Dynamics of Strategic Alliance Networks in the Global Information Sector, 1989-2000*

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ABSTRACT

Researchers have extensively documented dramatic increases in the formation of strategic alliances among corporations to achieve a variety of purposes: to conduct R&D projects, integrate products, penetrate new markets, formulate industry standards, undertake collective political actions. A complex macro-level structure emerging from their micro-level collaborations is the *strategic alliance network*, comprising subsets of firms within an organizational field that are interconnected by their repeated and overlapping partnerships through time. A strategic alliance network constitutes an opportunity structure that simultaneously facilitates and constrains the possibilities for field members to form new collaborative combinations. Network configurations also shape the outcomes of both alliances and their partnering organizations. As an organizational field evolves and institutionalizes, it develops stable positions, identified by clusters of firms that exhibit specially dense collaborative ties to one another, but sparser or nonexistent alliances with other organizational positions.

Our objective is to investigate dynamic structural changes in the strategic alliance networks of the global information sector (GIS) from 1989 to 2000, a period when this organizational field experience major transformations in technology and economic competition. This multi-industry sector encompasses the 145 largest North American, European, and Asian firms that either manufacture equipment (semiconductors; computers; peripheral devices) or create, distribute, and provide access to diverse informational content (satellite, wire, cellular, and pager telecommunications; software and database publishing; newspaper and magazine publishing; motion pictures, video and sound recording; radio, television, and cablecasting). Analyzing data on 3,571 strategic alliance announcements, we examine changes occurring at both macro- and micro-levels over the twelve years.

Time trends reveal that accelerating rates of alliance formation resulted in increasing numbers of new alliances across the twelve years, with mean organizational centralization peaking in the mid-1990s. Among the 30 most-active firms, structural differentiation increased across three years spanning the 1990s, with smaller, more specialized clusters emerging. By 2000, the Japanese companies had substantially concentrated their new alliance agreements among themselves, contradicting the globalization hypothesis that information organizations would create a stable alliance network structure consisting of a core block occupied by corporations from different nations. Our dynamic models of network evolution across the three years revealed that the 30 core companies chose alliance partners that increased two structural properties. Organizations sought new connections with organizations that had direct and indirect ties resembling their own alliance propensities. At the macro-level, these changing ties among the core global information sector firms generated a more differentiated strategic alliance network, one exhibiting greater structural balance and extensively circuitous linkages that enlarged the collective opportunity to forge new partnerships.

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The world business press annually reports announcements about thousands of new strategic alliances among corporations – interorganizational collaborations intended to research and develop new technologies, create new products, sell new services, or penetrate new marketplaces.[1] A huge academic cottage industry emerged over the past two decades, seeking to explain the formation and consequences of these proliferating alliances (see reviews by Knoke 2001:120-163; Todeva and Knoke 2003). Researchers have paid less analytic attention to the macro-level social structures of large alliance systems resulting from typically dyadic interorganizational agreements. Apart from the direct ties between two firms forming a specific alliance, organizations that participate in numerous alliances with different collaborators thereby generate elaborate webs of indirectly connected "partners of partners." Consider this 2001 example from the global information sector, which reveals how two Scandinavian telecomm companies were indirectly linked to Microsoft through their shared Japanese partners:

- **April 22, 2001:** Nokia, Ericsson and Motorola announced a joint corporate effort to create a universal standard to allow cell phone, pagers, and PDAs to send real-time instant messages to each other, regardless of equipment brand or the software.
- **April 25, 2001:** Ericsson and Sony confirmed they would combine their mobile phone businesses in an attempt to create the definitive next-generation handsets for consumers.
- **June 13, 2001:** More than 10 Japanese companies, including Sony and NEC, will set up a consortium to jointly develop next-generation semiconductor-manufacturing equipment.

[1] A strategic alliance involves at least two partner firms that: (1) remain legally independent after the alliance is formed; (2) share benefits and managerial control over the performance of assigned tasks; and (3) make continuing contributions in one or more strategic areas, such as technology or products (Yoshino and Rangan 1995:5).

- **Oct 21, 2001:** NEC and Microsoft announced they will form a strategic alliance for developing platform products, system integration and Internet services for corporate users.

The complex macro-level structure emerging from hundreds of micro-level collaborations is the *strategic alliance network*, comprising subsets of firms within an organizational field that are interconnected by their repeated and overlapping partnerships through space and time. A strategic alliance network constitutes an opportunity structure that simultaneously facilitates and constrains the possibilities for field members to form new collaborative combinations. These loosely coupled concatenations can trigger problems of trust, opportunism, and social control far more complicated than those encountered in simple dyadic affairs. Network configurations also shape the outcomes of both alliances and their partnering organizations. As an organizational field evolves and institutionalizes, it develops stable positions, identified by clusters of firms that exhibit specially dense collaborative ties to one another, but sparser or nonexistent alliances with other organizational positions. This section examines the empirical evidence about the changing strategic alliance network in an important field, the global information sector, from 1989-to 2000.

Alliance Formation and Outcomes

Most studies of alliance formation processes focus on micro-level dyadic relations, that is, on a pair of organizations creating a new partnership. In general, strategic alliance formation consists of these three sequentially linked decision processes: identification of goals that an organization want to achieve by entering into a strategic alliance, identification of a suitable partner, and choice of governance forms for the prospective alliance. Empirical analysts have

made fruitful contributions to understanding these processes, including decisions to collaborate (Pfeffer and Nowak 1976; Pfeffer 1987; Scott and Meyer 1994; Ebers 1997; Baker and Faulkner 2002); selection of alliance partners (Gulati and Gargiulo 1999); and choice of governance form (Williamson 1975; Williamson 1981; Gulati 1995). Institutional and resource dependence theories explain why organizations engage in network relations with others. Institutional theorists argued that organizations try to enhance their legitimacy in a field through inter-organizational relationships (Scott and Meyer 1994). One study of nonprofit foundations discovered that cooperation with other service providers is a frequently stipulated condition for social service agencies to receive large grants (Galaskiewicz and Bielefeld 1998). Resource dependence theorists asserted that organizations enter strategic alliance to gain critical resources such as money, information, technology, and market. At the same time, organizations in the alliance also avoid over-dependence on their partners that would risk their autonomy (Pfeffer 1987). In general, organizational core location within networks, prior ties to prospective partners, and middle managers' personal connections all affect the search for a suitable partner and the governance forms used to manage the alliance (Gulati 1995; Rosenkopf, Metiu and George 2001). The search for strategic partners and governance forms can be a frustrating process for many organizations that lack network leverage from previously well-establish relations with other firms in the field (Gulati and Gargiulo 1999).

Researchers have examined a broad range of alliance consequences such as alliance management (Larson 1992), accomplishment of alliance and partner goals, and organizational performance indicators such as innovation rates, product proliferation, and market competition or collusion (Stuart 2000). Larson (1992) investigated four alliances among seven establishments operating in a diverse set of industries. She found that trust and reciprocity replaced

administrative hierarchy and arm's length market to govern alliance partners in their daily exchanges. Organizations rarely relied on written contracts, administrative controls, economic incentives, or market data to coordinate their transactions with partners. Instead, to maintain a stable and sustained relationship, organizations constantly use informal and implicit contracts, which derived from prior ties, interpersonal relations, and reputation knowledge. Larson's research also indicated that organizations must commit resources to understand and adapt to their partners' needs. For inter-organizational ties to continue, organizational willingness and capacity to devote resources to tailor their partners' interests must consistently be present (Larson 1992:99).

In an analysis of semiconductor firms from 1985-1991, Stuart (2000) investigated the impact of alliances on firm innovation rates and economic growth, measured respectively as the number of patents granted and growth as annual semiconductor sales. The crucial factors were not the size of each firm's alliance portfolio (number of alliances formed during the previous five years), but the resource profiles of its partners. Specifically, both innovation and sales rates increased substantially if a firm was connected to more technologically innovative and revenue-rich alliance partners. These effects were especially potent for younger and smaller firms, suggesting they benefited most from access to larger, well-endowed partners. The consistent interactions of size and age with large and innovative partners were consistent with sociological arguments that affiliations enhance corporate reputations: "they build public confidence in the value of an organization's products and services and facilitate the firm's efforts to attract risk averse customers. In this sense, gaining an alliance partner signals a firm's quality" (Stuart 2000:808). An important implication of Stuart's analysis is that firms derive advantage from

their partners' corporate social capital, even if their strategic alliance fails to achieve its professed formal objectives.

Organizational Field Networks

Explanations of the structure of alliance within an organizational field network are underdeveloped compared to research on interorganizational relations at micro-levels of analysis. Most researchers investigate specific alliances as short-term cooperative efforts, without reference to the larger organizational fields within which they are embedded. Few theorists and researchers have analyzed the complete network structures of organizational fields (Hagedoorn and Schakenraad 1992; Powell, Koput and Smith-Doerr 1996; Kenis and Knoke 2002). Using the large MERIT database comprising 10,000 cooperative agreements (including 4,000 strategic technology alliances) among 3,500 international firms from 1980 to 1989, Hagedoorn and Schakenraad (1992) investigated trends over the decade. They argued that research development, cost sharing, and monitoring of technological advancement necessitated increasing partnerships among companies. They found varying rates of technology alliances during 1980s: new alliance growth was steady in the first half of 1980s, with a sharp rise in the mid-decade, followed by a more slowly increasing rate toward the end. Separate multidimensional scaling and cluster analyses of the networks of alliance ties among the 45 most active firms in each of the six industries disclosed relatively stable patterns for both halves of the 1980s (Hagedoorn and Schakenraad 1992:185). Many market leaders, as measured by annual sales, played prominent but not dominating roles in strategic partnering. However, little evidence supported an hypothesis that strategic technology alliances were a game led by "second-tier competitors."

(See also Hagedoorn 1993; Hagedoorn, Link and Vonortas 2000.) In an earlier analysis of the dataset used for this paper, Knoke and Yang (2000) found a steadily rising rate of strategic alliances from 1989 to 1998 among 145 core firms in the computer, mass media, and data services industries.

In their analyses of the evolution of collaboration among 400 firms in the human biotechnology industry from 1988 to 1997, Powell, Koput, and Smith-Doerr emphasized learning processes (see also Levinson and Asahi 1995). Pharmaceutical firms and start-up research companies formally allied to gain access to and competitive advantages from, respectively, new scientific knowledge and investment funds for research leading to marketable medical innovations. Prior experiences with managing interfirm relations, current network centrality, growth rates, and diverse portfolios of collaborative R&D activity explained these dynamic learning cyles and their effects on sales, nonoperating income, and internal R&S spending (Powell, Koput and Smith-Doerr 1996; Koput, Smith-Doerr and Powell 1997; Powell, Koput, Smith-Doerr and Owen-Smith 1999). Centrality in the overall alliance network, summing direct ties and indirect ties through partner firms, played a substantial role in determining individual firm performance in acquiring more patents, faster growth in size, and greater sales revenue.

Institutional theories assert that normative, coercive, and mimetic forces in an organization's environments influence organizational actions (DiMaggio and Powell 1983). Researchers could investigate the institutional effects on such organizational field-net outcomes as the accomplishment of alliance goals, impact on partnering organizations' performances, or larger societal consequences, in addition to the field-net structural impacts on alliance formation rates. Kenis and Knoke (2002) proposed several propositions about the effects of an organizational field network's formal properties – the configuration of communication ties

among the members of an organizational field – on the rates of strategic alliance formation among organizations in that field. However, testing those expectations would be hindered by difficulties in collecting longitudinal data on an entire field-net across a long span. Nevertheless, the relative scarcity of studies in network structures suggests abundant research opportunities in this area for future studies.

One consequence of the recent rapid increase in numbers and rates of strategic alliances was a rising intensity of rival or competing interorganizational clusters or blocks (Gomes-Casseres [1996:35] referred to such groups of firms bound together by multiple alliance ties as "constellations"). An interorganizational cluster consists of several companies joined together into a loose confederation through their direct and indirect ties to a core set of partners. As organizations linked themselves for common business purposes, group-versus-group became an emergent form of competition across global markets (Gomes-Casseres 1994:62). Perhaps the most striking recent example of this cluster competition occurred in the late-1990s in U.S. computer industry where a "Wintel" block centered around Microsoft and Intel was opposed by "the NOIS" cluster – Netscape, Oracle, IBM, and Sun Microsystems (Knoke and Yang 2000; Knoke 2001:147-150). In trying to dominate the computer manufacturing, software, and network browser markets, Microsoft and Intel forged extensive ties with other firms to promote personal computers favorable to Microsoft Windows and Internet Explorer. Their alliance strategic moves encountered strong resistance from the NOIS, which formed an anit-Wintel cluster to foster its own hardware, operating system, and internet browser standards. The U.S. Justice Department's anti-trust suit against Microsoft at the end of the century was the prominent legal manifestation of this cluster war.

Compared to earlier interorganizational business alliance, such as the Japanese *keiretsu* and American and European cartels, recent multi-organizational alliance clusters seem constructed for more narrowly defined goals focused on member organizations' individual needs. The primary purpose of traditional cartels spanning many industries has been to suppress competition and monopolize markets, whereas current alliance clusters typically coexist and provoke fierce competition (Gomes-Casseres 1994). The potential for decreased organizational autonomy and conflicting goals among cluster participants limits the development of a monopoly situation.

Two Research Hypotheses

In our initial scrutiny of the alliance announcements, we observed numerous collaborations between corporations from different nations and industries in the global information sector. Given their relentless drives to maximize organizational goals, firms should continually widen their horizons in the quest for new partners to supply critical information, remove barriers to market access, and share in the costs and risks of researching and developing innovative technologies. Thus, we expected that, as barriers to creating a genuinely global economy continually crumbled, a more inclusive strategic alliance network would emerge:

> **Globalization Hypothesis:** The search for competitive advantages through strategic partnering increases corporate integration across national boundaries, creating a stable alliance network structure consisting of a core block occupied by corporations from

different nations, rather than a structure characterized by nationally and regionally homogenous blocks.

Many factors might affect organizations' choices of alliance partners, including company resources, prior interorganizational ties, firm reputations, and network structural properties. We concentrated on understanding how the formal properties of a strategic alliance network shaped its members' subsequent choices of new partners. We expected that these decisions would result in the global information sector evolving toward a more internally coherent network structure:

Positive Preference Hypothesis: Organizations choose partners, using their knowledge of the current network structure, in efforts to create a more "positively evaluated" configuration.

The Global Information Sector

Because more detailed information on our dataset is available in Genereux and Knoke (1999), we only briefly summarize the data collection procedures of the Global Information Sector (GIS) project. First, we applied the new North American Industry Classification System (NAICS) to identify the information sector as comprised of the publishing, motion picture and sound recording, broadcasting and telecommunications, and information and data processing industries plus the related manufacturing industries of semiconductor machinery and computer and electronics products. Next, we assembled a list of the 400 large corporations in the GIS between 1989 and 1998, using the annual Fortune 500, Fortune 1,000, and Global 500 rankings,

as supplemented with corporate profile data from Hoovers, Infotrac, Standard and Poors, Who Owns Who online data services. We eventually trimmed this list to the 145 largest organizations operating during one or more years in the diverse industries comprising the GIS (see Genereux and Knoke 1999: Table 4). Finally, by systematically reading reports in various business press archives such as Newspaper Abstracts and Lexis-Nexis Academic Universe, we extracted information from any new alliance announcements between 1989 and 2000 that involved two or more of these 145 core GIS corporations. We found a total of 3,571 alliances spanning the dozen years covered by this report.

The data were stored primarily as organization-by-alliance or organization-by-organization matrices showing which firms were directly connected through an alliance partnership. We performed all the strategic alliance analyses of the GIS data reported below using either the UCINET or SIENA network analysis programs.

Organizational Volume of Activity and Centrality of Position

The volume of strategic alliance activity in the global information sector expanded dramatically between 1989 and 2000. As the annual trend lines in Figure 1 reveal, both the total number of new strategic alliances (in hundreds) and the mean alliances per organization (number of partnerships) increased about four-fold over the twelve years. The system generated only 107 and 98 alliances in 1989 and 1990, but reached 432 and 453 alliances in 1999 and 2000, respectively. Similarly, the mean number of alliances per existing organization rose from about 1.2 at the beginning to almost 4.5 in the final year. The two trend lines diverged slightly because the number of GIS core organizations shrank over time; by 2000, mergers and acquisitions had

reduce the initial 145 firms to 124. Despite the decreasing number of firms, their rates of collaborative activity accelerated during the last three years. However, the average number of partners forming each alliance showed little secular change, fluctuating after 1990 in a narrow range between 3.15 and 3.98 organizations per event (these partnerships include both GIS core and noncore organizations). Indeed, 70% of all alliances involved just two core organizations, a proportion that varied little over time. Thus, a primary macro-level trend in the global information sector was a steady proliferation of relatively small alliances.

The purposes for which GIS firms formed alliances shifted slightly over time. We content-coded all the published reports about each alliance, classifying each according to the two most relevant among nine types.[2] Figure 2 displays the percentages of all annual alliances classified according to these nine types. The two primary changes involved increasing attempts to adapt the products or integrate the services of different companies (from 14% to 34% of all alliances in 1989 and 200) and a late jump of equity investments (from less than 10% of alliances formed before 1999, to 17% and 19% during the final two years). Three types of alliances--research & development, production, and marketing--which together accounted for the large

[2] (1) Contract: To purchase vendor's off-the-shelf product or service; to order product or service according to buyer's specs; (2) License: To obtain rights to market an existing product or service in exchange for royalty or fee paid to original owner; (3) Production: To manufacture standardized goods or to provide direct services to particular clients; (4) Product Adaptation: To support or integrate existing technology with another firms' specific systems, programs, or devices (includes vendor alliances); (5) Research & Development: To create or demonstrate a new product or service by application of scientific principles; (6) Marketing: To sell, promote, publicize, distribute, or survey about products or services for end consumers; (7) Industry Standards: To create, adjudicate, or support industry-wide standards for products or services by a group of companies; (8) Legal-political: To sue competitors; to seek to enact or repeal legislative or regulatory decisions; (9) Equity stake: To invest for less than complete ownership of an organization without mention of a specific project; to attempt an equity takeover of a company in co-ownership with other firms.

majority of alliance purposes in every year, showed only trendless fluctuations over the 1989-2000 interval.

Our next analyses examine the changing patterns of alliance centralization of the GIS from 1989 to 2000. Three classic measures of centrality are degree, closeness, and betweenness (Wasserman and Faust 1994). Each measure is based on the idea that more central firms collaborate with many partners, while more peripheral organizations have fewer ties, and isolates have no connections to any other organization. *Degree centrality* simply counts the total number of partnerships that a corporation formed in a year (in-degree and out-degree centrality scores are identical in this study because an alliance relation is a symmetric choice).[3] As shown Figure 1, the mean number of partnerships increased considerably over time. The number of isolated organizations declined from 41% in 1989 to just 19% in 2000. *Closeness centrality* takes into account the distance between a pair of firms, measured by the minimum number of intermediaries required to connect that pair (e.g., through the "partners of partners"). As shown in the top diagram of Figure 3, the average closeness scores of the GIS organizations rose sharply from 1989 to 1994, leveled off until 1997, then fell sharply until 2000. In contrast, network-level centralization, which summarizes the extent to which a single organization has greater centrality than all others, showed marked stability around a low level. Finally, *betweenness centrality* captures the extent to which an organization appears on the paths connecting other pairs of organizations (i.e., the number of geodesics). It indicates an firm's power to mediate or control information and other resources exchanges. In the lower diagram in Figure 3, the organizations' average betweenness centralities also rose and fell across the twelve

[3] In a valued graph, where a firm may form multiple alliances with another organization, degree centrality measures the total number of distinct partnerships, not the number of partners. For example, in 2000 Microsoft's degree centrality score was 75, indicating that it made 75 agreements; however, only 22 of 29 core firms formed alliances with Microsoft.

years, although less steeply than the closeness trend. Again, network-level centralization was fairly stable throughout the period. Some insight into the changing centralization of the GIS can be gathered from identifying those firms with highest closeness and betweenness scores at three years spanning the decade:

	CLOSENESS	**BETWEENNESS**
1991	AT&T	AT&T; Time Warner
1995	IBM; Sun; Intel	AT&T; Intel; IBM
2000	Microsoft; IBM; Sun; HP	Microsoft; IBM

By the end of the century, the rise of IBM, Microsoft, and Sun to positions of dominance within the GIS strategic alliance network had pushed AT&T off center stage.

Structural Change in the Core

To examine the hypothesis that globalization processes increased the numbers of cross-national strategic alliances in the GIS, we examine changes in the structure of collaborative relationships among the core firms at three dates. Table 1 shows the 30 organizations that formed the most strategic alliances in 1991, 1995, and 2000. Fifteen were U.S. companies, followed by eight Japanese, five European, one Canadian, and one Korean firm. Most of these core firms were active primarily in the computer, software, semiconductor, telecommunications, or audiovisual equipment industries, but notably none were book and newspaper publishers, motion picture producers, or television broadcasters.

The histogram in Figure 4 shows the mean number of strategic alliances among pairs of core GIS firms within and between the Triad--the U.S., Japan, and European Union members. In

every year, these mean frequencies were usually higher among pairs of companies from the same geographic region than among cross-border pairs. Two exceptions involved the five core European organizations: in 1991 they averaged slightly more alliances to Japanese companies than among themselves (1.38 versus 1.30), while in 2000 their mean alliances with U.S. firms were also somewhat higher (0.76 versus 0.60). By far the most striking feature of Figure 4 is the abrupt increase in alliances among the eight core Japanese firms in 2000. The mean number of new agreements among pairs of Japanese firms (5.04) more doubled their previous intra-nation rates (1.89 and 1.75 in 1991 and 1995, respectively). Thus, contrary to the globalization hypothesis, the GIS organizations did not increasingly choose more geographically distant partners. Rather, the core firms of all three Triad blocks continued to favor their own countries or regions, with Japanese companies apparently experiencing a recent surge of national partiality.

Additional evidence that the 30 core GIS firms refrained from increasing their cross-national collaborations appears in multidimensional scaling analyses of the strategic alliance ties in 1991, 1995, and 2000. Our MDS application treated the number of new connections formed in a year between every pair of organizations as a nonmetric measure of proximity within a social space. Each year's proximity matrix was analyzed by the MDS program in UCINET, yielding acceptable two-dimensional fits, as reported in Figures 5-7. Hierarchical cluster analyses performed on the same proximity matrices (specifying the complete-link method on similarity measures) permitted construction of contiguity lines around subsets of organizations with the greatest similarity to one another. The lines shown in the figures surround the clusters that encompass members having more new alliances among themselves compared to their ties with members occupying other positions in the strategic alliance system. In each figure, the four

or five most central actors, based on their degree, closeness, and betweenness scores, are underlined.

The GIS core alliance network structure changed in three fundamental respects across the decade:

- The numbers of clusters increased and thus their average size shrank. The 1991 system consisted of four clusters containing an average of 6.5 organizations. By 1995, five clusters emerged with an average of 5.4 organizations. And five years later, a total of seven clusters each contained only 3.9 organizations on average.
- The most central organizations (as identified by their centrality scores) changed and dispersed among separate positions. In 1991, four of the five central firms occupied the same cluster, with AT&T adjacent to IBM, which is located in a second cluster at the center of the space. In 1995, four of the five most central firms were also in the same position, and AT&T was still next to IBM, but both in the same cluster at the center of the space. However, in 2000, the four most central firms were spread across three positions; AT&T was located in a cluster with two non-American telecommunications companies; and Microsoft had joined IBM at the spatial center of the sector.
- All eight Japanese companies migrated from multiple positions that included some non-Japanese firms to one exclusively Japanese position. In 1991, they occupied two positions and one firm (Matsushita) was unconnected. In 1995, the Japanese firms spread across four clusters. However, when they abruptly increased the number of intra-Japanese partnerships in 2000, all eight Japanese companies merged into a single position, appearing at the lower left side of Figure 7, with Toshiba as its central member.

In sum, the global information sector grew increasingly differentiated over time, as smaller, more specialized positions emerged that were occupied by more homogeneous sets of firms. The data offered scant support for the globalization hypothesis that, in their search for competitive advantages through strategic partnering, information sector firms would become increasingly integrated across national and industry boundaries, thus creating a stable alliance structure consisting of a core block occupied by corporations from different nations. Instead, the system apparently was moving toward a structure characterized by more homogenous national and regional blocks.

Evolving Network Structures

This section examines the evolution of the GIS strategic alliance network among the 30 core organizations across the years 1991, 1995, and 2000. Our hypothesis is that an organization chooses new partners or drops current partners in an effort to create a more positively evaluated alliance network structure, thus resulting in a subsequently more internally coherent network structure, from that organization's point of view. This hypothesis assumes an actor-oriented model of methodological individualism: an organization behaves like a utility-maximizing person by intentionally changing its relationships to create a network configuration whose structural properties are more rewarding to itself. Thus, every company prefers to form new partnerships that transform the alliance network into a more "pleasant" configuration of relations. For example, because actors typically prefer closed or transitive relations, they tend to form ties that connect them to the partners of their current partners (i.e., a "friends of friends" bias at the personal level). Or, the propensity toward balanced relations leads actors to choose

alliance partners who maintain similar activity levels (e.g., an organization with numerous partners prefers to ally with organizations that also have many partners). (See Snijders [2001] for an exhaustive list of possible network effects that may enter into an actor's objective choice functions.) Organizational decisions to add or drop relations are constrained by the present state of the alliance network in which all firms are embedded, but are uninfluenced by any earlier network structures (a Markov-chain process). Organizations are also assumed to possess full information about the current network, which is required to maximize their objective functions.

Using the SIENA (Simulation Investigation for Empirical Network Analysis) computer program for repeated social network (Snijders 2001), we estimate parameters for models of dynamic change as stochastic outcomes of a current alliance network structure, organizations' objective preference functions, and organizational attributes. SIENA estimates model effects using two or more binarized matrices by applying the method of moments, implemented as a continuous-time Markov chain Monte Carlo (MCMC) simulation (see details in Snijders 2001). To implement these models, we binarized the three annual GIS alliance matrices by collapsing every dyad's multiple partnerships to equal 1, while keeping no relationship equal to 0 (SIENA ignores diagonal values). Because a strategic alliance by definition is a reciprocal relationship between a specific pair of organizations, these dyadic ties constitute a nondirected (symmetric) matrix. Therefore, some objective function parameters do not have meaningful interpretations, in particular, the tendency to form reciprocated relations. The only organizational attribute we included was national similarity, creating dummy-coded variables for firms from each geographic area of the Triad (we classified the Korean company with the Japanese firms and the Canadian company with U.S. firms).

The densities of the three binarized matrices fell over time, from 0.74 of possible dyadic ties in 1991, to 0.56 and 0.50 in 1995 and 2000, respectively. Table 2 displays the model estimates of the organizations' objective functions and national origins for both the 1991-1995 and the 1995-2000 pairs of alliance networks. To account for the observed density changes, we included the rate and density parameters in each model. These two effects were significant only in the early period, reflecting the more rapidly changing core network density from 1991 to 1995. We also control for reciprocity, despite their lack of substantive meaning in these data, but its effect was too highly correlated with other objective functions to be included in the first period model. Reciprocity was not significant in the second period, and as we noted above, it would not have a meaningful interpretation because alliance partnerships are always mutual ties.[4] We also found no evidence that transitivity, alter popularity, or alter activity had significant effects on network evolution in either period. These parameters could not be included in the multivariate models due to multicollinearity, and each failed to achieve significance when entered into an equation without other effects.

Two significant effect parameters have important substantive interpretations. The balance coefficients are positive in each period, indicating a similarity between an organization's number of direct ties to its current partners and the selection of new strategic partners with similar numbers of ties. That is, an organization having many partners prefers to ally with other organizations that also have many partners. Likewise, firms with few allies tend to choose partners that also have few allies. The indirect ties parameters are also significantly positive in both periods, indicating organizational preferences for open, ramifying networks. That is, if an organization currently is indirectly connected (via one-step intermediaries) to organizations with

[4] Snijders (2001) recommended always including density and reciprocity in a SIENA analysis, even if substantive interpretations of those effects are not feasible.

many partners, they prefer new partners having similar indirect connections to prolific partners-of-partners. Conversely, firms indirectly linked to poorly allied companies tend to choose new partners that also have partner-poor indirect connections. In effect, both the balance and indirect ties parameters demonstrate a strong organizational preference in the GIS to choose new strategic alliance partners that replicate and extend existing network configurations. Over time, the GIS alliance network evolved into a differentiated system as some firms acquired numerous direct and indirect ties offering them a wealth of potential new partners, but other companies lacked the capacity to construct such extensive opportunities. In effect, the contact-rich firms got much richer while the poor players became beggars.

Finally, because SIENA emphasizes differences among actor attributes, the impacts of nationality appear as dissimilarity coefficients for U.S., Japan, and Europe in Table 2. Thus, a negative sign indicates that U.S. and Japanese organizations prefer alliances with partners from the same Triad component, relative to the European reference category. Although all four parameters were negative, only the intra-national inclination among U.S. firms was significant between 1991 and 1995. Apparently the alliance-formation spike among Japanese firms in 2000, evident in Figure 7, is fully explained by the balance and indirect biases in the dynamic model for 1996-2000 in Table 2.

Conclusions

We analyzed the changing macro-level structural relations of strategic alliance formation in the global information sector from 1989 to 2000. We found that the numbers of new alliances rose substantially across the twelve years, with mean organizational centralization peaking in the

mid-1990s. Among the 30 most-active firms, structural differentiation increased across three years spanning the 1990s, with smaller, more specialized clusters emerging. By 2000, the Japanese companies had largely concentrated their new alliance agreements among themselves, contradicting the globalization hypothesis that information organizations would increasingly seek partners across geographic and industry boundaries. Our dynamic models of network evolution across the three years revealed that the 30 core companies chose alliance partners that increased two structural properties. Organizations sought new connections with organizations that had direct and indirect ties resembling their own alliance propensities. At the macro-level, these changing ties among the core global information sector firms generated a more differentiated strategic alliance network, one exhibiting greater structural balance and extensively circuitous linkages that enlarged the collective opportunity to forge new partnerships.

Further research on the global information sector should proceed simultaneously in several directions:

- Construct and test a comprehensive, macro-level theoretical explanation for strategic alliance network formation processes and their consequences at several levels of analysis
- Reconstruct a historical narrative of global information sector, to understand better the emergence of this trans-national and trans-industrial system with its markedly mutable internal structures
- Uncover the structural details of strategic alliances among all GIS organizations in complete networks at each year over the two decades
- Model the dynamics of alliance network evolution, emphasizing contingencies of nation and industry

- Examine block- and dyad-level partnerships, as functions of organizational and network factors
- Analyze strategic alliance consequences for organizational performances: growth, profits, innovation

As we fit together the pieces of this dynamic puzzle, a more complete picture will come into view to explain and interpret how strategic alliance continually reconstruct the information world we all inhabit.

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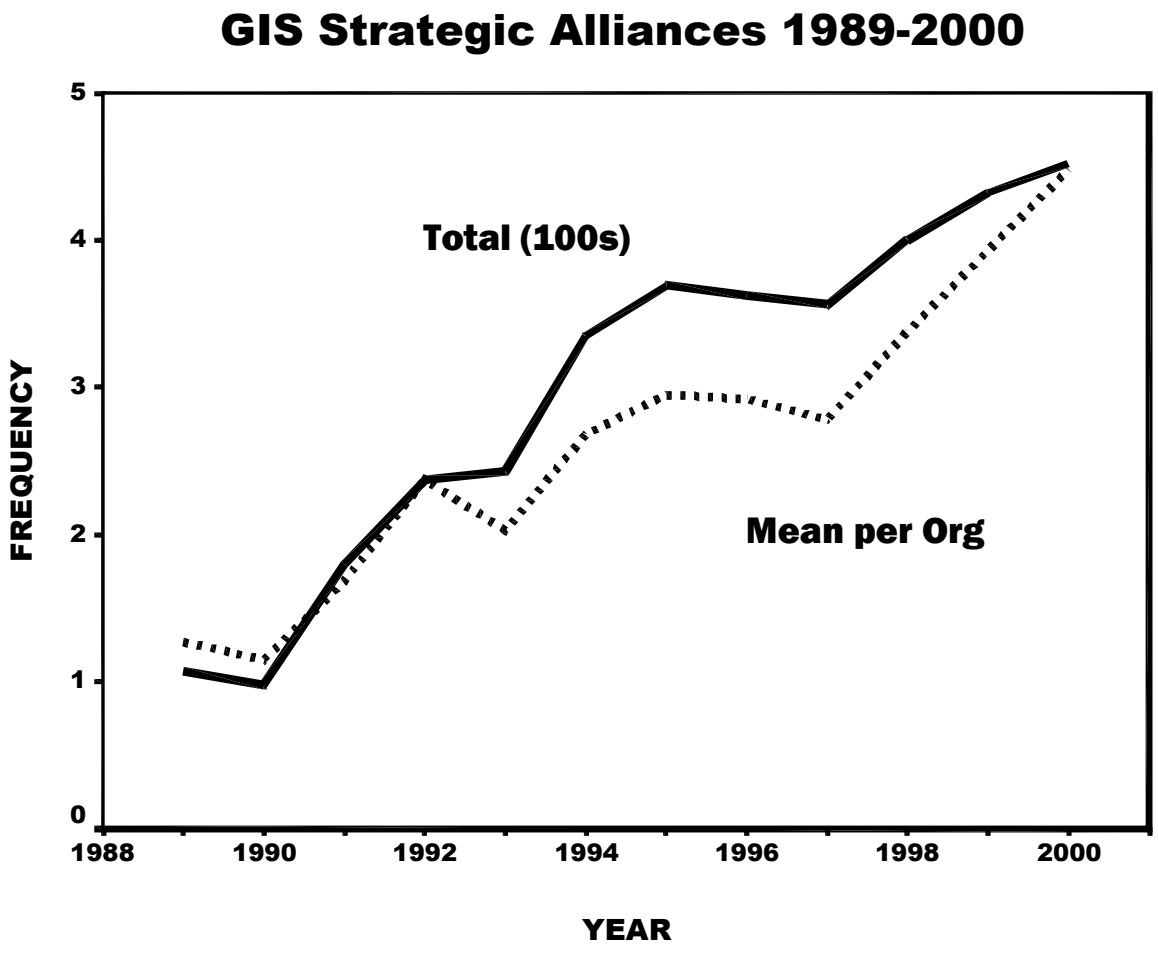

Figure 1. Trend in Total and Mean Numbers of Annual Strategic Alliances

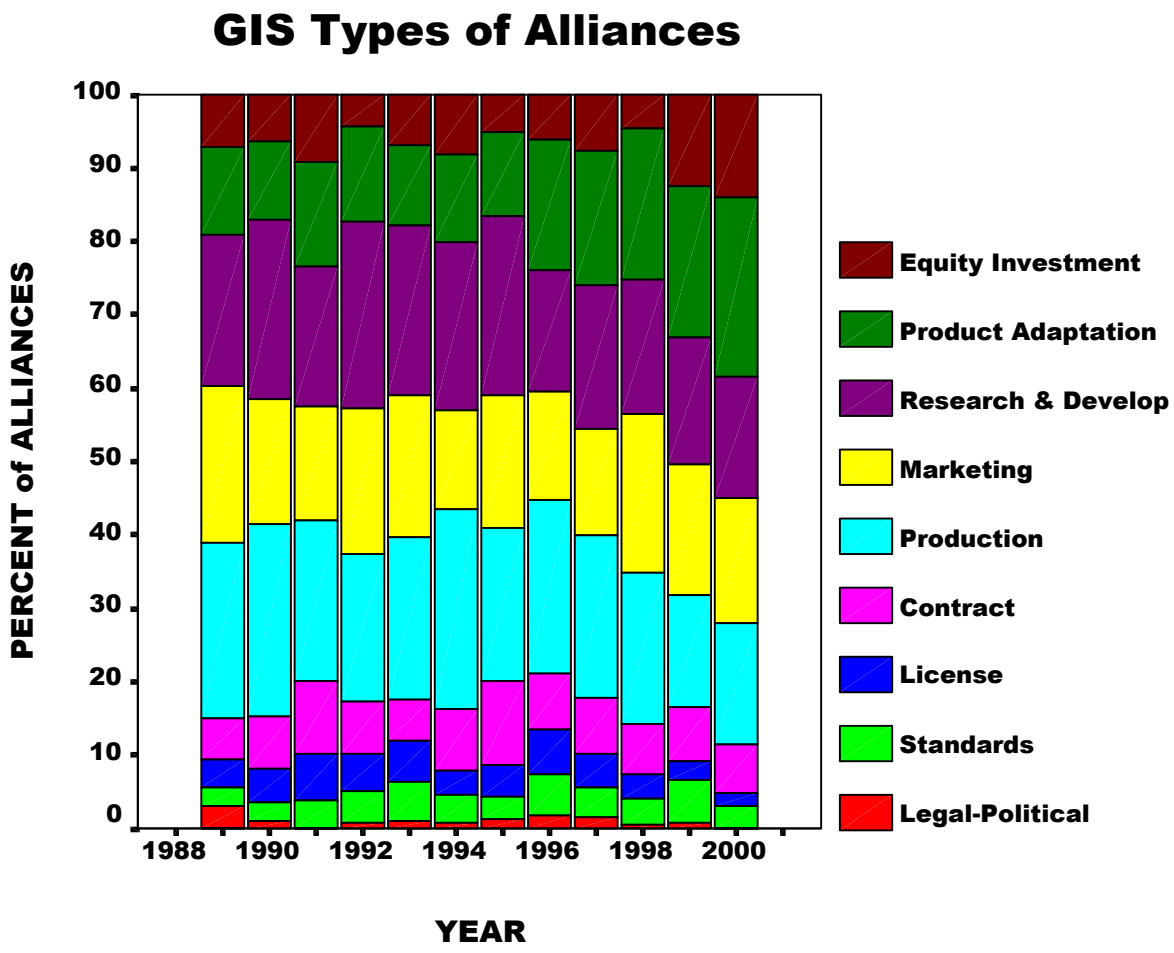

Figure 2. Trend in Types of Strategic Alliances

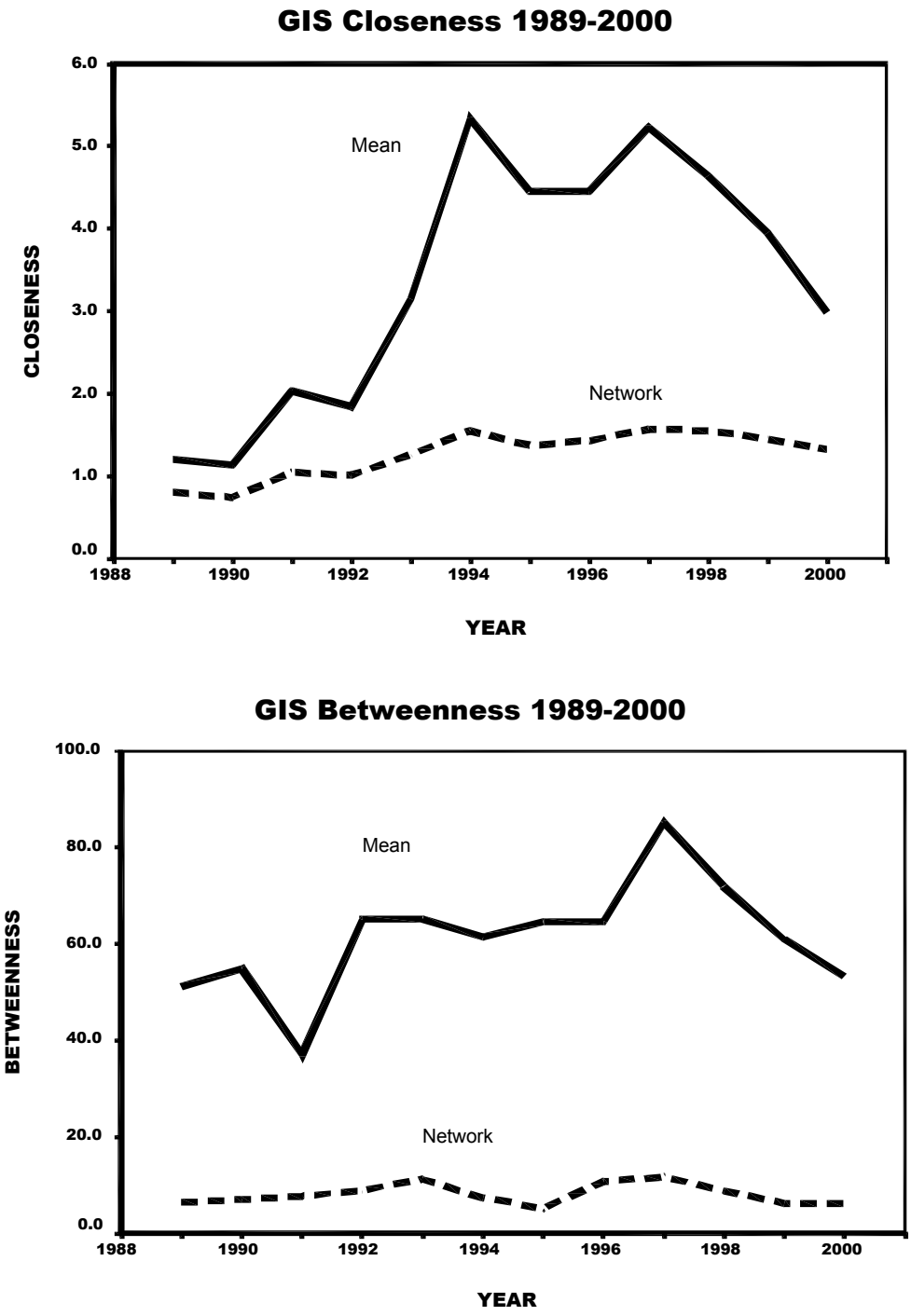

Figure 3. Trends in Closeness and Betweenness Centrality

Table 1. Thirty Most Active Firms, Classified by Nation and Primary Industry

Organization	*Primary SIC*
America Online AOL (USA)	Information retrieval
Apple (USA)	Computer
AT&T (USA)	Telecommunication
BellSouth BS (USA)	Telecommunication
Cisco (USA)	Communication equipment
Compaq (USA)	Computer
Hewlett-Packard HP (USA)	Computer
IBM (USA)	Computer
Intel (USA)	Semiconductor
Microsoft (USA)	Software
Motorola (USA)	TV equipment
Novell (USA)	Software
Oracle (USA)	Software
Sun Microsystems (USA)	Computer
Texas Instruments TI (USA)	Semiconductor
British Telecomm BT	Telecommunication
Ericsson (Sweden)	Telecommunication equipment
France Telecomm FT	Telecommunication
Philips (Netherlands)	TV equipment
Siemens (Germany)	Computer peripherals
Fujitsu (Japan)	Computer
Hitachi (Japan)	Computer
Matsushita (Japan)	AV equipment
Mitsubishi (Japan)	AV equipment
NEC (Japan)	Computer
NTT (Japan)	Telecommunication
Sony (Japan)	AV equipment
Toshiba (Japan)	AV equipment
Bell Canada BCE	Telecommunication
Samsung (Korea)	Semiconductor

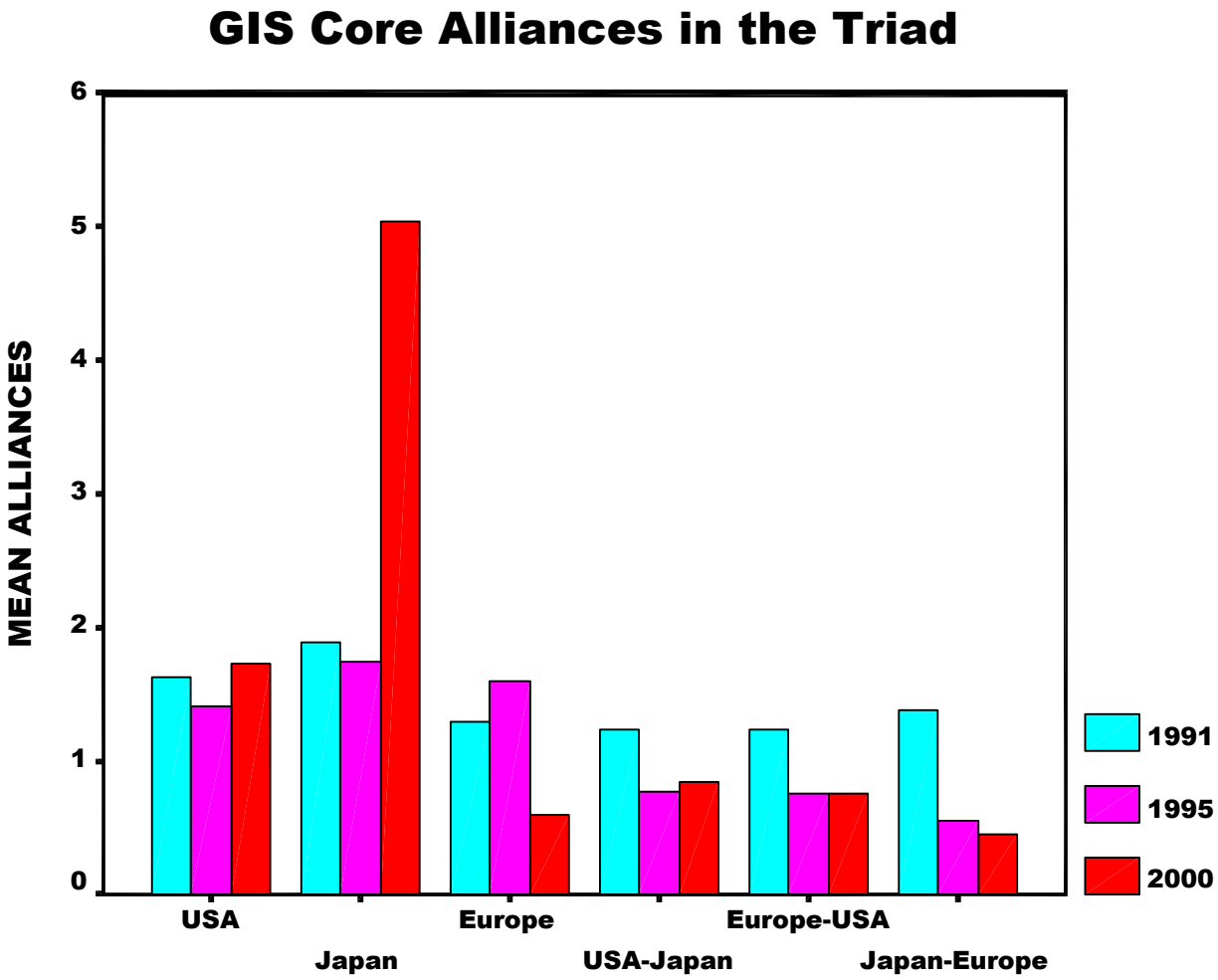

Figure 4. Mean Alliances Within and Between Triad, 1991-1995-2000

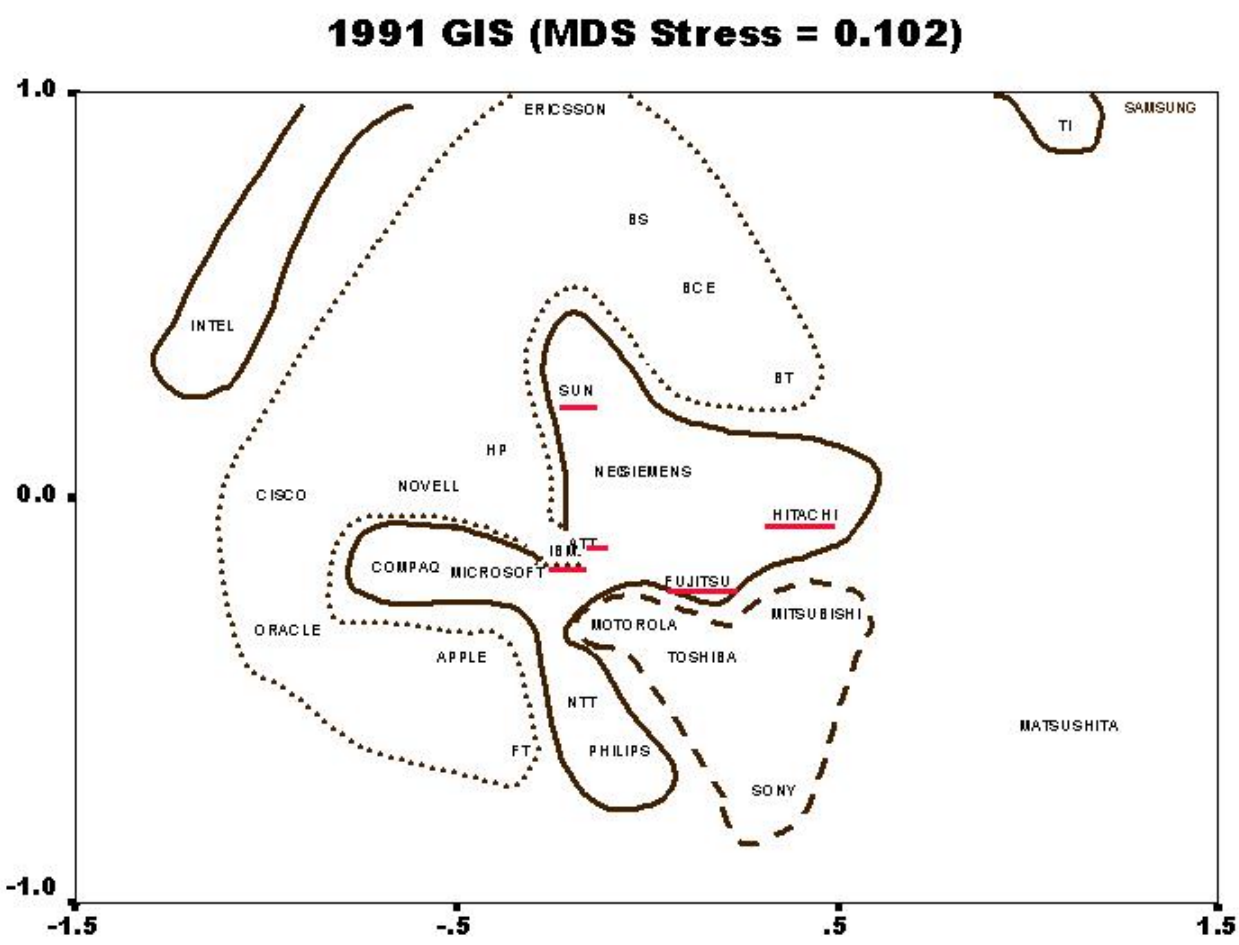

Figure 5. Multidimensional Scaling of Core Firms 1991

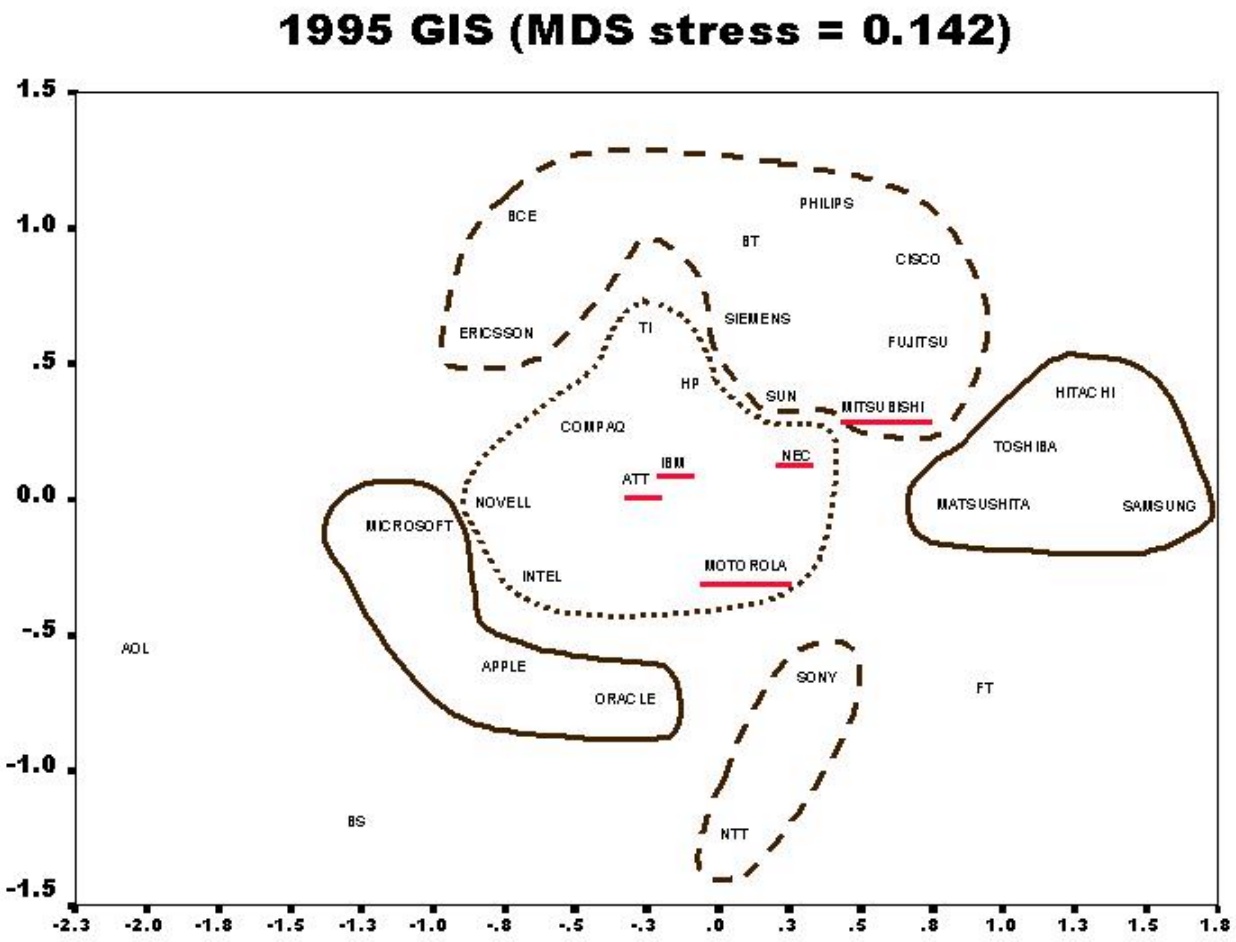

Figure 6. Multidimensional Scaling of Core Firms 1995

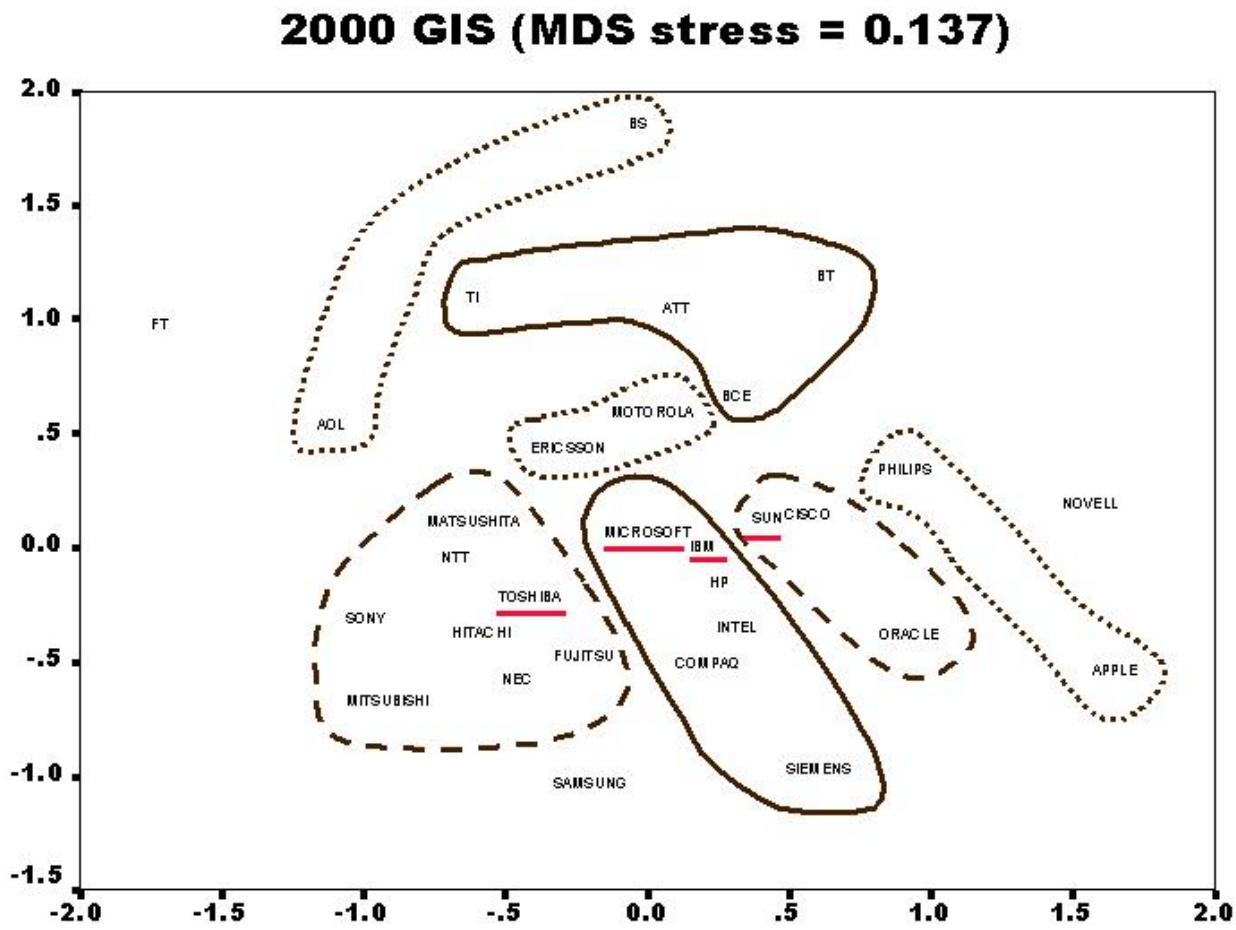

Figure 7. Multidimensional Scaling of Core Firms 2000

Table 2. SIENA Parameters for Alliance Choices 1991-1995 and 1995-2002

OBJECTIVE FUNCTION	1991-1995	1995-2000
Rate	63.26***	116.50
Density	1.65***	-0.27
Balance	1.77***	1.21**
Indirect ties	1.29**	1.02*
Reciprocity	--	2.48
U.S. dissimilarity	-0.40**	-0.12
Japan dissimilarity	-0.22	-0.05
Europe dissimilarity	--	--