Global networks in telecommunication and transportation

Young Choi

International Communication Gazette 1993 51: 113
DOI: 10.1177/001654929305100202

Gazette **51**: 113–136, 1993.

Global networks in telecommunication and transportation

YOUNG CHOI

Department of Communication, State University of New York at Buffalo, Buffalo, New York 14260, U.S.A.

Abstract. This study examines the global network structures of telecommunication and transportation, and tests structural relationships among countries in the global system. Specifically, telephone and air travel networks are examined. The results of zero-order correlation, canonical correlation, and LISREL analysis show a high correlation between telecommunication and transportation network. NEGOPY reveals a similar structure for both networks. It identifies one large group with western industrialized countries as center and the rest as periphery for both networks. These results suggest the replication of inequalities in political and economic areas between center and periphery countries. It turns out that telephone is obviously one of the 'space-adjusting technologies' that change the significance of distance and allow for higher degrees of accessibility to remote locations. Only one country is identified as an isolate in the telephone network, whereas many isolate countries exist in the transportation network.

Introduction

One of the big changes in the global system is the rapid increase of the level at which countries interact. The advanced technologies of communication and transportation allow people to interact with each other more often than before, making international interaction more possible and more frequent. Some empirical research in international transaction has been conducted in the area of international relations since World War II, especially, in the area of trade at global level (Steiber, 1979; Breiger, 1982; Schott, 1986) and mail transactions at regional level (Chadwick & Deutsch, 1973; Deutsch, 1956; Merritt & Clark, 1977).

Among the scholars in international transaction, a few sociologists (Snyder & Kick, 1979; Kick, 1978) have made an effort to analyze various aggregated, cross-national data as indicators of a country's position in the global system to test dependency/world system perspective empirically.

They utilized all possible data, which concentrated on economic, political, and social indicators, to cover the entire world and its working relationships for testing dependency/world system perspective. Their efforts, however, often seemed to be undermined due to lack of appropriate data and method to test the theory. Blumer (1983) noted that due to the weakness of methodology including design, measurement, and data collection, most claims of dependency and cultural imperialism research tended to collapse into exercises in interpretation.

As Russett (1977) notes, any good global model has to include major factors that take into account the structural relationships between center and periphery and that have the capability of changing structure. Among the factors that cause system changes, technology development is one of the most influential. Specifically, development of new communication and transportation technology has brought extensive changes in the global system. These two factors, which clearly show interactions between two countries, are very important in structural analysis because "dependency is measured by partner concentration" (Senghass, 1977, p. 161). Of course, no indicator can measure dependency with validity over time (Senghass, 1977). However, new indicators such as telecommunication and transportation will have to be introduced to the field to keep up with rapid changes in global system.

The purpose of this study is to examine the global network structures of telecommunication and transport, and to test the structural relationship among countries in the global system. Specifically, the telephone network for telecommunication and airplane passenger network for transportation are examined. The paper begins with a brief discussion of measurement of international transaction, followed by a discussion of telecommunication and transportation trade-offs as a theoretical basis for comparison between these two networks. Then, network analysis and the NEGOPY network analysis program, and data will be discussed. Finally, results and conclusions will follow.

Measurement of international transaction

Many researchers considered that political conditions and military forces played the primary role in international relations. However, rather than its military forces alone, today, power of a country is often defined in terms of economic conditions. A country's productive capacity, its resources, and the extent of its trade have always played an important role in the last three centuries, and this leads to increased economic interdependency. Researchers in dependency/world system perspective argue that the industrialized countries in collusion with local elites in the Third World conducted policy to keep the less developed countries economically dependent (Frank, 1969; Galtung, 1971; Wallerstein, 1976). A combination of various factors such as resources and trade has enormously increased the importance of economic conditions, which used to and is the basis of most international transaction research.

However, many other forces would also influence to change the global system. These include the impact of not only economic or military area but also communication technology. Specifically, development of telecommunication and transportation technologies has brought extensive changes in the global system. For example, rapid advances in computer and telecommunication technologies are making it possible to generate information transmitted instantaneously around the world, resulting in the creation of the so called "global village". The evolution from industrial society to post-industrial or information society has also brought changes in the form and structure of the global system (Bell, 1973; Porat, 1978). The major communication variables such as telecommunications are now key components in modern information societies. Thus, they require the same attention that was given to the trade of industrial production during the manufacturing age.

During the last several decades, many scholars such as Deutsch (1953, 1956), Russett *et al.* (1964), and Merritt (1972) have used various communication variables and models to explain the global system in a limited way. One of the approaches to communication and international relations in the early 1970s was "events-interaction analysis". A group of researchers (e.g., Azar, Brody & McClelland, 1972; Burgess & Lawton, 1972) examined various variables such as international conflict and crisis, military intervention, and foreign policy behavior in their studies by utilizing communication models and terminologies, and content analysis as their methods. Their primary tasks were to interpret various "event" data as the interactions of nations. Consequently, their measurements of international transaction were made by various "events", which were quite sporadic and regional.

Given the fact that those event variables, like military intervention (e.g., Kick, 1983), seldom happens, utilizing the network variables such as telecommunication and transportation is more meaningful than using those event variables because international telecommunication and transportation have always been an ongoing process. These two factors, telecommunication and transportation, are very important in structural analysis because they clearly show interactions between two countries. Originally, the dependency school's main focus is on distribution and exchange rather than production (Olson & Groom, 1991). The concept of exchange and its related concept interaction are important because every nation in the global system is destined to interact with each other with advanced communication and transportation technologies. Therefore, the focus of study in international transaction should be on interaction, more specifically, international networks, that is, exchange of people and information.

The measurements of relative proportions among different international transaction, from diplomatic elites to military intervention, to trade, and to telecommunication, can be made in several dimensions such as volume, content, direction, time, effectiveness, event, etc. Among them, as Deutsch (1956) argues, volume of communication is the first dimension of international transaction. The measurements of telecommunication and transportation transaction in this study are made in two dimensions, volume and direction of communication, which show a clear picture of international transactions.

Telecommunication and transportation trade off

Spencer and Thomas (1969) referred to transportation and communication innovations as "space-adjusting technologies" that change the significance of distance and allow for higher degrees of accessibility to specific locations. However, it may also be appropriate to call them "time-adjusting technologies" in that time is freed for alternative use in a variety of activities, not just in increasing the number of kilometers logged per day.

Social practices prescribe the precise timing and locations of events (such as work and school) that restrain human movement, resulting in general maximum distance limits between activity sites. Technology provides potential extension of these distance limits by altering the amount of time required for given tasks and by lessening the time required for movement between places – time that might be applied to other activities or that could be used to allow for even greater distances between activity sites.

If it required 74 hours to travel by stage coach from Boston to New York in 1800, only 5 hours by automobile in 1980, and 10 seconds by telephone in 1980, then these two places have been approaching each other in time-space at the average rate of 23 minutes per year by automobile and 24.7

minutes per year by telephone. Such measures provide a convenient way of characterizing the degree of transportation and telecommunication innovation between any pair of places and for determining relative changes in their overall accessibility with other places, and show some possibilities of substitution of telecommunication for transportation. These measures of convergence at global level objectively express what has long been characterized as a shrinking world (Hudson, 1983b).

A utility-optimizing approach (Hupkes, 1982) sheds light on the debate over the transportation-telecommunications trade-off. Advanced telecommunications such as the telephone are assumed to be cheap and easy to use and to have achieved a wide distribution around the world, especially among businesses, allowing for some substitution for various kinds of transportation such as shopping and business trips.

The impact of communication technologies on transportation depends largely on their accessibility to potential users. Telephone is the most widely distributed telecommunication media. There are more than 450 million telephones in the world. The availability of an inexpensive and reliable telephone service, made even more versatile by means of computer-related connections, should be a powerful incentive to substitute telecommunications contacts for the more costly and more time-consuming face-to-face communications. It is the ability to link the telephone with computers that offers entry to high-level telecommunications potentials.

However, the role of telecommunications in reducing travel needs is complex. Travel and the use of telephone are clearly not perfect substitutes: The limits of substitutability have been emphasized in many studies (Brand, 1970; Kraut, 1989; Pool, 1979; Reid, 1977; Saunders *et al.*, 1983; Short, Williams, & Christie, 1976). If telephone can serve as a substitute for travel, its use also tends to increase total volume of communication. Then, the increased communication could make it possible to have more transport traffic, and, finally, lead an increase in the total amount of travel. Tyler called this 'generation effect of telecommunications' (Hudson, 1983a). Hudson also noted that advanced communication technologies contribute to increased travel due to greater economic activity facilitated by such communication (Hudson, 1983b).

On the other hand, another group of scholars began to consider transportation as an independent variable, and see the effect of transportation on telecommunications. According to Short *et al.* (1976), the opening of a road bridge between South-West England and South Wales actually caused a telephone traffic jamming between those areas. However, there is not much research conducted that explicitly identifies transport traffic that has been induced by an overall increase in rapid communication.

Although empirical evidence of causality is somewhat sparse, it is clear that there are strong interactions between the telephone and alternative transport such as air travel or the postal system. Both complementarity and substitution may be present: a smoothly running transport system will necessitate fewer telephone calls to overcome disorganization in freight, business, and personal travel, but will stimulate telecommunications demand by promoting trade and other interaction. An efficient postal system depends on efficient transport and may be substitute for certain uses of telecommunication.

Beniger (1986) argues that there would be no transportation increase without telecommunications. According to Beniger, industrial revolution has caused a "control crisis". By the mid-nineteenth century, social processing of material flows threatened to exceed in both volume and speed the system's capacity to handle. He argues that one of the reasons of information's dominance over the world's largest and most advanced economies is information's control ability over this crisis. According to Beniger, this "control revolution" has continued unabated from its origins in the last decades of the nineteenth century, and it has been accelerated by the development of computer technologies.

It is true that electrical communication via a telegraph had helped to control the new systems of transportation and commerce. For example, the major problem of railroad transportation at early days was its inability of control over the railroad. However, with the rapid diffusion of the telegraph, the danger of collisions gradually disappeared. Similar crises of control in air transportation have been solved with advanced communication and computer technologies. The entire system of transportation has been developed with coordination and integration created by communication since its very early days (Beniger, 1986). The two kinds of contact (telecommunications and transportation) may reinforce each other rather than substituting for one another.

This paper examines the structures of international telecommunication and transportation networks and their functional relationships. Presumably, there will be a high association (correlationship) between the two networks. However, it is also true that transportation is affected by distances between communication parties in some way, the time required for communication, and the alternative forms of communication available, especially in a global scale. There are two components which influence the degree of interaction between two countries: 'spatial and social distance' (Clark & Merritt, 1987).[1] Many researchers (Zipf, 1949; Deutsch & Isard, 1961; Merritt, 1972; Clark & Merritt, 1987) have studied on the effect of the spatial (geographical or physical) distance on international transaction flows such as trade and mail. Their tentative conclusion is that there is a high negative relationship between the spatial distance and the strength of interactions. In this sense, geographical distance may affect the transportation network, but may not affect the telephone network in this study because telephone is obviously a "space-adjusting technology" that changes the significance of distance and allows for higher degrees of accessibility to remote locations.

The purpose of this study is to examine the global network structures of communication and transportation, and to test structural relationship among countries in the global system. The paper will describe and compare international network structure of telephone and transportation. It will also show how transportation and telecommunication networks explain international structure of interaction. In most instances in the field of communication, there is simply too little known about this phenomenon.

Method

Data

The 1989 transportation data are obtained from the *Digest of On-Flight Origin and Destination* (OFOD) from *International Statistics* describing the amount of air traffic volume between two cities. The data were gathered by ICAO (International Civial Aviation Organization) and include approximately 3,500 city to city air traffic volume, measured by number of passengers, freight (ton), and mail (ton). The data are aggregated by country, and include 137 countries. The analysis of the transportation network reported here is based upon the number of passengers. The last three digits of the original data were truncated to fit the NEGOPY program.

The 1989 telephone network data were gathered as part of a self-report survey by AT&T and published in *The World's Telephones* (AT&T, 1990). Representatives of the various countries were asked to report the most frequently called countries and the number of message sent. Since not all countries reported the number of messages, the analysis of the network reported here is based only upon the most frequently called countries. The data were reported in rank order of the number of messages and were treated in this way in the analysis. The United Kingdom did not report its frequencies of international telephone calls. However, since the reported data are directional, the UK was added as a node based on its rank as a receiver of telephone messages. The data include 94 countries. The 10 most frequently called countries were reported for 1989. The links were coded 10 for the most frequently called country, 9 for the second most, 8 for the third, and so on.

Network analysis

A number of structural analysts (Fisher *et al.*, 1977; Mitchell, 1974; Wellman, 1983) use networks to describe the underlying structures of people's contacts and to specify how these structures affect the behavior of those involved. Rogers and Kincaid (1981) explain network analysis as a set of research methods for identifying structures in systems based on the relations among system's components. Mitchell (1974) argued that network analysis is very useful in explaining what is going on in a large-scale social situation. It is just impossible to explain a country's economic structure at the individual level analysis. Network analysis of the international system provides insightful perspectives on the structural relations among countries (e.g., Snyder & Kick, 1979). Furthermore, international transactions as communication processes involve not only attributes but also relationships. According to Monge 91987), a communication network is a structure that is built on the basis of communication relationships. In this sense, network analysis is one of the best tools to describe the large-scale structure based on global level interactions.

The NEGOPY network analysis program was used to describe the international telecommunication and transportation network. NEGOPY provides not only role indications for each network member (liaisons, group members, isolates, attached isolates, and tree nodes[3]) but also other indicators of relationship among the network members such as centrality and linkage. The following network descriptors were examined; system density, connectedness, centrality, and integration. *System density* is the degree to which the nodes, countries, of a system are linked to one another. It is the number of actual links divided by the number of possible links. *Connectedness* is the degree to which a node is connected to other nodes (the number of links a country has). *Centrality* is the mean number of links it takes to reach all other nodes in a group. In other words, the average distance between one node and all others in a group. *Integration* is the proportion of a node's links that are connected to one another.[4] Parameters were set at the default values for all group detection and other algorithmic functions. The minimum link strength was 1 for telecommunication network and 1,000 (number of passenger) for transportation network. Both networks were treated as non-directional (Rice, 1979).

Results

NEGOPY identified one group for the telephone network.[5] The telephone network for the 94 countries included 93 group member countries and 1 country as an attached isolate (Marshall Islands), with no liaison and no dyad member. System density was 0.133.

NEGOPY also identifies one group with 114 group member countries for the transportation network, which originally includes 137 countries. However, there are 22 isolates, including 16 attached isolates, and 1 tree node, with no liaison and no dyad member in the transportation network. System density was 0.130, which is quite similar to that of the telephone network.

Isolated countries in the transportation network are Cameroon, Maldives, Martinique, Seychelles, Surinam, and Tonga. Attached isolates are Angola, Botswana, Burma, Cayman Islands, Congo, Comoro, French Guiana, Gabon, Ghana, Quadeloupe, Haiti, Liberia, Saipan, Upper Volta, Vietnam, and Western Samoa. Sierra Leone is identified as a tree node.

Almost half of the isolates are islands countries located in the Pacific and the Indian Ocean and in the Caribbean. Eight isolates are located in the African continent. The remaining countries are two socialist nations in South Asia, Burma and Vietnam, and two tiny countries in South America, French Guiana and Surinam. Among the isolates in the passenger network, six countries (Cayman Islands, Comoro Islands, Western Samoa, Seychelles, Cameroon, and Botswana) are identified as group members in the telephone network. There are no group members in the telephone network which belong to the isolate countries in the passenger network.

The various network indicators such as number of links, centrality and integrativeness from NEGOPY reveal a similar structure for the telephone and the transportation network. As shown in the economic area, some of the western industrialized countries such as the United States, West Germany, France, United Kingdom, and Italy are most central in both networks. Switzerland is also one of the most central countries in both networks

Table 1. International telephone network

	Centrality			
	links	row mean	standard distance	integration
U.S.A.	80	1.13	−3.838	0.125
United Kingdom	70	1.24	−3.311	0.149
Germany, Fed. Rep.	63	1.32	−2.943	0.172
Italy	52	1.46	−2.258	0.198
France	51	1.47	−2.205	0.198
Switzerland	35	1.64	−1.362	0.311
Spain	27	1.74	−0.888	0.330
Belgium	22	1.78	−0.677	0.459
Australia	21	1.79	−0.625	0.348
Singapore	16	1.84	−0.414	0.475
Greece	16	1.84	−0.414	0.600
Republic of S. Africa	15	1.85	−0.361	0.571
India	16	1.85	−0.361	0.383
Brazil	15	1.86	−0.309	0.610
Venezuela	14	1.87	−0.256	0.473
Portugal	15	1.87	−0.256	0.514
Colombia	14	1.87	−0.256	0.549
Taiwan	13	1.88	−0.203	0.577
Chile	13	1.88	−0.203	0.667
Panama	13	1.89	−0.151	0.590
Austria	12	1.89	−0.151	0.652
Argentina	12	1.89	−0.151	0.758
United Arab Emirates	12	1.90	−0.098	0.409
Turkey	11	1.90	−0.098	0.764
Mexico	12	1.90	−0.098	0.667
Korea, Rep. of	10	1.90	−0.098	0.667
Zimbabwe (Rhodesia)	10	1.91	−0.045	0.756
Uruguay	10	1.91	−0.045	0.889
Sri Lanka	8	1.91	−0.045	0.643
Paraguay	10	1.91	−0.045	0.778
New Caledonia	8	1.91	−0.045	0.643
Kuwait	11	1.91	−0.045	0.545
Gibraltar	9	1.91	−0.045	0.806
Bahrain	9	1.91	−0.045	0.694

Table 1 (Continued).

	Centrality			
	links	row mean	standard distance	integration
Zambia	10	**1.92**	0.007	0.689
Thailand	9	**1.92**	0.007	0.722
Tanzania	9	**1.92**	0.007	0.639
Norway	9	**1.92**	0.007	0.722
Morocco	9	**1.92**	0.007	0.917
Malaysia	8	**1.92**	0.007	0.821
Iran	8	**1.92**	0.007	0.750
Indonesia	9	**1.92**	0.007	0.806
Botswana	**9**	**1.92**	0.007	0.778
Uganda	**7**	**1.93**	0.060	0.571
Sierra Leone	**8**	**1.93**	0.060	0.857
Seychelles	8	**1.93**	0.060	0.679
Namibia (S.W. Africa)	9	**1.93**	0.060	0.722
Monaco	**8**	**1.93**	0.060	0.929
Malta	**8**	**1.93**	0.060	1.000
Luxembourg	**8**	**1.93**	0.60	0.964
Israel	8	**1.93**	0.060	0.964
Ecuador	10	**1.93**	0.060	0.689
Cameroon	**8**	**1.93**	0.060	1.000
Bermuda	**8**	**1.93**	0.060	0.750
Bahamas	**8**	**1.93**	0.060	0.786
Syria	**6**	**1.95**	0.113	0.733
French Polynesia	**6**	**1.95**	0.113	0.733
Cyprus	**7**	**1.95**	0.113	1.000
Cayman Islands	**9**	**1.95**	0.113	0.500
Swaziland	**7**	**1.96**	0.165	0.952
Suriname	**6**	**1.96**	0.165	0.800
Oman	**8**	**1.96**	0.165	0.714
Jamaica	**7**	**1.96**	0.165	0.762
Iceland	**6**	**1.96**	0.165	0.933
Finland	**6**	**1.96**	0.165	1.000
Ethiopia	**6**	**1.96**	0.165	1.000
El Salvador	**8**	**1.96**	0.165	0.857
Czechoslovakia	**7**	**1.96**	0.165	0.857
Costa Rica	**8**	**1.96**	0.165	0.750
Comoro Islands	**6**	**1.96**	0.165	0.733

Table 1 (Continued).

	Centrality			
	links	row mean	standard distance	integration
Senegal	7	1.97	0.218	1.000
Philippines	8	1.97	0.218	0.607
Peru	7	1.97	0.218	0.810
Fiji	8	1.97	0.218	0.643
Papua New Guinea	7	1.98	0.271	0.905
Cuba	6	1.98	0.271	0.867
Western Samoa	4	1.99	0.323	0.833
Tunisia	6	1.99	0.323	1.000
Solomon Islands	6	1.99	0.323	1.000
Dominican Republic	7	1.99	0.323	0.667
Netherlands Antilles	6	2.00	0.376	0.733
Honduras	8	2.00	0.376	0.643
Madagascar	6	2.02	0.481	0.867
Dominica	4	2.02	0.481	0.833
Macau	6	2.03	0.534	0.600
Belize	2	2.04	0.587	1.000
Republic of Sudan	6	2.08	0.745	0.533
Palau (Micronesia)	4	2.08	0.745	0.833
Hungary	7	2.09	0.798	0.905
German Dem. Rep.	6	2.15	1.114	0.933
Rwanda	3	2.40	2.325	0.667
Qatar	3	2.75	4.011	1.000
Nauru	3	2.75	4.011	0.667

Note: N = 93; Group column mean = 1.92; Standard deviation = 0.206; Total link = 568; Possible links = 8556; Group density or connectedness = 0.066.

presumably due to the banking industry. Soviet bloc countries such as USSR, Czechoslovakia, and East Germany, belong to those of periphery countries in both networks. Singapore, India, Brazil, Greece consist of the second most central countries which turn out to be the periphery countries in the center, or the center countries in the periphery group, or the semi-periphery countries if the terminology of dependency/world system perspective is utilized (Galting, 1971; Wallerstein, 1976, 1979).

One of the interesting findings in the passenger network is that Egypt, Thailand, and Saudi Arabia are among the most central countries, ahead of Spain and Japan. For example, the number of links of these three countries

Table 2. International air passenger network

	Centrality			
	links	row mean	standard distance	integration
Germany, Fed. Rep.	64	1.50	−1.752	0.282
France	62	1.50	−1.732	0.288
U.S.A.	62	1.52	−1.692	0.231
United Kingdom	56	1.57	−1.591	0.321
Netherlands	47	1.64	−1.430	0.400
Switzerland	43	1.68	−1.330	0.423
Italy	36	1.74	−1.189	0.467
Egypt	36	1.74	−1.189	0.452
Thailand	36	1.80	−1.069	0.494
Saudi Arabia	32	1.81	−1.049	0.452
Singapore	33	1.82	−1.008	0.502
Japan	30	1.82	−1.008	0.515
India	28	1.82	−1.008	0.545
Greece	27	1.82	−1.008	0.581
Belgium	27	1.83	−0.988	0.536
Brazil	31	1.85	−0.948	0.417
Spain	29	1.87	−0.908	0.520
Canada	28	1.87	−0.908	0.471
United Arab Emirates	33	1.88	−0.888	0.460
Denmark	27	1.88	−0.888	0.624
Austria	27	1.88	−0.888	0.584
Hong Kong	24	1.93	−0.767	0.601
Australia	23	1.95	−0.727	0.514
Venezuela	23	1.95	−0.707	0.474
Turkey	17	1.96	−0.687	0.471
Pakistan	28	1.96	−0.687	0.558
Philippines	17	1.97	−0.667	0.779
Argentina	22	1.97	−0.667	0.437
Korea, Rep. of	16	1.98	−0.647	0.825
Portugal	19	1.99	−0.627	0.602
Sweden	17	2.00	−0.607	0.809
Poland	17	2.01	−0.587	0.735
Kenya	23	2.03	−0.546	0.340
Hungary	17	2.03	−0.546	0.662
Kuwait	24	2.03	−0.526	0.591
Finland	16	2.04	−0.526	0.758

Table 2 (Continued).

	Centrality			
	links	row mean	standard distance	integration
Bahrain	21	2.04	–0.526	0.643
Yugoslavia	12	2.07	–0.446	0.939
New Zealand	14	2.07	–0.446	0.582
Malaysia	18	2.07	–0.446	0.771
Norway	11	2.08	–0.426	0.964
Colombia	16	2.08	–0.426	0.658
Chile	11	2.08	–0.426	0.709
Indonesia	16	2.09	–0.406	0.742
Oman	18	2.10	–0.386	0.614
Peru	14	2.11	–0.366	0.780
Czechoslovakia	11	2.11	–0.366	0.873
Ireland	8	2.12	–0.325	1.000
Ecuador	11	2.12	–0.285	0.909
Taiwan	10	2.15	–0.265	0.733
Mexico	14	2.15	–0.265	0.538
Tunisia	14	2.16	–0.245	0.637
Syria	18	2.17	–0.225	0.595
Qatar	16	2.17	–0.225	0.742
Cyprus	14	2.17	–0.225	0.857
Cuba	11	2.19	–0.184	0.491
Mauritius	8	2.22	–0.104	0.821
Germany, Dem. Rep.	7	2.22	–0.104	0.762
Ethiopia	8	2.22	–0.104	0.679
USSR	9	2.24	–0.064	0.889
Ceylon (Sri Lanka)	11	2.24	–0.064	0.909
Trinidad and Tobago	9	2.27	–0.004	0.611
Zaire	7	2.27	–0.016	0.286
Malta	7	2.27	–0.016	1.000
Barbados	8	2.27	0.016	0.714
Bangladesh	14	2.27	0.016	0.714
Costa Rica	10	2.29	0.056	0.489
Panama	14	2.30	0.076	0.560
Iran	9	2.30	0.076	0.806
Yemen	9	2.31	0.097	0.833
Zambia	6	2.32	0.117	0.733
Grenada	3	2.33	0.137	1.000

Table 2 (Continued).

	Centrality			
	links	row mean	standard distance	integration
Fiji	6	2.35	0.177	0.867
Bolivia	9	2.35	0.177	0.611
Tanzania	9	2.37	0.237	0.528
Nepal	6	2.38	0.257	0.933
Iraq	4	2.40	0.298	1.000
Iceland	4	2.41	0.318	1.000
Puerto Rico	10	2.42	0.338	0.422
Jordan	6	2.42	0.338	0.733
Israel	3	2.42	0.338	1.000
Uruguay	3	2.42	0.358	1.000
French Polynesia	5	2.42	0.358	0.700
Papua New Guinea	3	2.42	0.378	1.000
Malagasy Republic	2	2.46	0.438	0.000
Antigua and Barbuda	6	2.46	0.438	0.667
Nigeria	5	2.47	0.458	0.300
Honduras	5	2.47	0.458	0.900
Romania	2	2.48	0.478	1.000
Bahamas	4	2.48	0.478	1.000
Paraguay	3	2.49	0.498	1.000
Netherlands Antilles	3	2.50	0.519	1.000
Dominican Republic	2	2.50	0.519	1.000
Jamaica	2	2.50	0.539	1.000
Côte d'Ivoire	7	2.52	0.579	0.238
Sudan	3	2.60	0.760	1.000
Libya	3	2.62	0.800	1.000
China	3	2.65	0.880	1.000
Morocco	3	2.66	0.900	0.667
Somalia	2	2.67	0.920	1.000
New Caledonia	3	2.74	1.081	1.000
Cook Island	3	2.74	1.081	0.667
South Africa	3	2.76	1.121	0.667
Mozambique	2	2.81	1.242	0.000
Malawi	4	2.82	1.262	1.000
Uganda	3	3.00	1.664	0.667
Rwanda	3	3.00	1.664	0.667
Burundi	2	3.01	1.684	1.000

Table 2 (Continued).

	Centrality			
	links	row mean	standard distance	integration
Nicaragua	**3**	3.04	1.742	1.000
Mali	**4**	3.04	2.447	0.500
Togo	**2**	3.37	2.508	1.000
British Virgin Island	2	3.39	2.548	1.000
Guinea	3	3.49	2.769	0.667
Senegal	**2**	4.33	4.678	1.000

Note: N = 114; Group column mean = 2.27; Standard deviation = 0.440; Total link = 838; Possible links = 12882; Group density or connectedness = 0.083

with other countries in a group is bigger than those of Spain and Japan, although their volume of interactions (the actual number of passengers) is less than those of Spain or Japan. (For instance, the number of passengers from Japan to other countries is approximately three times larger than that of Thailand.) The centrality of Saudi Arabia could be explained with the pilgrimage to Mecca, whereas Thailand and Egypt with tourism. Egypt is also the greatest population country in the Arab world.

One of the differences between the two networks is that the telephone network consists of rather one group members without many isolates or liaisons, whereas many isolates exist in the passenger network. As indicated above, there are 22 isolates in the passenger network, whereas only one attached isolate was found in the telephone network. Physical distance may affect the passenger network. In other words, people simply can or do not visit a tiny island in Pacific such as Western Samoa.

Another difference is that the United States is not *the* center country in the passenger network, whereas it is *the* most central country in every measure of centrality in the telephone network. West Germany is the center country in the passenger network. Again, physical distance may affect the passenger network. A close examination of original data reveals that Frankfurt is more central than New York or Los Angeles in terms of not only the number of links with other major cities around the world but also the volume of traffic. For example, the number of passengers from Frankfurt international airport to other countries is slightly larger than that of major international New York airports (8.8 million vs. 7.5 million).

Table 3 shows that there are statistically significant correlations among the various indicators in the telephone and the passenger network. Especially, the number of links and integration between the two networks are highly correlated with each other (0.83 for the number of links and 0.65 for integration).

Table 3. Zero order correlations among telecommunication and transportation network indicators

		Telecommunication			Transportation		
		links	centrality	integration	links	centrality	integration
Tele.	links	1.0000					
	cent.	–0.8707	1.0000				
	integ.	–0.7874	0.7163	1.0000			
Trans.	links	0.8357	–0.6993	–0.7384	1.0000		
	cent.	–0.6240	0.5679	0.5501	–0.8734	1.0000	
	integ.	–0.6122	0.5007	0.6524	–0.7927	0.6624	1.0000

N = 67
All coefficients are significant at p = 0.001.

Canonical correlation analysis was used to examine the relationship between three sets of indicators of the passenger network and those of the telephone network. Canonical correlation analysis, which can be viewed as an extension of multiple regression analysis, examines the relationship between two sets of variables (see Thompson, 1984). The canonical correlation coefficient is very high (0.885, p = 0.000), which means there is a high correlationship between the indicators from the telephone network and those from the transporation network. In other words, there is a high correlation between the telephone and the transportation network in their structures.

LISREL analysis is another way to test the relationship between two sets of variables (see Joreskog & Sorbom, 1985). LISREL, which consists of two parts; the structural equation model and the measurement model, is an approach that can be used for the analysis of causal models with multiple indicators of latent variables, reciprocal causation, measurement errors, and so on. The path diagram in Table 4 supports the result of canonical correlation analysis: it shows that the estimated correlation between the two networks, represented by two latent unobservable variables (ξ_1 and ξ_2) is

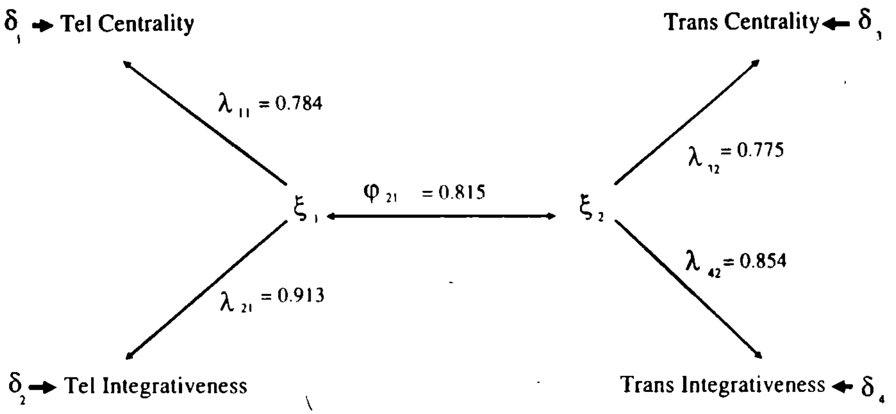

Fig. 1. Path diagram for telephone and transportation networks.

very high ($\phi_{21} = 0.815$). Furthermore, the total coefficient of determination, which shows how well all the network indicators jointly serve as measurement instruments for all the latent variables (ξ-variables), is remarkably high, 0.95, indicating that the measurement model is very good. Of the measures of ξ_1 (telephone network), telephone integration is more reliable ($\lambda = 0.913$), and of the two indicators of ξ_2 (transportation network), transportation integration is also more reliable ($\lambda_{42} = 0.854$). The overall goodness of fit of the model to the data is excellent. The goodness of fit index is 0.97 and the root mean square of the residuals is 0.03.

Discussion

Research on the changes in the political or economic order of an individual country or the whole world, are familiar topics in the area of international relations. In this study, two international transaction variables which might cause extensive changes in global system, telecommunication and transportation, were examined.

The fundamental changes that took place in the transportation of commodities and the transmission of information in the last half of the nineteenth century have been aptly characterized as a communication revolution. Since then, new inventions, new materials, and new methods have produced vast improvements in communication and transportation.

The telephone is the major electronic communication technology which has played an important role since its existence. The extension of this service to most parts of the world begins to bind ever tighter global interaction for last century. The result of this study supports a notion of a universal electronic information network which is capable of reaching almost everyone almost everywhere. Given the fact that the telephone network includes 1 group with 93 member countries out of a total of 94 countries, the telephone is obviously one of the "space-adjusting technologies" that change the significance of distance and allow for higher degrees of accessibility to remote locations.

On the other hand, the transportation network has a lot of isolate countries. Twenty three countries are not group members. Geographical distance may affect the transportation network. It is safe to say that transportation is affected by distances between communicating parties in some way.

According to Pool (1979), within three years after the telephone was invented in 1876, the *London Spectator* newspaper predicted that the new device would replace personal meetings. He also reports that H.G. Wells foresaw in his book, *Anticipation*, a growing use of new means of communication to conduct business from a distance and to reduce the load on transportation. Although it does not necessarily mean the substitution of telephone for transportation, high correlations among the indicators between the telephone and the transportation network indicate, at least, some high associations between these two variables. However, it is difficult to draw conclusions about the causal relationship between telecommunication and transportation. Transportation may be both complementary to and competitive with telecommunications. Their câusal relations are complex and many. And the indirect effects through such mediating factors as trade and diplomatic ties may be much more important than the direct relations themselves.

The results in this study raise a very important question, whether new electronic technologies of communication help to break down or strengthen the gap between the center and periphery countries. Contrary to the belief that the electronic communication technologies such as telephone would help construct new economic and social geographies and new forms of spatial division and integration (McLuhan, 1964), this space-adjusting technology constitute new forms of inequality. The result of telephone network analysis shows the replication of inequalities in political and economic area between center and periphery countries. In this sense, although world system theorists argue that world system perspective must be historical and deal in centuries, even for the study of contemporary problems (So, 1988; Chirot and Hall, 1982), its broad perspective (Wallerstein, 1976, 1979) could be utilized for describing the international network structure of telecommunications and transportation.

As a next step, physical communication, represented by trade volume, written communication, by mail, will be examined. Other antecedent variables which might affect the global network such as population, geographical distance, and language, will be analyzed with the electronic (telecommunication) and face-to-face communication (transportation) networks, to draw a clearer picture of a global system. One of the major shapers of electronic communications channels is transnational organizations such as multinational corporations and intergovernmental organizations (Gillespie & Robin, 1989). Research on these organizations would be interesting. Applying dependency theory and world system theory would be helpful to explain the structural relationship among countries in the global system.

Summary

This paper examined the international telephone and transportation networks and tested structural relationships among countries in the global system. In sum, the various indicators, such as system density, connectedness, number of links, integrativeness, from NEGOPY revealed a similar structure for the telephone and the transportation networks in terms of linkage and centrality. As indicated above, system densities, connectedness, and centralities for both networks are very similar to each other. NEGOPY identified one large group with some of western industrialized member countries as center in the group for both networks, indicating the replication of inequalities in political and economic area. However, there were also some differences between the two networks in terms of having isolates presumably due to physical distance. Only one country was identified as an isolate in the telephone network, whereas many isolate countries existed in the transportation network. About one sixth of the total countries (137) examined in this study were not group members. Geographical (physical) distance may affect the structure of the transportation network. The results of canonical and LISREL analysis showed a high correlation between the telephone and transportation network.

Notes

1. Social distance can be explained with culture, language, ethnic background, etc. Among them, language similarity is one of the factors which can be measured relatively precisely and easily. It is not so difficult to speculate that people who speak the same language might be expected to communicate much more with each other than those who do not. Clark and Merritt (1987) found that language similarity had some effect on mail transaction, although the impact of physical distance was greater than that of language similarity on mail transaction among EEC members. No examination was given to these factors because testing the effect of these two factors on international transactions is beyond the scope of this study. However, it would be interesting to test them in the future with other variables such as physical distance and population size.
2. Other network analysis methods, such as factor analysis, cluster analysis, MDS (multi-dimensional scaling), graph-theoretical methods are also discussed by Rice and Richards (1985).
3. Liaison is a country which has more than 50% of its linkage with members of groups in general, but not with members of any single group. An attached isolate means it has only one link, whereas an isolate has no links whatsoever. Tree node is the first country to which one or more attached isolates are attached. Group member is a country who has more than 50% of its linkage with other members in the same group. It must have at least two links with other members. (See Richards, 1989)
4. A complete explanation of NEGOPY is well discussed in: Barnett (1989), Rice & Richards (1985), Richards (1989), Richards and Rice (1981).
5. The default value of 50.01 percent was used for the minimum inter-group linkage needed to be identified as a group member for both telephone and transportation network. In other words, group members must have more than half of their linkages with other members of the same group.

References

AT&T (1990) *The world's telephones: A statistical compilation as of January 1, 1989* (Morristown, NJ: AT&T).

Azar, E., Brody, R. & McClelland, C. (1972) *International events interaction analysis: Some research considerations* (Beverly Hilss, CA: Sage Publications).

Barnett, G. (1989) 'Auditing communication network' (Unpublished manuscript, State University of New York at Buffalo).

Bell, D. (1976) *The coming of post-industrial society* (New York: Basic Books).

Beniger, J. (1986) *The control revolution: Technological and economic origins of the information society* (Cambridge, Mass.: Harvard University Press).

Blumer, J. (1983) 'Communication and democracy: The crisis beyond and the ferment within', *Journal of Communications* 33: 166–173.

Brand, D. (1970) *Urban transportation innovation* (New York: American Society of Civil Engineer).

Breiger, R. (1982) 'Structures of economic interdependence among nations'. In: P. Blau & R. Merton (Eds.), *Continuities in structural inquiry* (London: Sage Publications):

pp. 353–380.

Burgess, P. and Lawton, R. (1972) 'Indicators of international behavior: An assessment of events data research'. In: D. Vincent (Ed.), *Sage professional papers in international studies* (London: Sage Publications): pp. 1–96.

Chadwick, R., & Detusch, K. (1973) 'International trade and economic integration'. *Comparative Political Studies* 6: 84–109.

Chirot, D. & Hall, T. (1982) *World-system theory: Annual review of sociology* 8: 81–106.

Clark, C. & Merritt, R. (1987) 'European community and intra-European communications: The evidence of mail flows. In: Cioffi-Revilla, Merritt, & Zinnes, *Communication and interaction in global politics* (Newbury Park, CA: Sage Publications): pp. 209–235.

Deutsch, K. (1953) *Nationalism and social communication* (Cambridge, MA: MIT Press).

Deutsch, K. (1956) 'International communication: The media flows'. *Public Opinion Quarterly* 20: 143–160.

Deutsch, K. & Isard, W. (1961) 'A note on the generalized concept of effective distance'. *Behavioral Science* 6: 308–311.

Fisher, C., Jackson, R., Steve, A., Gerson, K., Jones, L., & Baldassare, M. (1977) *Networks and places: Social relations in the urban setting* (New York: The Free Press).

Frank, G. (1969) *Latin America: Underdevelopment or revolution* (New York: Monthly Review Press).

Galtung, J. (1971) 'A structural theory of imperialism' *Journal of Peace Research* 8: 81–118.

Gillespie, A. & Robins, K. (1989) 'Geographical inequalities: The spatial bias of the new communication technologies *Journal of Communication* 39(3): 7–17.

Hudson, H.E. (1983a) 'The role of telecommunications in development: A synthesis of current research'. In: O. Gandy Jr., P. Espinosa, and J.A. Ordover (Eds.), *Proceedings from the tenth annual telecommunications policy research conference* (Norwood, NJ: Ablex Publishing Corporation): pp. 292–307.

Hudson, H.E. (1983b) *When telephones reach the village* (Norwood, New Jersey: Ablex Publishing Corporation).

Hupkes, G. (1982) 'The law of constant travel time and trip – rates'. *Futures* 14: 38–46.

Joreskog, K. and Sorbom, D. (1985) *LISREL VI: Analysis of linear structural relationships by the method of maximum likelihood* (Sweden: Department of Statistics, University of Uppsala).

Kick, E. (1983), 'World-system properties and military intervention-internal war linkages'. *Journal of Political and Military Sociology* 11: 185–208.

Kick, E. (1987) 'World-system structure, national development, and the prospects for a socialist world order'. In: T. Boswell and A. Bergesen (Eds.), *America's changing role in the world system* (New York: Praeger): pp. 127–155.

Kraut, R. (1989) 'Telecommuting: The trade-offs of home work'. *Journal of Communication*, 39(3): 19–47.

McLuhan, M. (1964) 'Introduction'. In: H.A. Innis, *The bias of communication* (Toronto: University of Toronto Press).

Merritt, R. (Ed.) (1972) *Communication and international Politics* (Urbana: University of Illinois Press).

Merritt, R. & Clark, C. (1977) 'An example of data use: Mail flows in the European balance of power, 1890–1920'. In: K. Deutsch, B. Fritsh, A. Jaquaribe & A. Markouits (Eds.), *Problems of world modeling: Political and social implication* (Cambridge, Massachusetts: Ballinger Publishing Company): pp. 169–205.

Mitchell, J. (1974) 'Social network'. *Annual Review of Anthropology* 3: 279–299.

Monge, P. (1987) 'The network level analysis'. In: C.R. Berger and S.H. Chaffee (Eds.), *Handbook of communication science* (Newbury Park, CA: Sage Publications): pp. 239–270.

Olson, W. & Groom, A. (1991). *International relations then and now* (London: Harper Collins Academic).

Pool, I. (1979) 'The Communications/Transportation Tradeoff'. In: Alan Altshuler (Ed.), *Current issues in transportation policy* (Lexington, Mass.: D.C. Health), pp. 181–192.

Porat, M. (1978) 'Global implications of the information society'. *Journal of Communication* 28: 70–80.

Reid. L. (1977) 'Comparing telephone with face-to-face contact'. In: Ithiel de Sola Pool (Ed.), *The Social Impact of the telephone* (Cambridge, Mass.: MIT Press): pp. 386–414.

Rice, R. (1979) 'Investigation into validity and reliability of NEGOPY, a computer program for communication network analysis'. Paper presented to ICA, Philadelphia.

Rice, R. & Richards, W. (1985) 'An overview of network analysis methods'. In: B. Dervin and M. Voigt (Eds.) *Progress in Communication Sciences* Vol. VI (Norwood, NJ: Ablex).

Richard, W. (1989) *The NEGOPY network analysis program* (Burnaby, B.C.: Department of Communication, Simon Fraser University).

Richards, W. & Rice, R. (1981) 'NEGOPY network analysis program'. *Social Networks* 3: 215–233.

Rogers, E. & Kincaid, L. (1981) *Communication networks: Toward a new paradigm for research* (New York: Free Press).

Russett, B. (1977) 'Data priorities for modeling global dependence'. In: K. Deutsch, B. Fritsh, A. Jaquaribe & A. Markouits (Eds.), *Problems of world modeling: Political and social implication* (Cambridge, Massachusetts: Ballinger Publishing Company): pp. 153–159.

Russett, B. *et al.* (1964) *World handbook of political and social indicators* (New Haven, CT: Yale University Press).

Saunders, R. *et al.* (1983) *Telecommunication and economic development* (Baltimore MD: Johns Hopkins University Press).

Schott, T. (1986) 'Models of dyadic and individual components of a social relation: Applications to international trade'. *Journal of Mathematical Society* 12: 225–249.

Short, J., William, B. and Christie, B. (1976) *Social psychology of telecommunications* (London: John Wiley and Sons).

Senghaas, D. (1977) 'Future analyses on global dependence: An exchange with Bruce Russett'. In: K. Deutsch, B. Fritsh, A. Jaquaribe & A. Markouits (Eds.), *Problems of World modeling: Political and social implication* (Cambridge, Massachusetts: Ballinger Publishing Company), pp. 161–167.

Snyder, D. & Kick, E. (1979) 'Structural position in the world system and economic growth, 1955–1970: A multiple-network analysis of transnational interactions'. *American Journal of Sociology* 1096–1126.

So, A. (1990) *Social change and development* (Newbury Park, CA: Sage Publications).

Spencer, J. & Thomas, W. (1969) *Cultural geography: An evolutionary introduction to our* *humanized earth* (New York: John Wiley).

Steiber, S. (1979) 'The world system and world trade: an empirical exploration of conceptual conflicts', *The Sociological Quarterly* 20: 23–36.

Thompson, B. (1984) *Canonical correlation analysis: Uses and Interpretation* (Newbury Park, CA: Sage Publications).

Wallerstein, I. (1976) *The modern world system* (New York: Academic Press).

Wallerstein, I. (1979) *The capitalist world-economy* (Cambridge: Cambridge University Press).

Wellman, B. (1983) 'Network analysis: Some basic principles'. In: Randall Collins (Ed.), *Sociological theory 1983* (San Francisco: Jossey-Bass).

Zipf, G. (1949) *Human behavior and the principle of least effort* (Cambridge, Mass.: Addison-Wesley).