The Role of the Global Telecommunications Network in Bridging Economic and Political Divides, 1989 to 1999

By Peter Monge and Sorin Adam Matei

This research explores the role of telecommunicative globalization in bridging world political and economic divides. Current approaches define globalization primarily in terms of increased density of network ties between nations, a perspective the present article extends into a more comprehensive framework. Exchange and balance theories are combined into a multitheoretical, multilevel model consisting of hypotheses regarding the mutuality, transitivity, and cyclicality of telephonic flows between nations that differed in economic and democratic attributes in 1989 and 1999. Statistical p* *procedures demonstrate that tendencies toward mutuality and transitivity in the world telecommunications network have significantly increased between 1989 and 1999. These findings hold both for telecommunication flows among a full set of 110 nations of the world and for links between rich and poor and democratic and nondemocratic nations. The article concludes by examining implications of these results for network globalization theories.*

Between 1989 and 1999 international telephonic traffic quadrupled (Telegeography, 2001). A number of factors have contributed to this explosion in telecommunication flows. The cost of international calls has decreased in some Western economies by a factor of 10 (ITU, 1999, 2000; OECD, 2001). Technological advances have put more transmission capacity in the ground or in space at lower costs (Held, McGrew, Goldblatt, & Perraton, 1999; Telegeography, 2001). Deregulation increased competition and spurred price wars between a plethora of new telecommunications companies. Finally, for the first time in many decades the democratic transformation of Russia and Eastern Europe has provided millions of people

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the opportunity to communicate freely across borders. Disappearance of totalitarianism as a global threat has eased international tensions, facilitating cross-national communication not only between Eastern and Western European nations, but also among many African, Middle Eastern, and Asian countries that traditionally aligned themselves with one of the two main ideological camps.

A natural outcome of these processes has been increased telephonic traffic between people living or working across national borders. For example, in 1999 Romanians, Chinese, and Poles increased the time they spent talking on the phone with people in other countries by a factor of 6 to 7 over the amount they communicated in 1989. Angola, Benin, and Taiwan have equally benefited from these transformations (Telegeography, 2001).

The transformations that affect the telecommunications arena go beyond simple quantitative traffic increase. The structure of the world telecommunications system seems to have changed in important ways, too (Barnett, 2001). The skeleton of this new world order is composed of a denser and better interconnected network of connections between countries. The goal of this article is to demonstrate that fundamental structural changes have occurred in the network and that these changes can be explained, within a network framework, by a transformationalist theory of globalization.

The current shift in the telecommunications landscape, which we will describe in greater detail below, is just one aspect of a larger process of social, economic, and political transformation now commonly called globalization (Monge, 1998). Over the past quarter century a number of theories have been developed about the meaning and impact of the process of globalization (Castells, 1996; Held et al., 1999; Hirst & Thompson, 1996; Robertson, 1992; Scholte, 2000; Wallerstein, 1974). Giddens (2000) organizes these efforts into three groups. First are the hyperglobalists, represented by the work of Amin (1997), McChesney (1997), Ohmae (1995), or Wriston (1992), who argue that the world is evermore tightly meshed in the net of the global economy. According to their right or left wing ideology, this process will have beneficial or deleterious effects. The second group, labeled the skeptics, denies the existence of emergent globalization in favor of heightened internationalization, thus rejecting the idea of a "globalization impact" per se (e.g., Hirst & Thompson, 1996). Finally, the transformationalists argue that globalization is a powerful force that is fundamentally changing the world order, although they recognize that these transformations should be understood as a give-and-take process in which economic globalization is both a cause and an effect (Held & McGrew, 2002).

Among the transformationalists, the most comprehensive theory is that of David Held and his colleagues (Held et al., 1999). They define globalization "as *the spatial organization of social relations and transactions—assessed in terms of their extensity, intensity, velocity, and impact-generating transcontinental or interregional flows and networks of activity, interaction, and the exercise of power*" (p. 16, italics in the original). Thus, globalization is conceptualized as the density of multiplexed connections that tie together different nation-states, multinational corporations, religions, ethnicities, and other human groupings. It is through these rich connections that capital, labor, culture, and other human products flow and are integrated into a global system. Further, these networks are theorized to exist at multiple levels in the global system, thus creating a complex, multilevel, multifaceted web of flows.

Held et al. (1999) theorized that globalization means more than simple increases in the rate at which goods, people, money, or information flow across borders. It also means that individuals and nations make decisions, organize themselves, and share in the fruits of the global revolution differently. Held et al.'s most concise expression of this idea is that globalization has "four analytically distinct types of impacts: *decisional, institutional, distributive, and structural*" (p. 18, italics in the original).

Although all four types of impacts are important, the present research focuses on the structural and distributive aspects. *Distributive impacts* refer to processes that redirect and potentially bias the exchange of products and services around the world. *Structural changes* refer to shifts in the basic arrangements of relationships between nations. For some analysts (Amin, 1997), distributive and structural impacts are part of a zero-sum game: While select people, groups, nations, and regions of the world get more and better products and services, others get fewer and poorer ones. The structural changes mean, most often, that the privileged become more privileged, while the underprivileged become less so. For other researchers these configurations and processes are more complicated (Barnett, 2001; Norris, 2001).

Held's distributive-structural impact concepts, which we operationalize in this article, is part of the long-standing discussion about the extension and causes of the digital and economic divides of the world (Mansell & Wehn, 1998; Norris, 2001). This debate has traditionally translated into an argument about why some parts of the world have a higher concentration of telecommunicative and digital products and services than other parts (Norris, 2001) and whether the structural arrangements that emerge from these distributions can be overcome. Held et al's (1999) theory proposes that in trying to understand distribution/structural differentials our attention should be focused on degree of connectedness—in terms of intensity, extension, and velocity. Thus, Held et al.'s transformational theory can be used to study phenomena typically analyzed under the rubric of the digital divide. However, the Held et al. theory omits an important factor. It does not provide a theoretical explanation for what creates the connections and flows, that is, the structure, and whether these structural differentials tend to deepen or not. Thus, to solve this problem we turn to recent work that provides the basis for theoretical explanations for global telecommunications network structure and flow.

Structural changes in the world telecommunications system can usefully be described using social network theory. According to Monge and Contractor (2003), at its core "network analysis consists of applying a set of relations to an identified set of entities" (p. 30). Roads link different points of origin with different destinations, and electrical grids connect power sources and outlets. In the present research, countries are considered as nodes of a global network of telecommunicative traffic.

The structure of the world telecommunication system is very complex, including a variety of actors and levels of analysis (Monge & Contractor, 2003). These can go from very fine grained, that is, individuals, to larger and larger structures, including regional, national, continental, or intercontinental nodes. Because the nation-state is still one of the more important sites of political regulation and business activity, we examine the flows between nations. Thus, we are interested in understanding the structural changes in the world telecommunicative system, considering it as a complex, multilayered network established between national nodes. The label "telecommunicative system" covers a number of realities, including both the physical networks and the content transacted by them. The later can be further operationalized as a number of flows, differentiated by type. Bits, minutes, or kinds of content (voice, data, and images) are just some of the possible distinctions that can be made. Of these diverse phenomena we have further focused on telephonic traffic between nations, more precisely on the amount of voice traffic that flows between various states. This choice is determined by the fact that voice traffic between nations incorporates a variety of phenomena: social, economic, cultural, and political. In contrast to data traffic, which might be more strongly influenced by business and economic structures of a nation, voice traffic reflects both the level of wealth in a country—richer people can afford to spend more on international calls—and the political climate in the nation—authoritarian and totalitarian nations limit or even forbid telephone calls across borders.

Our choice for network analysis is also justified by the fact that this analytic approach is distinguished by its emphasis on relationships—linkages between nodes. This focus stands in sharp contrast to other areas of the social sciences, which have tended to study "attributes," the characteristics of people, groups, and organizations, in isolation from the relations between them (Monge & Contractor, 2003). Relations possess a number of important properties, including the number of entities involved, strength, symmetry, transitivity, reciprocity, and multiplexity.[1] In this study we focus on three specific types of network arrangements: mutuality, transitivity, and cyclicality. Each of these network structures denotes a shift in the nature of relationships among nation-states. We describe the relationships, with their theoretical justifications, in the sections that follow.

Dependency, Exchange, and Balance Theories as Explanations for Telecommunication Flows

Dependency Theory

A possible explanation for the pattern of global telecommunication flow is provided by a form of dependency theory known as world-systems theory (Barnett, Salisbury, Kim, & Langhorne, 1999; Chase-Dunn, 1998; Chirot, 1982; Wallerstein, 1974), which posits that the world is organized according to a core-periphery model. A number of countries extract a larger economic and political advantage than their "fair share" by being centrally positioned in the world economic and telecommunicative networks (Smith & White, 1992). Moreover, while central na-

[1] Mathematical formulae for the network metrics used in this article can be found in most standard network texts, such as Wasserman and Faust (1994) or Scott (2000).

tions are strengthened by their centrality, peripheral nations are weakened by their economic and technological marginality. The digital and economic divides are seen as structural, not conjectural. Globalization, in this respect, is an old rather than new phenomenon because it is, to a certain extent, coterminous with capitalist industrialization.

Translated into telecommunicative terms, dependency theory advances the idea that as this world-system becomes more centralized at the core, it will become more "rarefied," even fragmented, at the periphery (Amin, 1997; McChesney, 1997). Globalization isolates marginal countries. They are left behind in the economic race, lacking exposure to the international traffic of ideas, information, and knowledge (Amin, 1997). Part of the reason for this is that there is less mutuality in the flows in the linkages. Further, this type of arrangement suggests less balance in the network, that is, less mutual flow among different regions of the network, both in terms of cycles and in terms of transitivity.

Another facet of this theoretical approach is that telecommunicative inequalities are not only a result of economic divides but also of political ones, especially those created by colonialism and their successor social orders. Third world countries rarely establish connections among themselves and especially across political divides. Their connections are mostly with their former colonial or ideological masters—in a hub and spokes pattern—such that lateral connections have to go through the center, that is, the wheel of the world of telecommunications lacks an outer rim (Barnett, 2001).

A number of researchers are now challenging this paradigm, including some from its own ranks. Barnett (2001) noted that there have been significant shifts from the periphery toward the center, and that the composition of the periphery is far from stable over time because upward mobility is possible. He proposes a less deterministic theoretical model, whereby future trajectories in the world telecommunication system are not necessarily influenced by location in the world-system. Moreover, Barnett (2001) found that there is an intense traffic within regions ("within the spokes"), confirming other studies that talk about the rise of regionalism within the process of globalization (Nierop, 1994; Snyder & Kick, 1979).

Exchange Theory

An alternative explanation to dependency theory that can account for the patterns of global telecommunication flow is exchange theory. Monge and Contractor (2003) explained that social exchange theory, originally developed by Homans (1974) and Blau (1964), seeks to explain human action by a calculus of exchange of material or information resources. In its original formulation, social exchange theory attempted to explain the likelihood of a dyadic relationship based on the supply and demand of resources that each member of the dyad had to offer. Emerson (1972) extended this original formulation beyond the dyad, arguing that in order to examine the potential of exchange, it was critical to examine the larger network within which the dyad was embedded. Since then, several scholars have developed this perspective into what is now commonly referred to as network exchange theory (Bienenstock & Bonacich, 1997; Cook & Whitmeyer, 1992; Skvoretz & Willer, 1993).

Network exchange theory posits that the bargaining power of participants is a function of the extent to which they are vulnerable to exclusion from communication and other exchanges within the network. The argument is that individuals, companies, or nations forge network links on the basis of their understanding of the relative costs and returns in exchanging their investments with others in the network. In line with this reasoning we advance the idea that a global order emerges not only when flows become more intense or extensive, but also when they become increasingly mutual. *Mutuality* (link reciprocity), or equality of exchange, represents a fundamental structural transformation because it also marks a moment when power differentials are challenged. An international order cannot be called global until the multitude of links that it creates are more equally balanced and distributed than one dominated by nonreciprocal, unequal dependent exchanges (Micklethwait & Wooldridge, 2000). In essence, globalization happens not only when increasing numbers of people and nations have the chance to reach out to others but also when all partners to the conversations initiate these connections.

Some might say that it matters little who initiates a connection if the goal—buying a product, spreading the word—is achieved. However, as in general economics, who has the upper hand in the transaction matters: There can be "sellers' markets" and "buyers' markets." In telecommunications, the presence or absence of reciprocity makes the difference between international actor and international client—in the old, Latin sense of the word. This reasoning leads to the following:

> H1a: As predicted by exchange theory and counter to dependency theory, mutuality will be a statistically significant predictor of the configuration of relational ties in the global telecommunications network, as revealed by traffic patterns.

Mutuality is also important because it allows us to focus on the distributive impact of globalization over time, that is, on whether mutuality (reciprocity) has increased over the past 10 years. From an exchange theory perspective, as the telecommunication network becomes denser and the volume and flow of traffic greater, the likelihood of reciprocity should commensurately increase, leading to:

> H1b: Mutuality is more likely to occur as a statistically significant predictor of relational ties of the global telecommunications network in 1999 than 1989.

Balance Theories

The structure of the world telecommunications network is very complex, reflecting countries' memberships in various economic, social, political, and military blocks. In consequence, the network can rarely be explained just by looking at nations' dyadic relationships. Instead, it is important to pay attention to more sophisticated arrangements, which take into account triads or higher levels of network organization.

Taking the triad as the simplest social arrangement, sociologists have long noticed that individuals have a propensity to co-orient to one another in terms of third parties (Simmel, 1964). In other words, if two parties establish a relationship, they are also likely to connect to at least one other common partner (Feld & Elmore, 1982; Freilich, 1964; Gulati & Gargiulo, 1999). In network terms this can be explained as an effect of balance theory (Scott, 2000).

Balance in network structures can be measured by looking at the degree to which transitive and cyclical triads occur. Transitive triads are those in which $I \rightarrow J \rightarrow K \leftarrow I$. Cyclical triads are closed loops, $I \rightarrow J \rightarrow K \rightarrow I$. Applying transitivity and cyclicality to telecommunication flows, the issue becomes: If central country I establishes a link with marginal country J and another link to marginal country K, will J also connect to K? A transitive triad emerges when I initiates both connections, and J, the first country contacted, also connects to K. In a cyclical triad I initiates the connection to J, which initiates a connection to K, which, in turn, links back to I. Transitivity and cyclicality are employed in this research to indicate the extent to which balance has developed across the divides in the world telecommunications infrastructure. This leads to:

> H2a: As predicted by balance theory, transitivity is likely to be a statistically significant predictor of relational ties in the global telecommunications network.

Similar to the reasoning advanced for mutuality, we also expect that transitivity had a greater explanatory power in 1999 compared to 1989:

> H2b: Transitivity is more likely to occur as a statistically significant predictor of relational ties of the global telecommunications network in 1999 than in 1989.

Hypotheses 3a and 3b apply the same reasoning to cyclicality:

> H3a: As predicted by balance theory, cyclicality is likely to be a statistically significant predictor of relational ties in the global telecommunications network.

> H3b: Cyclicality is more likely to occur as a statistically significant predictor of relational ties of the global telecommunications network in 1999 than in 1989.

Exogenous Attributes as Predictors of the Global Telecommunications Network

The effects of exchange and balance theories—that is, presence or absence of mutuality, transitivity, or cyclicality—become particularly interesting when there are power and resource differentials between the network nodes. In the terms proposed by exchange theory, if a superior node connects to an inferior one, what is the likelihood that the tie will be reciprocated? Similarly, in balance theory terms, if the inferior node connects to a superior one, what are the chances that it will connect to a third node—also inferior and also connected to the superior node—to compensate for the imbalance between the two inferior nodes and the superior one?

Applied to the present research problem, the questions can be formulated as follows: When a poor or less democratic country establishes a telecommunicative relationship with a richer or more democratic nation, how likely is it that the later will reciprocate the tie? Or, how likely is it that this tie will lead the inferior partner to establish another link with a country similar to it and similarly connected to the advanced country in order to balance the triad?

Asking the question, "What is the structure of the world telecommunications network" in conditions of unequal distribution of power and resources is not just intrinsically interesting. It also helps us go beyond the endogenous explanatory forces (i.e., the configurations internal to the networks alone) shaping telecommunication flows. We can now inquire about the exogenous forces that shape the network in terms of the attributes of the nodes, in this case, the countries that comprise the world system. Two such attributes, economic development and democratic achievement, are worth exploring because they represent important fault lines in the global landscape (Norris, 2001).

The Economic Divide

The economic divide is the one most frequently discussed in the development literature (Firebaugh, 1999). It is important because the larger the economic gap between nations, the larger the distance between their abilities to access telecommunicative products and services and, in consequence, to participate in the worldwide whirlwind of communication. Is, however, a country's position on one or the other side of the economic divide destiny? Did the likelihood of establishing mutual, transitive, or cyclical telecommunication flows across the economic divide increase or decrease during the globalization decade of 1989–1999? The reasoning presented above leads us to believe that these ties are, in fact, more likely to occur and leads to:

> H4a, 4b, 4c: Tendencies to mutuality (4a), transitivity (4b), and cyclicality (4c) explain the observed structure of telecommunicative ties between rich and poor countries better in 1999 than in 1989.

Democracy

Relatively little discussion, especially under the rubric of "global divide," has focused on the role democratic institutions and practices play in shaping the global telecommunications flows, although political arrangements are among the most frequent obstacles to globalization. The "democratic divide" deserves our attention because it translates into a fork in the path to development. A democracy, unlike an authoritarian state, will allow quite different ideas, goods, and people to be exchanged with the outside world. As Przeworski et al. (2000) showed, this does matter in terms of economic development. Although democracy does not automatically translate into economic development, if established and maintained over long periods of time, it will make a considerable difference in the economic and technological fate of a nation.

The 1989 Eastern European revolutions lifted the Iron Curtain. This sent ample reverberations throughout the world, easing international tensions and sparking secondary waves of democratization. The globalization decade has witnessed a climate of greater interaction across the political divide, even among countries still at the opposite end of the spectrum. This should have energized the tendency toward mutuality, transitivity, and cyclicality of telecommunicative ties between countries situated on different sides of the democratic divide. This leads to the following set of hypotheses:

> H5a, 5b, 5c: Tendencies to mutuality (5a), transitivity (5b), and cyclicality (5c) explain the observed structure of telecommunicative ties between democratic and nondemocratic countries better in 1999 than in 1989.

Method

Research Strategy

Data for the present research are but one of many possible instantiations of the globalization process: the network of telephonic traffic between nations measured at two points in time, 1989 and 1999. In the Held et al. (1999) framework, globalization is revealed by increased network extensivity, which is called "density" in network theory. Indeed, the present data show increased density: In 1999 there were 421 pairs of countries in the world in which at least one of the partners' outgoing traffic to the other one exceeded 5% of their volume of outgoing international calls, compared to 390 pairs in 1989 (Telegeography, 2001). Similarly, Barnett (2001) and Barnett et al. (1999) have reported increased call volume and network density during this decade. However, the hypotheses formulated above test and extend the Held et al. theory, addressing the larger issue of whether the patterns of connections between countries from different sides of the world's social, economic, or technological divides can be explained by a tendency of the telecommunication network toward mutuality, transitivity, and cyclicality.

Monge and Contractor (2003) developed a Multitheoretical Multilevel (MTML) model that facilitates empirical examination of multiple theories at multiple levels of analysis for network phenomena, such as global telecommunications. Each of these, such as balance theory and exchange theory, may help to explain and predict the occurrence of *different endogenous components* of network structures, that is, internal network configurations. The MTML model examines all theoretically relevant levels that compose a specific network, including dyads, triads, cliques, and so on. Also, the MTML framework permits identification of the role that the *attributes* of network nodes play in explaining the particular manifestation of the network being examined. This is mainly achieved by creating *block models* by which the network is divided into subnetworks on the basis of cases that possess common characteristics (Anderson, Wasserman, & Crouch, 1999). Presence of specific network structures can be assessed both within and between blocks.

The Data Set and the Endogenous Focal Telecommunications Network

The data analyzed in this article were acquired from the International Telecommunications Union (1999), Telegeography (2001), the World Bank (2001), and Freedom House (1999).

The telecommunications networks. The ITU and Telegeography data sets provide information about direction of international telephone traffic between 110 countries for 1999 and between 107 countries for 1989, representing about 80% of the world population. The 1989 and 1999 data sets are the focal networks to be explained by theoretical endogenous network structures and by exogenous factors such as nodal attributes and other networks. We organized data into two adjacency matrices. In each matrix, there are 110 (107) rows and 110 (107) columns, corresponding to the number of countries in each data set.

A valid connection between two countries was found and marked as a 1 if the amount of traffic measured as minutes of voice telephonic traffic from the sending to the receiving country represented more than 5% of the outgoing traffic of the sending country.[2] This decision was justified by the fact that, based on our preliminary analyses, nations of the world make most of their international calls to about four other countries. The outgoing traffic sent to these nations represents 80% of the total of minutes spent on international phone calls in each country. This means that the outgoing telephonic traffic takes the form of a J-shaped logarithmic distribution: the four most intensely called nations fall under the steep segment of the curve, while most of the other destination nations, which receive very few calls, fall under the long and gentle portion of the curve. Twenty percent of each country's outgoing traffic is thus divided among 100 nations, which theoretically means that on average each of them receives about .2% of a nation's outgoing traffic. In consequence, we decided to include in our matrix only the countries found under the steep portion of the curve, which typically represent 5% or more of the outgoing traffic. This dichotomization procedure is generally recommended for logarithmically distributed variables (Streiner, 2002).

The Exogenous Variables and Networks

The two exogenous variables refer to economic and political attributes, GDP/capita and democratic status, which are used in formulating Hypotheses 4a–c and 5a–c. They are used to operationalize the block models required by the MTML methodology.

Economic development. This was measured using Gross Domestic Product (GDP) per capita, obtained from the World Bank Development Indicators database. A country was assigned a GDP score of 3 if it was ranked in the upper third, 2 if in the middle third, and 1 if in the lowest third of GDP per capita ranking of 110 (107) countries. The present analysis focuses on connections countries in the first two (rich and medium rich) categories establish with nations in the third (poor) category. The first two groups are labeled as "rich" nations and the other category as "poor."

Democracy. Political achievement (level of democracy) is a rank-order measure produced by the Freedom House, a nonprofit organization. The index score measures the democratic process on a 1 to 3 scale: 1 represents *nondemocratic countries,* 2 are *partially democratic nations,* and 3 are *fully democratic nations.* A country is assigned its score by coders who assess presence of freedom and the

[2] Thus, they are directed links. Summary statistics and raw data are available from the authors.

opportunity to exercise a number of political rights and civil liberties (Freedom House, 1999; Karatnycky, 1994). The index is not just a measure of formal democracy, but also of democratic performance in a substantive way, including both formal rights and degree of effective civic and political participation (e.g., gender equity). The present analysis examines telecommunicative relationships among democratic or partially democratic (labeled "democratic") countries with the nondemocratic nations.

Analysis

Recently developed *p** analytic techniques (Wasserman & Pattison, 1996) and software packages—Multinet (Seary & Richards, 2000)—applied to networks provide the tools for generating inferential claims regarding the statistical significance of theoretical mechanisms and nodal attributes as specified by the MTML model. These *p** methodologies offer a synthetic characterization of the probability distribution for a random graph, combining a variant of logistic regression with network analysis (Anderson et al., 1999; Monge & Contractor, 2003; Wasserman & Pattison, 1996).

Typically, *p** models postulate that the probability of observed links in a network is proportional to an exponential function of a linear combination of the statistics for various types of network structures. The dependent variable in such a model is the logit or log odds of the probability that a relational tie is present (Anderson et al., 1999). The explanatory variables are hypothesized structural network features, such as choice, mutuality, transitivity, or cyclicality, expressed as a vector of parameter estimates for these types of network structures in the entire network (Wasserman & Pattison, 1996). A *p** model indicates if tendencies to different types of theoretical network structures can explain the observed links in the network. This type of analysis can produce parameter estimates for the entire network, or for subsets of nodes, by adding to the model exogenous variables derived from node attributes (in the present case, wealth or political regime; Anderson et al., 1999; Wasserman & Pattison, 1996). The parameters obtained through this version of *p** analysis are called *block parameters,* representing the odds that a tie between countries with specified attributes (e.g., rich vs. poor) will occur when predicted by the tendency to various types of network structures (e.g., dependency, mutuality, transitivity, or cyclicality) in that subset of links (i.e., between rich and poor countries). Block parameters are usually estimated above and beyond effects in the network as a whole.

The hypotheses were tested employing three basic *p** models, each using four network statistics as explanatory endogenous variables (choice—intercept, mutuality, transitivity, and cyclicality). The first model tests hypotheses 1a–b, 2a–b, and 3a–b, which assume a positive and increasing impact of mutuality, transitivity, and cyclicality on the world telecommunications network in general. The second model tested hypotheses 4a–c, that there would be a positive and increased impact of the same network structures on links between rich and poor nations, and the third model examined hypotheses 5a–c, that the network structures would have a positive and increased impact on links between democratic and nondemocratic nations. Each of these models estimates the impact of tendency to mutuality, transitivity, and cyclicality on the odds that a link would be observed between nations in 1989 and in 1999. The difference between models is that, whereas the first one predicts the links at year level, the second and the third use block modeling for generating more specific parameter estimates for the links between rich and poor and democratic versus nondemocratic nations.

In all three cases the initial model fitting has been done with a data set created by combining the adjacency matrices for the 1989 and 1999 networks into a "disconnected matrix." This data set design, similar to the one recommended by Anderson, Wasserman, and Crouch (1999) for multiple network analysis produced a 217 x 217 adjacency matrix, with the two networks of interest on the principal diagonal and two random networks of similar sparseness on the off diagonal.[3] The two random networks were introduced into the disconnected matrix to facilitate fitting both global and block-model parameters in MultiNet, the software package used for analysis.[4]

Generating models for both years simultaneously presents the advantage of allowing comparison of parameter estimates across years and determination of whether tendency to a specific network structure explains to a greater or a lesser extent the observed links in 1999 compared to 1989. This procedure also provides estimates of parameters controlling for other types of network structures and for global effects. This means that it is possible to determine the extent to which tendency to a specific network structure explains the observed links while taking into account the fact that other, concurrent network structures might also explain the same observed reality.

Significance testing for the differences between the 1989 and 1999 parameters was performed using two procedures, which both required further fitting of the three base models. First, we constrained the year matrices, in the first, and the blocks of interest in the second and third models, to be equal. This procedure, similar to that used in structural equation modeling for determining if significant group differences exist (Bollen, 1989), estimates the parameters for the 2 years (or for the two blocks) as if they were homogeneous (equal). We then compare the central goodness of fit measure, -2 log pseudo-likelihood (-2LPL) for these constrained models, with those for unconstrained (base) models. If the -2LPL value for the constrained models is higher by a value larger than the χ^2 critical value corresponding to the change in degrees of freedom due to the constraining process, then we can conclude that the unconstrained models are superior to the constrained ones, and that the parameter differences between groups are significant.

However, because we used multiple network structures, equalizing the blocks tells only if the parameters that explain their observed structure are different taken together, not if each network structure in part makes a specific contribution to this difference. To detect the extent to which each network structure in part was

[3] The sociomatrix for multiple networks takes the shape $X^{(m)} = \begin{pmatrix} x_{89} & x_{rand} \\ x_{rand} & x_{99} \end{pmatrix}$, where x_{89} and x_{99} are the observed matrices, and x_{rand} the random ones. The random matrices were obtained by using the Excel "random number" function to obtain approximately four links per row.

[4] Due to computational constraints, MultiNet cannot fit models that provide both global and local (block) parameters when all blocks are specified.

responsible for these differences, the parameters for each network structure were systematically removed from the base models.[5] If, in each case, removal produced a model that was significantly different from the base one and the increase in -2LPL was greater than the χ^2 critical value corresponding to the change in degrees of freedom due to the elimination process, then we concluded that the difference between years applies to that network structure as well.

Results

Overview
Model fitting for each of the three models began by introducing all explanatory variables simultaneously. The models were all found to be "best fit" relative to the variables they contained because the goodness of fit measures (-2LPL) did not change after eliminating nonsignificant parameters.[6] Further analysis showed that mutuality and transitivity, but not cyclicality, better explained the observed telecommunicative network in 1999, compared to 1989. In what follows we provide a step-by-step account of the results and how these translate in accepting or rejecting the claims made in each of our five clusters of hypotheses.

Hypotheses 1a and b Through 3a and b
H1a, 2a, and 3a predicted that mutuality, transitivity, and cyclicality would be statistically significant predictors of the observed global network. The relevant coefficients in Table 1 are positive for mutuality and transitivity, but negative for cyclicality, supporting H1a and 2a, but not 3a. The 1989 and 1999 parameters for mutuality are both positive (B_{m89} = 2.03, B_{m99} = 2.61) and significant at $p < .01$ supporting H1a, which claimed that a tendency to mutuality is a statistically significant predictor of relational ties in the global telecommunications network. The results were similar for transitivity, both parameters being positive (B_{t99} = .75, B_{t89} = .63) and significant at $p < .01$, which support the claim made in H2a that a tendency to transitivity is a statistically significant predictor of relational ties in the global telecommunications network. However, the parameters for cyclicality are negative (B_{c89} = -.96; B_{c99} = -1.21), which fails to support the claims made in H3a, that a tendency to cyclicality is a statistically significant predictor of relational ties in the global telecommunication network.

H1b, 2b, and 3b, which claim that mutuality, transitivity, and cyclicality are more likely to occur as statistically significant predictors of relational ties of the global telecommunications network in 1999 than in 1989, were tested by comparing the beta values for mutuality, transitivity, and cyclicality across years and by

[5] For the second and third models, this meant removing the parameters (i.e., mutuality, transitivity, cyclicality) only for the specified blocks.

[6] The parameters found nonsignificant were these: in the first model, "global cyclicality"; in the second, "1989 mutuality"; and in the third, "global cyclicality." Because eliminating each of these parameters from the models increases the -2LPL value by less than the χ^2 critical value for the degrees of freedom lost, we report in the article the results generated by the initial fitting.

Table 1. p^* Parameters for Mutuality, Transitivity, and Cyclicality as Predictors of Observed Telecommunicative Links in 1989 and 1999

		B	Standard error	$Wald_{PL}$	p	exp(B)	Changes in -2 log pseudo-likelihood upon removing parameter	
Choice	Global	-3.54	0.05	5894.66	< 0.01	0.03		
	1989	-1.64	0.12	191.84	< 0.01	0.19	400.94	<.01*
	1999	-1.75	0.12	204.17	< 0.01	0.17		
Mutuality	Global	0.38	0.19	3.97	< 0.05	1.46		
	1989	2.03	0.29	48.93	< 0.01	7.62	121.67	<.01
	1999	2.61	0.27	92.79	< 0.01	13.65		
Transitivity	Global	0.09	0.03	7.59	< 0.01	1.09		
	1989	0.63	0.04	230.12	< 0.01	1.87	465.83	<.01
	1999	0.75	0.04	290.13	< 0.01	2.12		
Cyclicality	Global	-0.12	0.08	2.39	> 0.10	0.89		
	1989	-0.96	0.13	56.07	< 0.01	0.38	93.04	<.01
	1999	-1.21	0.14	77.53	< 0.01	0.3		

Model -2 log pseudo-likelihood = 10,790.75.

*$p < .01$; χ^2 critical value is 9.2 for $df = 2$.

testing the statistical differences between these values. Testing for statistical differences was performed by constraining the year subnetworks to be equal and by systematically eliminating each network parameter from the model to determine if it contributes to the model fit. The results confirm H1b and 2b but not 3b.

For H1b, which claims that mutuality is more likely to occur as a statistically significant predictor of relational ties of the global telecommunications network in 1999 than 1989, the results indicated a positive increase between 1989 and 1999, $B_{m99} = 2.61 > B_{m89} = 2.03$. Constraining the 2-year submatrices in the model to be equal increases the -2LPL value by 28, from 10,791 to 10,818, which is larger than the 13.2 points for $p < .01$ significance at $df = 4$, which indicates that parameter differences between years are significant. Of these, the one for mutuality significantly contributes to the model fit. As shown in the second to last cell of the mutuality row in Table 1, the -2LPL value changes by 121.67 points after removing this network structure from the model. The value is considerably larger than the 13.27 points required by the χ^2 critical value necessary for significance at $p < .01$ with $df = 2$. Thus, the data support H1b.

For H2b, which claims that transitivity is more likely to occur as a statistically significant predictor of relational ties of the global telecommunications network in 1999 than 1989, the results confirm it, too: $B_{t99} = 0.75 > B_{t89} = 0.63$. This increase is statistically significant since transitivity significantly contributes to the model fit, the -2LPL value changing by 465.83 points after removing this network structure from the model, which is again larger than the 13.27 points required by the χ^2 critical value necessary for significance at $p < .01$ with $df = 2$.

H3b, which claimed that cyclicality is more likely to occur as a statistically

Table 2. p^* Parameters for Mutuality, Transitivity, and Cyclicality as Predictors of Observed Telecommunicative Links Between Rich and Poor Countries in 1989 and 1999, Block 2

		B	Standard error	$Wald_{PL}$	*p*	exp(*B*)	Changes in -2 log pseudo-likelihood upon removing parameter	
Choice	Global	-3.54	0.05	5894.66	< 0.01	0.03		
	1989	-2.01	0.21	94.89	< 0.01	0.13	274.64	<.01*
	1999	-2.13	0.21	102.33	< 0.01	0.12		
Mutuality	Global	0.38	0.19	3.97	< 0.05	1.46		
	1989	0.91	0.53	3.00	< 0.10	2.49	43.877	<.01
	1999	2.87	0.43	44.98	< 0.01	17.56		
Transitivity	Global	0.09	0.03	7.59	< 0.01	1.09		
	1989	0.75	0.06	145.28	< 0.01	2.12	308.81	<.01
	1999	0.87	0.07	163.31	< 0.01	2.39		
Cyclicality	Global	-0.12	0.08	2.39	> 0.10	0.89		
	1989	-0.87	0.26	11.21	< 0.01	0.42	39.75	<.01
	1999	-1.29	0.26	24.68	< 0.01	0.27		

Model -2 log pseudo-likelihood = 10,750.65.

*$p < .01$; χ^2 critical value is 9.2 for $df = 2$.

significant predictor of relational ties of the global telecommunications network in 1999 than 1989, is not supported by the data. The parameter estimates for both years are negative, which indicates that observed network patterns reject the expectation of cyclicality in both years.

H4a-c and 5a-c claimed that mutuality, transitivity, and cyclicality explain the observed structure of links between rich and poor and democratic and nondemocratic nations better in 1999 than they do in 1989. Testing these hypotheses was done through the second and third p^* models, where three block-parameters were estimated separately for each year: (a) for links between countries found at the same level of economic development or sharing the same democratic status, (b) for links between countries found at the opposite ends of the economic and democratic spectrum, which is the block of interest, and (c) for links between nations found in the middle category and the other two groups.[7]

The parameter estimates for 1989 and 1999 for block number 2 (ties between rich and poor nations) provided by the second p^* model appear in Table 2, and those provided by the third p^* model, for ties between democratic and nondemo-

[7] There are three categories because the attribute data were divided into three categories: rich, medium rich, and poor, and democratic, part democratic, and nondemocratic. The block model matrix for economic development, is

$$X^{GDP} = \begin{pmatrix} b1_{poor-poor} & b2_{poor-medium} & b2_{poor-rich} \\ b2_{medium-poor} & b1_{medium-medium} & b3_{medium-poor} \\ b2_{rich-poor} & b3_{rich-medium} & b1_{rich-rich} \end{pmatrix}$$

where b1, b2, and b3 are the block numbers. Each block spans multiple matrix cells. For example, the block of interest, b2, spans across four cells: $b2_{medium-poor}$, $b2_{rich-poor}$, $b2_{poor-medium}$, and $b2_{poor-rich}$.

Table 3. *p Parameters for Mutuality, Transitivity, and Cyclicality as Predictors of Observed Telecommunicative Links Between Democratic and Nondemocratic Countries in 1989 and 1999, Block 2**

		B	Standard error	$Wald_{PL}$	*p*	exp(*B*)	Changes in -2 log pseudo-likelihood upon removing parameter	
Choice	Global	-3.54	0.05	5894.66	< 0.01	0.03		
	1989	-1.81	0.23	61.30	< 0.01	0.16	191.263	<.01*
	1999	-1.84	0.21	76.28	< 0.01	0.16		
Mutuality	Global	0.38	0.19	3.97	< 0.05	1.46		
	1989	0.83	0.64	1.69	> 0.10	2.29	37.84	<.01
	1999	2.77	0.44	39.92	< 0.01	16.02		
Transitivity	Global	0.09	0.03	7.59	< 0.01	1.09		
	1989	0.67	0.07	96.84	< 0.01	1.96	218.176	<.01
	1999	0.77	0.07	116.72	< 0.01	2.17		
Cyclicality	Global	-0.12	0.08	2.39	> 0.10	0.89		
	1989	-0.67	0.27	6.34	< 0.02	0.51	42.19	<.01
	1999	-1.52	0.29	27.44	< 0.01	0.22		

Model -2 log pseudo-likelihood = 10,753.46.

*$p < .01$; χ^2 critical value is 9.2 for $df = 2$.

cratic nations, are presented in Table 3. The results in these tables support H4a, 4b, 5a and 5b, which claim that mutuality and transitivity better explain the links between rich and poor and democratic and nondemocratic nations in 1999 compared to 1989. In each situation the beta values for 1999 are greater than the ones for 1989, and the differences between years are statistically significant. The results, however, do not confirm hypotheses 4c and 5c, which claim that cyclical structure also can explain telecom relationships across the two divides.

Concretely, in the second model summarized by Table 2, fitting the links between rich and poor nations, the block parameters for mutuality are positive, and their value increases dramatically between 1989 and 1999, from .9 to 2.87, confirming H4a. The block parameters for transitivity are also positive, increasing by a smaller, but still significant extent, from .75 to .87 (Table 2), confirming H4b. Testing for the significance of the value increases for mutuality and transitivity was performed using the same procedure detailed above. Constraining the second blocks in the 1989 and 1999 submatrices to be equal produces a model whose -2LPL is significantly higher (10,768.82) than the one for the unconstrained model (10,750.65), the difference between the two values, 17.27, being greater than the $p < .01$ critical χ^2 value, 13.27, for the 4 *df* eliminated through constraining. In addition, each network structure (mutuality and transitivity) significantly and independently contributes to the model fit, as the -2LPL value significantly increased when the variables were removed from the model (see the last two columns of Table 2). The results do not support, however, H4c, which stated that tendency to cyclicality explained the observed structure of telecommunicative ties between democratic and nondemocratic countries better in 1999 than in 1989. In both years the block parameters for links between rich and poor countries are negative.

The results obtained through the final model, which examined the links between democratic and nondemocratic nations, were similar to those reported above, confirming H5a and b, but not c. The parameter for mutuality was positive and increased again dramatically, from .83 to 2.77, while the one for transitivity, also positive, changed, just like in the previous model, by a smaller extent, from .67 to .77. The statistical significance of these differences was also confirmed by comparing the constrained with the unconstrained model. The -2LPL (10,767.27) for the constrained model was greater by 13.77 points than the -2LPL for the unconstrained one (10,753.5), a value sufficiently large to ensure significance at $p < .01$, for 4 *df* (χ^2 critical value = 13.27). Finally, each parameter significantly contributed to the model fit, as the -2LPL for value changes for each variable in the last two columns of Table 3 indicate. The data do not, however, support H5c because the parameter values for cyclicality were negative, which indicates that cyclicality as a theoretical network structure is less, not more, likely to explain the observed network.

Discussion

The increased explanatory power of reciprocity and transitivity in 1999 compared to 1989 unveiled in this study shows that during the globalization decade of the 1990s the world telephonic network became richer, fostering a more balanced network environment. These findings support and extend Held et al.'s network theory of globalization. Significantly, mutuality and transitivity were more likely to explain the links observed in 1999 between nations situated at different levels of democracy and economic development than those present in 1989. The increase was quite evident for mutuality. When converting the logit values (beta values) into odds ratios, we noticed an increase from 2.3 to 16.2 for connections between democratic and nondemocratic countries, and from 2.5 to 17.5 for connections between poor and rich countries. Following the traditional interpretation of odds ratios suggested by Crouch and Wasserman (1997), this means that the chances for reciprocation increased across economic and political divides, reaching a level of 16 or 17 to 1 in 1999.

Transitivity also increased, although the differences between 1989 and 1999 were quite small, indicating only modest change. The odds that poor or nondemocratic nations would link to rich or democratic ones increased by 20%. Taken together, these findings indicate that the connective tissue of the world as a whole has become stronger and possibly more flexible. This does not eradicate inequalities and power differentials. However, in a world where increases in network ties are generated by complementary partners to the discussion, the possibility of mobility, balance, and ultimately reduction of power differentials, at least within specific parameters, becomes more probable.

Strong tendency to mutuality and its over-time increase justify the use of exchange theory rather than dependency theory as an explanatory mechanism for the world telecommunications network. The international telephone traffic, like other networks, emerges at the intersection of their members' "enlightened self-interest." Being open to reciprocity, regardless of one's level of power, is the surest warranty for efficacious action and integration in any system. The tendency toward mutuality found through the present study converges with another important implication of exchange theory: When systems become denser, the actors participating in them are more, not less, likely to become interdependent.

Tendency to transitivity in the world telecommunications network also suggests that the classical dichotomy between centralization and decentralization, which has dominated the discussion about the structure of the world telecommunications network (Barnett, 2001), needs to be adjusted to accept the idea that networks might become both more centralized and decentralized at the same time. A transitive triad, as described previously, is anchored on actor I, who sends unilateral links to J and K. This would be a clear sign of dependency. However, precisely due to this unbalance, J or K connect to one another to compensate for the power differential manifested in their connections to I.

In concrete terms, an increase in tendency to transitivity means that the classical problem of electronic colonialism should be reformulated. On the one hand, the presence and persistence of transitivity throughout the globalization decade might be an indirect confirmation of an increased trend toward the regionalism that both Nierop (1994) and Barnett (2001) have explored. On the other hand, dependency relations between central and peripheral countries have not disappeared. The fact that tendency to cyclicality is constantly negative, which suggests the absence of this structural component from the world telecommunications network, shows that lateral connections are not likely to emerge all the time. A cyclical triad is a closed loop. In it, the balancing act takes the form: If I connects to J, and J to K, K will connect back to I. In the present study, these feedback loops are less, not more, likely to occur, especially across economic and political divides. The explanation, related to the persistence of power differentials is directly intuitive: If France dominates Ivory Coast and Ivory Coast dominates Ghana, it is very unlikely that Ghana will get the upper hand in its relationship with France. The combined results for transitivity and cyclicality indicate that, from a balance theory perspective, countries on opposite sides of the world divides are more likely to band with their peers (if in a weak position) to find an equilibrium point in their relationships with central nations.

The research reported in this paper used network analytical techniques to test the Held et al. (1999) network theory of globalization and to extend it with predictions from exchange and balance theories. Future work should explore a wide variety of network theories with the new MTML p^* model, which seeks explanations in the decomposition of the focal network, in attributes of the nodes, and in the contributions of other networks or the same networks at earlier points in time (Monge & Contractor, 2003). In the present case, exchange and balance theories successfully predicted dyadic and triadic level theoretical mechanisms to account for mutuality and transitivity in the global telecommunications network; both findings considerably extend past work on network density (or extensivity, in Held et al.'s terms), but other theories should also be examined and at other levels of analysis, including the clique level and that of the entire network. In the present research, economic and democratic attributes of the global system proved to be successful predictors of mutuality and transitivity, but other attributes, such as military alliances, net migration, and cultural affiliation, should also be examined. Finally, features of the 1989 telecommunications network were compared with their counterparts in the 1999 telecommunications network. More frequent panels of telecommunications network data, such as yearly or quarterly, would provide better predictions and a more refined understanding, and other networks, such as tourism and cultural flow networks, should also increase our understanding of globalizing networks. Future work that applies the new MTML p^* models to a wide range of network theories, including globalization, should considerably expand our understanding of currently unknown network processes.

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