 3.28]
In-three-star	−0.75	[−0.88, −0.64]	−1.05	[−1.18, −0.94]
Memory	0.21	[0.06, 0.38]	0.43	[0.21, 0.71]
Delayed reciprocity	−0.20	[−0.37, −0.05]	−0.42	[−0.70, −0.21]
Trade proportion	3.11	[2.58, 3.71]	3.07	[2.48, 3.56]
Allies	0.72	[0.50, 0.93]	0.87	[0.62, 1.14]
Geographic distance	$-5e^{-05}$	[$-7e^{-05}$, $-3e^{-05}$]	$-6e^{-05}$	[$-8e^{-05}$, $-4e^{-05}$]
Joint democracy	0.75	[0.47, 0.96]	0.78	[0.48, 1.06]
Polity distance	0.07	[0.06, 0.09]	0.07	[0.05, 0.08]
Relative CINC	1.82	[1.51, 2.16]	1.96	[1.56, 2.39]

Table 3
TERGM estimates with the network defined on six-month intervals excluding the United States. Models include one estimate per network statistic, covering the entire time period. 1000 bootstrap iterations are used to construct the 95% confidence intervals. *Note*: Confidence intervals for effects that are NOT significant at the 0.05 level are bolded.

	Existing sanctions		Sanctions onset	
	Estimate	95% CI	Estimate	95% CI
Edges	−8.92	[−9.50, −8.50]	−9.66	[$-1e^{15}$, −9.15]
Reciprocity	3.30	[2.76, 3.91]	2.96	[2.34, $4e^{14}$]
Isolates	1.33	[1.09, 1.52]	1.17	**[$-2e^{13}$, 1.44]**
Out-two-star	0.61	[0.53, 0.75]	0.57	[0.44, $9e^{13}$]
Out-three-star	−0.07	[−0.14, −0.05]	−0.06	[$-1e^{13}$, −0.01]
In-two-star	2.86	[2.61, 3.12]	3.44	[3.18, $1e^{14}$]
In-three-star	−1.22	[−1.36, −1.09]	−1.54	[$-1e^{14}$, −1.37]
Memory	0.30	[0.00, 0.64]	0.21	**[−0.03, $2e^{11}$]**
Delayed reciprocity	−0.29	[−0.64, $-5e^{-04}$]	−0.21	**[$-2e^{11}$, 0.03]**
Trade proportion	5.37	[4.51, 5.97]	5.82	[4.99, 6.72]
Allies	0.35	[0.09, 0.59]	0.48	**[$-1e^{14}$, 0.78]**
Geographic distance	$-7e^{-05}$	[$-9e^{-05}$, $-5e^{-05}$]	$-8e^{-05}$	[$-6e^{9}$, $-6e^{-05}$]
Joint democracy	0.86731	[0.60, 1.13]	1.16	**[$-1e^{14}$, 1.43]**
Polity distance	0.05	[0.04, 0.07]	0.05	[0.03, 0.07]
Relative CINC	1.66	[1.30, 2.07]	2.09	[1.57, $5e^{12}$]

cause the network to become more sparse, which makes it more difficult to identify the parameters.

The annual results excluding the U.S. are reported in Figs. 9 and 10. Overall, the network effects exhibit the same general patterns as those including the U.S. The reciprocity effect is positive while delayed reciprocity is negative. The two-star effects are consistently positive and three star effects are negative. There is positive memory in the network and a persistent positive parameter on isolates. In terms of exogenous covariates, the stability in the polity distance effect is notably less stable once the U.S. is removed from the analysis.

Tables 2 and 3 give the results with the networks defined on six-month intervals. Due to the sparsity of these networks, it was not possible to reliably identify the time-varying effects. However, we can inspect the constant effects over the period under study for agreement with the time-varying models. The models in Table 2 are most comparable to the ones we report in the main manuscript. All of the effects are statistically significant at the 0.05 level, which is likely an artifact of estimating one set of parameters that covers 58 years. However, the signs of the effects agree with our findings in the time-varying, annual models. The reciprocity effect is positive, while delayed reciprocity is negative. The two-star effects are positive and three star effects are negative. There is positive memory in the network and a positive parameter on isolates.

The TERGM's sensitivity to sparsity is illustrated clearly in the Sanctions Onset model, excluding the U.S. from the network, given in Table 3. This network routinely has a median of around 20 edges, so it does not provide substantial structure necessary to infer fifteen parameters. The extreme bounds exhibited in the bootstrap confidence intervals illustrate that the six-month interval, though providing more networks, does not provide more stable results than the annual interval.

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