Porous and Fuzzy Boundaries:

A Network Approach to Corporate Diversification*

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ABSTRACT

Accelerating global trends towards diversified multinational corporations allegedly blur the boundaries between conventional industries. To explicate empirically the porous-and-fuzzy-boundary metaphor, we analyze a two-mode network in which a set of industries and a set of firms are structurally connected when firms engage in production or service activities conventionally classified as a distinct industries. Applied to the 2005 Global Information Sector, this structural relational approach identifies two types of firm clusters: diversified firms that operate in two or more information industries, and focused firms that concentrate on a single industry. We also show that specific multiple-industry combinations account for more variation in corporate performance than attributable to the additive effects of conventional industrial classifications. We conclude with suggestions for further network analyses and theory construction to gain a better understanding of the increasingly porous and fuzzy boundaries between industries in the global economy.

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> *"Industry and market boundaries are porous and 'fuzzy' especially where globalization is taking place."*
>
> (McGee, Thomas and Pruett 1995:261)

Accelerating global trends over recent decades in corporate expansion, governmental deregulation, and technological innovations have diversified multinational enterprises into business lines spanning conventional industry boundaries. Researchers have periodically noted an "imprecision of industry definition and the 'fuzziness' of industry boundaries in economic environments characterized by product differentiation and technological change" (Venkatraman and Thomas 1988:546; see also McGee, Thomas and Pruett 1995; Cantwell and Santangelo 2006; Bernard, Redding and Schott 2006). The propensity towards blending transindustrial products and service activities inside diversified corporations is especially striking among information sector firms, which operate in the telecommunications, broadcasting, entertainment, software, data processing, and related manufacturing industries (Nicholls-Nixon and Jasinski 1995; Baldwin, McVoy and Steinfield 1996; Chan-Olmsted and Chang 2003). A colorful example is Vivendi SA – a French conglomerate active in music, video games, television, film, publishing, telecoms, and the Internet – whose current incarnation involved the 2000 merger of Seagram, Canal+, and Vivendi; a spin-off of its original core water and waste companies; and the sale of Universal Studios to NBC in 2006. To explicate empirically the porous-and-fuzzy-boundary metaphor, we apply social network concepts and methods that reveal the structural relations among industries and firms in the information sector and their consequences for firm performance.

In the following sections, we first discuss production-oriented concepts of industry, then describe the technological and political forces purportedly driving product convergence among industries in the information sector. After briefly reviewing theories and research on corporate diversification and its effects on firm performance, we specify a two-mode network approach in which a set of industries and a set of firms are structurally connected when firms engage in production or service activities conventionally classified as a distinct industries. We then present research hypotheses about industrially focused and diversified firm clusters and their effects on firm financial performance. After describing the industry-firm network data from the Global Information Sector for 2005, we conduct a series of network analyses and find evidence consistent with the hypotheses. We conclude with suggestions for further network analyses and theory construction to gain a better understanding of the increasingly porous and fuzzy boundaries between industries in the global economy.

Increasingly Blurred Boundaries

Neoclassical microeconomic theories of the firm conventionally postulate single-product or -service organizations, thereby simplifying the explanation of competition among a set of firms all producing a unitary good. Production-oriented or supply-based definitions of *industry* conceptualize that "the producing units that are grouped within the industry's boundaries share a basic production process, they use closely similar technology. Producing units in no other industry share the same technology and production process" (Economic Classification Policy

Committee 1994:3; see also Nightingale 1978). In other words, an industry comprises all economic units (firms or establishments) that use an identical production function and whose boundaries are drawn such that the units in other industries use different production functions. In contrast, economies of scope theories assert that multiproduct firms can improve production or distribution efficiency by combining diverse products or services under one roof (Panzar and Willig 1981; Bailey and Friedlaender 1982). A firm may reduce its set-up costs by manufacturing distinct products within a shared facility or by selling and shipping diverse products to a retailer. Synergies among services allegedly arise through providing customers with a complete range rather than a single service. Familiar examples of multiproduct enterprises are an automobile plant with assembly lines for trucks, cars, and SUVs; an investment bank that conducts equity research and sells securities; and a golf course whose pro shop sells equipment, clothing, and even travel packages. One examination of product-switching behavior by U.S. manufacturing firms found that two-thirds had altered their product mixes every five years, with one-third of the increased shipments from 1972-97 due to the "net adding and dropping of products by survivors" (Bernard, Redding and Schott 2006:1). Those findings "raise broader questions of the boundaries of the firm and the determinants of firm dynamics. … even basic concepts, such as a firm's industry become far more nuanced when firms produce sets of products that change over time" (p. 25).

Among information industries in particular, both technological and political forces drive the forms and rates of product and service convergence. Convergence often refers to creation of the Information Superhighway – a seamless integration of digitized voice, video, and computer network technologies combined with work platforms, Internet-enabled wireless devices, and broadband distribution infrastructures (e.g., Danowski and Choi 1998; Morrison 1999; Schwartz and Shafer 2003; Chon et al. 2003). Analysts also describe how convergence among technological innovations leads increasingly to mutually competitive encroachments by firms in the telecom, content-provision, and computer industries on one another's traditional turfs (Katz 1996; Lee 2007). Heightened competition for potential new customers and business opportunities, coupled with efforts to spread and reduce financial risks, generate successive waves of cross-industry mergers, acquisitions, licensing, and strategic alliances (Albarran and Dimmick 1996; Chan-Olmsted 1998; Chan-Olmsted and Chang 2003). Convergence of substitutable products and services (e.g., wireless and landline phones) tends to intensify inter-industry competition, but the convergence of complementarities necessary to create bundled services (e.g., personal digital assistant devices and wi-fi networks) may have the opposite effect of reducing competition (Bauer 2005). For example, convergence-generated competition more likely accelerates cross-industry integration among firms in the cable, wired, wireless, and satellite telecom industries than, for example, among motion picture and computer software companies.

Although technological innovations facilitate integrated multimedia systems, the pace of adoption and implementation is also strongly shaped by governmental regulation and sociocultural environments. During the 1990s, neo-liberal public policy shifts in the United States, the European Union, Latin America, and elsewhere converged on market-oriented reforms to eliminate obsolete and inflexible laws, rules, and regulations that were hindering investments and limiting competition (Hills and Michalis 2000; Levi-Faur 2003; García-Murillo 2005; Witold, Zelner and Guillén 2005). Privatization of state-owned telecommunications firms and reductions in executive political influence over regulatory agencies led to the dismantling of many entry barriers in the cable, broadcasting, and telephone industries, thus opening them to large influxes of new multiple-service providers (Thatcher 2004; Eberlein and Grande 2005). Permissive cross-industry and cross-national mergers and acquisitions further contributed to blending multiple industries inside multinational corporations. Some retrospective assessments of the U.S. Telecommunications Act of 1996 suggested that it initially fostered competition and multimedia convergence (Bush, Beahn and Tuesley 2005; Robbins 2006). However, other researchers concluded that recently "competition has been giving way to consolidation" (Noam 2006:549), as exemplified by AT&T's reacquisition of two Baby Bell spin-offs and by rising economic concentration in the telephony, cable television, and high-speed Internet access industries (Atkin, Lau and Lin 2006).

Corporate diversification theories in finance economics and strategic management examine the origins, trends, and consequences for firms engaging in multiple-industry activities. Those literatures are "voluminous, diverse, and quite old," posing "an age-old question" of whether corporate diversification – the number of business units operating in different industries under the control of a single firm – creates or destroys shareholder value compared to focused firms, which operate in only one industry (Martin and Sayrak 2003:37-38). Research on 1960s conglomerates and the 1980s bust-up takeover era usually found a negative covariation, called the "diversification discount," between a firm's decision to diversify and its value (e.g., Lang and Stulz 1994; Berger and Ofek 1995; Denis, Denis and Sarin 1997; Matsusaka 2001). But more recent evidence from the era of increased multinational globalization suggests that diversified firms attain either neutral or superior performance outcomes (e.g., Campa and Kedia 2002; Gomes and Livdan 2004; Mathur, Singh and Gleason 2004; Villalonga 2004b; Varanasi 2005; Doukas and Kan 2006). Agency theories hypothesize that corporate executives may undertake to diversify a firm's industrial portfolio – particularly through mergers, acquisitions, and joint ventures – as a means of reducing exposure to market risk (Denis et al. 1997; Hermalin and Katz 2000; Martin and Sayrak 2003; Nam et al. 2006). On the one hand, diversification may boost firm value by generating managerial synergies and cross-industry efficiencies through greater utilization of excess production facilities, shared R&D, joint legal and financial staffs, integrated marketing and distribution channels, increased debt capacity, and access to more resources through better networking in a broader environment (Villalonga 2004a). On the other hand, diversified firm values may erode through conflicts arising among intracorporate cultures, increased coordination costs, and strains from coping with increased managerial, structural, and organizational complexities. As the firm's agents, executives are personally motivated to pursue diversification strategies that also yield private benefits such as greater power, better job security, and higher financial compensation, thus bringing them into conflicts of interest with shareholders (Aggarwal and Samwick 2003). As the firm's principals, shareholders may view corporate diversification, which risks decreasing the value of their security holdings, as a more costly strategy than simply diversifying their personal stock portfolios.

Research on corporate diversification typically measures industry aggregates, for example, the number of 4-digit SIC codes among a firm's business units. Regression equations use either counts of the total number of business segments, a dichotomous indicator for diversified versus focused firms (e.g., Campa and Kedia 2002; Mathur et al. 2004; Gomes and Livdan 2004), or the Herfindahl and entropy indices which weight segments by their sales contributions (Berry 1975; Jacquemin and Berry 1979). Some typologies classify firms into broad categories ranging from "single industry" to "unrelated diversified" (e.g., Rumelt 1982). However, all such aggregations obscure the complex structural relations connecting particular firms to particular industries, and are unable to investigate whether certain combinations of industries differentially affect firm behaviors and performance outcomes. Firms embedded within a specific industrial network configuration may experience competitive advantages or disadvantages relative to firms located in alternative structural arrangements. Given that the interplay among corporate diversification strategies, technological convergence, and political dynamics relentlessly engenders complexity in the information sector, how can researchers decide empirically where to draw industry boundaries? What relational links between industries and firms generate particular combinations of diversified and focused firms? Do firms operating business units in diversified industries experience better or worse performance outcomes than firms focusing their efforts in a single industry? Before attempting to answer to these research questions, the follow section discusses a social network approach to conceptualizing structural relations among industries and firms and presents our research hypotheses.

Hypotheses about Two-Mode Networks

Social network analysis provides both a structural perspective and a research methodology for investigating industry-firm relations. As elucidated by Wellman (1988) and Emirbayer (1997), the fundamental principles underlying network analysis include: (1) actors' behaviors are best explained by their relations with other actors, and are not reducible to their attributes or attitudes; (2) actor interdependence requires examining the entire set of relations in a system, not focusing only on pairwise ties; and (3) "groups sometimes have fuzzy rather than firm [*sic*] boundaries" (Katz et al. 2004:312), because actors typically maintain cross-cutting ties to multiple groups within a network. A fourth important network principle is that the structural configurations of actors and relations serve simultaneously as an opportunity and a constraint on possible actions that affect consequent outcomes. Social network data consist of a finite set of nodes (actors and/or objects) and at least one relation (collection of ties of a specific kind) among those nodes (Wasserman and Faust 1994:20). The most prevalent type is a *one-mode network*, in which a single relation is observed on a single set of actors. A classic example is a friendship network in which the children in a classroom name their close friends. However, a less-common type, containing two sets of actors and a relation connecting the first and second sets, is not surprisingly known as a *two-mode network* (Wasserman and Faust 1995:120). Familiar examples are community elites who belong to social clubs (Galaskiewicz 1985) and countries that are members of military alliances, trade pacts, or international organizations (van Rossem 1996). In our application, the two modes are industries and firms and a relation between modes exists when a firm engages in production or service activities classified as a specific industry. Connections among members of one mode are all indirect, occurring only if they have ties to the same member of the other mode. Thus, two firms are linked if they compete in the same industry, and two industries are connected if the same firm participates in both. Across an entire set of industries, clusters (subsets) of industries may have identical or highly similar relations with the same group of firms. At one extreme, if every firm operates in only one industry, each industry cluster would consist of a subset of focused firms with no connections to any other industry cluster. In contrast, to the extent that many firms participate in several industries, then some clusters would consist of subsets of diversified firms participating in the same set of multiple industries. An observed configuration of clusters empirically answers to the question about where to draw boundaries within an economic sector encompassing both industrially diversified and focused firms. An expectation of mixed industry clusters in the information sector leads to our first hypothesis:

Hypothesis 1: Structural analysis of the two-mode industry-firm network in the information sector identifies discrete clusters of focused-industry and diversified-industry firms.

A salient property of any two-mode network is the *duality* of the relations occurring simultaneously within both modes (Breiger 1974; Wasserman and Faust 1994:294-295; Field et al. 2006). "The value of a *tie* between any two individuals is defined as the number of groups of which they both are members. The value of a tie between any two groups is defined conversely as the number of persons who belong to both" (Breiger 1974:181-182). Just as we can identify clusters of industries via shared firms, we may also find clusters of firms with only one industry or with several industries in common. That is, two firms are connected if they operate in the same industry, and clusters of firms could be characterized as either focused or diversified, according to the particular combinations of industries in which they participate. We analyze the two-mode network from both dual relational perspectives to gain additional insights into industry-firm network structures.

We believe that important economic opportunity and threat structures emerge from the pattern of interconnected industries when some firms engage in diversified-industry production and service activities because of identical complementarities. Disregarding the indirect linkages among firms with several common industries may overlook possible synergies and liabilities arising when trans-industrial enterprises recurrently encounter one another across compound industrial situses. Organizational principals and their agents are likely to develop distinct perspectives and characteristic mindsets, which are not shared by focused firms that concentrate their efforts within one industry or by other diversified firms participating in quite different multiple-industry combinations. Convergence around a set of institutional norms and practices may arise even if competing firms don't interact directly, as a consequence of their structural embeddedness within unique economic, political, and social environments. Moreover, as occurs in another well-known two-mode context – interlocking boards of directorates – corporations situated within identical diversified-industry context are also more likely to interact directly: exchanging information, forming strategic alliances and joint ventures, acting collectively to further their common political interests. Firms involved in diversified industries thereby gain more access to knowledge, resources, and cooperative assistance than firms lacking multiple-industry ties. These expectations lead to our second hypothesis, about the relationship between diversification and performance:

Hypothesis 2: Diversified-industry clusters explain additional variation in firm performance above the additive effects of conventional industry classifications.

Firm financial performance is difficult to conceptualize and measure, and is typically treated as a multidimensional construct requiring multiple indicators (see Devinney et al. [2005] for an overview of issues in performance measurement). A fundamental dichotomy distinguishes between accounting and market performance indicators (Keats and Hitt 1988; Keats 1990). Accounting measures, such as return on assets and return on investment, reflect a firm's past economic performance. In contrast, market measures, such as earnings per share and market capitalization, are future-regarding indicators that represent the investing public's collective discounted present valuation of a firm's future economic performance. Diversified firms in the

Global Information Sector may experience differential outcomes on these two types of performance indicators relative to focused firms. By operating business segments across multiple-industry environments, a diversified firm runs greater simultaneous risks that may produce poor accounting performance indicators. However, by integrating emergent technologies and markets, it may also exhibit a capacity to transform itself which promises to reap future profits and market share, as reflected in stronger market performance indicators. These expectations lead to our third hypothesis:

Hypothesis 3: Firms in diversified-industry clusters have poorer accounting-based performance but stronger market-based performance relative to focused-industry firms.

Testing these research hypotheses requires two-mode network data on a set of industries and firms and a variety of performance indicators. An initial consideration is to choose an appropriate classification industry system, as discussed in the next section.

Industry Classification Systems

The Central Statistical Board of the U.S. developed the Standard Industrial Classification (SIC) in 1939 as a hierarchical taxonomy of industries for classifying “various types of statistical data by industries and to promote the general adoption of such classification as the standard classification of the Federal Government” (Pearce 1957; see also Economic Classification Policy Committee 1994). At the four-digit level, the SIC scheme purported to aggregate manufacturing plants into uniform industries, using “notions of ‘activities of establishments,’ what is carried on at a location by a controlling ownership” (Nightingale 1978:37). But the SIC industry concept was not based on any consistently applied economic criteria. Instead, it grouped some economic establishments by similarity of product or service demand and others according to similar technology or production processes (U.S. Census Bureau 2006a). Several economic researchers criticized the SIC as an inadequately measure of industry or market homogeneity. Clarke (1989) noted that SICs “have remained the most popular delineator of economic markets used in empirical industrial organization” (Clarke 1989:17). However, his analyses of the sales, profits, stock prices of 985 mining, construction, and manufacturing firms revealed that, although SIC codes were useful at the broader one- and two-digit levels, they were “far less successful at grouping similar firms at the three- or four-digit levels. Since these latter levels are those that most economists view as being close to economic markets, the SIC does poorly at delineating economic markets” (29). Subsequent studies uncovered similar SIC deficiencies in aggregating firms into internally homogeneous industry groups (e.g., Guenther and Rosman 1994; Ong and Jensen 1994; Kahle and Walkling 1996; Peneder 2003).

Starting in 1997, government statistical agencies in the U.S., Canada, and Mexico began implementing the North American Industry Classification System (NAICS), supplanting the SIC which had been last revised in 1987 (U.S. Office of Management and Budget 1997). The NAICS was the first industry classification system to apply a consistent “production-oriented” concept to group together economic units using “like processes to produce goods or services” (U.S. Census Bureau 2006a). It created 358 new six-digit industries, reorganized the industry hierarchy to reflect recent changes, and imposed classification comparability across the three North American economies (Saunders 1999; Ojala 2005). A major restructuring was the creation of a two-digit

Information Sector (code 51) with initially four three-digit subsectors, which was expanded to six subsectors in the 2002 NAICS revision (Malone and Elichirigoity 2003). For example, where the SIC had classified all printing and publishing industries together under a single two-digit manufacturing sector (code 27), the NAICS split them among the manufacturing (printing, code 32) and the information (publishing, code 51) sectors. One assessment using financial ratio variances to assess intra-industry homogeneity concluded, "Overall, the results suggest that NAICS definitions lead to more cohesive industries" compared to the SIC categories (Krishnan and Press 2003:685).

Measures and Methods

To measure the network structure of industries and firms in the Global Information Sector, we began with the 2002 North American Industry Classification System, which defined the Information sector as three types of establishments producing and distributing information as a commodity:

> (1) those engaged in producing and distributing information and cultural products; (2) those that provide the means to transmit or distribute these products as well as data or communications; and (3) those that process data. Cultural products are those that directly express attitudes, opinions, ideas, values, and artistic creativity; provide entertainment; or offer information and analysis concerning the past and present. Included in this definition are popular, mass-produced, products as well as cultural products that normally have a more limited audience, such as poetry books, literary magazines, or classical records. (U.S. Census Bureau 2006b)

The 2002 NAICS elaborated its original two-digit Information sector (NAICS code 51) from four to six three-digit subsectors: Publishing Industries (except Internet) (511); Motion Picture and Sound Recording Industries (512); Broadcasting (except Internet) (515);

Telecommunications (517); Internet Service Providers, Web Search Portals, and Data Processing Services (518); and Other Information Services (519). For the GIS, we also included one manufacturing subsector, Computer and Electronic Product Manufacturing (334), whose firms frequently create or adapt technological innovations requiring close coordination with software and telecommunications firms in the Information Sector. But we excluded manufacturing and retailing industries that produce or sell such consumer products as Printing (323), Electrical Equipment, Appliance, and Component Manufacturing (335), and Electronics and Appliance Stores (443).

We identified the largest firms in the Global Information Sector for 2005 using the 2006 online lists of *Forbes* magazine's Global 2000 and *Fortune* magazine's Fortune 500 and Global 500. We combined the firms listed under those magazines' industry headings that appeared most relevant to the GIS, resulting in approximately 350 corporations.[1] We obtained their 2005 NAICS codes from two sources, Thomson Corporation's Gale Company Profiles and Datamonitor, again taking the union of both sets. If a source reported a six-digit NAICS code (i.e., national industry, a level of detail not widely used in the U.S.), we truncated it to the corresponding five-digit value. We then deleted all corporations that operated in no GIS subsector (e.g., advertising agencies). The 275 remaining firms were active in at least one of the 33 GIS five-digit industries, although many were also active in other non-GIS industries. These firms ranged in revenues from Nippon Telegraph & Telephone ($101 billion in 2005) to Pixar Animation Studios ($300 million). By continents, the firms were headquartered in North America (51.6%), Asia (26.9%), Europe (18.2%), and elsewhere (3.3%). Table 1 displays the 3-digit NAICS subsectors, the 5-digit NAICS industries, their full and abbreviated labels, and the numbers of GIS firms operating in each industry. The median number of industries in which firms participated was 2.00 (mean = 2.55, standard deviation = 1.94); more than 57 percent were active in at least two 5-digit industries.

We created a two-mode 275 x 33 firm-by-industry binary matrix, where a cell entry of 1 indicates that the row firm operates in the column industry, and a 0 entry indicates absence. For all pairs of columns we computed a 33 x 33 matrix of Jaccard similarity coefficients, defined as the ratio between the size of an intersection to the size of a union for two industries. A Jaccard value indicates the extent to which the firms in two industries overlap. It is computed by dividing the number of firms operating in both industries by the total number of firms participating in either industry. The two-by-two tables in Figure 1, whose four cells are labeled *a* through *d*, illustrate the joint frequency distribution of two quite different industry pairings, newspapers with television and semiconductors with wired telecommunications. Of the 41 firms operating either televisions or newspapers, 17 operated both, a substantial overlap of these two sets. Hence, their Jaccard similarity coefficient = (a / (a + b + c)) = 17/41 = 0.41. By contrast, only three of 128 firms participated in both the wireless and semiconductor industries, yielding a meagre 0.02 Jaccard value. Among the 528 industry pairs in the 33 x 33 matrix, 50.8% did not overlap at all (i.e., Jaccard = 0.00), meaning that no firm operated in both industries. The remaining pairs ranged from 0.010 to 0.793 (satellite telecoms and telecom resellers), with a mean Jaccard value of 0.10 and a standard deviation of 0.11.

We then transposed the two-mode 275 x 33 firm-by-industry binary matrix into a 33 x 275 industry-by-firm matrix. For all pairs of columns we computed a 275 x 275 matrix of Jaccard similarity coefficients, which indicate the extent to which two firms have overlapping industries. Among the 37,675 firm pairs, 75.9% had Jaccard values = 0.00, meaning that they no industries in common. The remaining pairs ranged from 0.005 to 1.000 (2.9% of firm pairs shared all their industries), with a mean Jaccard value of 0.09 and a standard deviation of 0.21.

Results

Figure 2 shows the dendogram from a hierarchical cluster analysis of the 33 x 33 industry-by-industry Jaccard similarity matrix, using the complete-link criterion. At the highest level of aggregation, the analysis identifies six large *diversified-industry clusters* and three *focused-industry singletons*. To aid interpretation, Figure 3 superimposes contiguity lines around the six diversified-industry clusters in a multidimensional scaling plot using the same Jaccard matrix (a nonmetric two-dimensional solution whose stress = 0.239).[2] The closer that two clusters appear in this space, the greater the extent of industry overlap among firms operating in both clusters, while larger distances indicate greater industrial dissimilarity among the clusters' member firms. The main cleavage in Figure 3 lies between the three diversified-industry firm clusters at the bottom right and the three clusters at the top center. The bottom clusters consist predominantly of equipment manufacturing (NAICS industries in subsector 334) and telecommunication industries (in subsector 517), whose proximity in that region implies stronger ties among these industries than to other parts of the Global Information Sector. However, the presence of the software industry (in subsector 511) inside the cluster with computer manufacturing, navigational equipment, and reproducing media, and the presence of data processing (in NAICS subsector 518) among the telecoms reveal some heterogeneity within those two diversified-industry clusters. The three clusters at the top of Figure 3 also exhibit substantial subsector heterogeneity, which would persist even if the large cluster of industries in the publishing, motion picture, and broadcasting subsectors were divided into two subclusters (dotted line). The three focused-industry singletons are located toward the margins of the space, suggesting that they have few firms in common with any other industry clusters. Although no industry occupies the exact center of the space, the proximities among the four closest industries (software, reproducing media, cable programming, and directory publishers) suggest that they might be pulled towards one another by interdependencies among their technologies and applications.

We next subjected the 275 x 275 matrix of Jaccard similarity coefficients for all pairs of firms to a second hierarchical cluster analysis. Although its dendogram is too enormous to display, Table 2 summarizes the resulting 26 firm clusters that were identified at the highest aggregation level. It labels clusters according the principal NAICS industries in which the firms operate and lists some prominent members. Each of the 26 firm clusters has at least one industry in which all its member firms participate. The 15 *focused-firm clusters* labeled in boldface capitals each have only a single dominant industry, with no other industry prevalent among least half its member firms. In contrast, 11 *diversified-firm clusters* (labeled using hyphenated lower case letters) have between two and five additional industries in which half or more of their member firms participate (in four of these diversified-firm clusters, all the firms also share a second industry; in another five clusters, more than 70 percent of firms share a second industry). These 11 diversified-firm clusters contain 45.5% of the 275 GIS firms.

Table 2 reveals that seven of the 15 focused-firm clusters consist only of firms operating in seven NAICS industries that appear in no other cluster (movie exhibition, audiovisual equipment, broadcasting equipment, Internet service provision, directory publishing, navigational equipment, other publishing). Firms that participate in the 26 other NAICS industries are dispersed among two or more clusters. For example, 39 of the 73 firms in the semiconductor industry comprise a focused-firm cluster (cluster 10 in Table 2). But the 34 other semiconductor firms are spread among three diversified-firm clusters (clusters 5, 9, 16). Likewise, companies operating in the six NAICS telecom industries are scattered across five clusters, only one of which is an focused-firm cluster (wireless telecoms in cluster 8). Similar dispersion of diversified-firm clusters occurs among corporations involved in the communication equipment, computer manufacturing, data processing, periodical publication, software, telephone apparatus, television, and wired telecom industries.

To reveal graphically the industrial heterogeneity of the GIS firm clusters, Figure 4 displays an MDS plot for intercluster proximities calculated as weighted path lengths.[3] Specifically, we first normalized the cell counts in each row of a 24 x 33 firm-cluster-by-industry matrix so they add to 1.00. (None of the three firms in the movie exhibition and other publishing clusters had industries in common with any other clusters, so those two clusters could not be plotted.) The normalized values in a row are the proportions of that firm cluster's ties distributed among the 33 NAICS industries. We then multiplied this normalized matrix by its transpose, producing a 24 x 24 cluster-by-cluster matrix, where a higher weighted path value indicates greater similarity of a pair of firm clusters' ties to all 33 industries. For example, the firms in the semiconductor cluster exhibit much more industrial similarity to firms in the computer-semiconductor cluster (0.366) than to members of the wireless firm cluster (0.016). Hence, those first two firm clusters appear spatially much closer in MDS plot than either does to the third.

The contiguity lines superimposed on the MDS plot in Figure 4 show that four of the five groupings of firm clusters include both focused and diversified industries (the exception is the dyadic Audiovisual and Computer group). For example, the telecom group at the bottom combines two focused-industry clusters (ISP and Wireless) with four industrially heterogeneous firm clusters. The two groups at the upper left involve mixtures of publishing and mass media clusters, respectively. The large heterogeneous group on the right side combines four focused-industry with four diversified-industry clusters of firms. Two diversified-industry clusters of firms involved in computer manufacturing fall into that group, in close proximity to the focused-industry Software and Semiconductor clusters, rather than into the adjacent dyadic group containing the focused-industry Computer cluster. Also in the large group are both clusters of telecom apparatus-communication equipment manufacturers, separated from the adjacent group containing the telecom service-provider clusters.

Finally, we examine how well the clusters identified through relational analyses of firms and industries explain variation in firm performance. We obtained financial statements of the 275 GIS firms for fiscal year 2005, and their stock market valuations at the end of calendar year 2006, primarily from Reuters.com or company annual reports. Tables 3 and 4 report the results from analyses of covariances (i.e., multiple regression equations with both continuous and categorical independent variables). The independent variables in each equation are the firm's age (in years since founding until 2006), the natural logarithm of the number of employees, a set dummy-coded variables for 32 NAICS industries (one dummy in a set of categories must be omitted, thus avoiding linear dependence and serving as the reference category), and another set of dummy variables for the 12 firm clusters with diversified industries (see Table 2). The top panel of each table displays the standardized coefficient (β^*) only for significant effects of the latter set, which reveal a firm cluster's effects on the dependent variable in standard-deviation units, thus facilitating comparisons across categories.

Controlling for the other independent variables, six industrially diversified clusters significantly affected at least one of the six accounting-based measures shown in Table 3. Six firm clusters significantly affected at least one of the five market-based indicators analyzed in Table 4. The bottom panels of Tables 3 and 4 report statistical tests of the differences in multiple R^2s for each performance equation compared to an equation without the diversified clusters. This procedure assesses only the additional variation in firm performance contributed by the interaction effects (i.e., diversified firm clusters) beyond the proportion explained by the additive effects of the set of 32 NAICS industry dummy variables. It's a conservative test of Hypothesis 2, in the sense that any variation which is jointly shared by the industry dummies and the diversified-industry clusters is allocated entirely to the former. The F-ratios are significant for all 11 comparisons, with a range of increased multiple R^2 between 1.6 and 8.3 percent. Although several increments are small, in five instances the proportional increment to the R^2 of the additive equation rises between 22 and 52 percent. These results are consistent with the expectation in Hypothesis 2 that diversified-industry clusters account for additional variation in firm financial performance beyond that attributable to the additive effects of the NAICS industry classification system for the Global Information Sector firms.

Finally, the standardized regression coefficients in Tables 3 and 4 reveal evidence consistent with Hypothesis 3, that some diversified-industry clusters have poorer accounting-based performance but positive market-based performance relative to focused-industry firms. In particular, clusters 11, 12, and 19 each combine wired telecoms with one or more other GIS industries, indicating that their firms seek to transcend the boundaries of traditional land-line telecommunication services. As shown in Table 3, after holding constant their separate industry effects, the interaction effects represented by these clusters' coefficients reveal poor performances on several accounting-based measures. The firms in at least two of these three clusters have significantly lower net income, higher total assets, lower returns on assets and on income, and higher debt and liability. For the forward-looking market-based performance measures in Table 4, a few clusters exhibit more favorable outcomes: firms in cluster 11 have higher earnings per share and dividends per share, while those in clusters 12 and 19 have larger market capitalization. Taken together, both sets of results imply that investors may positively view the GIS diversified firms' longer-run prospects, despite their less than stellar accounting performances in the shorter run.

Conclusion

We advocate a network approach to investigating the purported porous and fuzzy boundaries between industries, that is, an interlacing of transindustrial product and service activities within corporations. The key to conceptualizing the network properties of industries lies in viewing them not simply as firm attributes, but as important arenas within which organizations socially construct competitive and cooperative relations with other units engaged in specific types of productive activities. Our analyses of the two-mode network of industries and firms in the Global Information Sector for 2005 revealed that more than half the corporations participated in two or more of the sector's 33 industries. Cluster analyses of both the industry-firm and firm-industry two-mode matrices revealed numerous clusters comprised of diversified industries and industrially diversified firms, respectively. Multiple regression analyses of financial performance indicators – controlling for company size, age, and the additive effects of industry – found significant increases to explained variance attributable to particular diversified-industry firm clusters. Not only are the boundaries among GIS firms porous and fuzzy, but a capacity to bring together certain combinations of disparate product or service activities under one roof evidently affects corporate fate.

Numerous opportunities abound for extending future research on industry-firm network investigations that could fill in facets unaddressed by this paper. For example, we treated as equivalent every industry in which each firm operates. A more nuance approach would be to weight industries according to the proportion of firm revenues that they generate, although obtaining these data is a daunting task. We also ignored the dozens of non-GIS industries in which various firms participated. Bringing these other industry links into the analysis would illuminated the broader contexts within which the information industries are embedded. Another extension is to compare the GIS industry-firm network structure to other sectors to determine which features are widely shared and which are distinctive to rapidly changing technological environments. Contrasts among old-line manufacturing and emergent service sectors could be especially illuminating. A further addendum is the examine the effects of industry multiplexity on a wider range of firm behaviors, including the formation of strategic alliances, merger and acquisition activities, and R&D innovations as indexed by patents. Interorganizational collaborations are a type of network relation that can be fruitfully integrated into the study of industry-firm networks.

Our analyses provide only a cross-sectional snapshot of the GIS industry-firm network in 2005. A logical extension is to track that network over time, by collecting and analyzing retrospective data spanning the prior two to three decades. The impacts of macro-level events, particularly political deregulation of markets, can only be assessed by temporal data analyses. Longitudinal analyses can uncover the sector's evolutionary dynamics, revealing when diversified-industry clusters emerged and whether they occurred primarily through: internal corporate developments as focused-industry firms added diversified product lines; mergers and acquisitions among companies located in different industries; and the creation of new diversified-industry firms. Assembling a comprehensive history of industry changes is a huge task, requiring that precise data on corporate SICs codes prior to 1998 be translated through correspondence tables to the NAICS codes applicable in five-year revisions since 1997. Additional methodological issues in network change analysis must be resolved, in particular how to handle missing data and the continual turnover in organizational populations across extended periods. But the payoff in explaining transformational industry convergence would be enormous.

Although the NAICS system is a considerable improvement over the SIC for classifying industries, it has a rival in the Global Industry Classification Standard (GICS), jointly developed by Standard & Poor's and Morgan Stanley Capital International. The GICS was designed for professional investment managers rather than academic researchers, and classifies companies on the basis of their principal business activity rather than their production technologies. A comparative analysis of four industrial classification schemes, including the NAICS, found that the GICS was better at identifying industrial peers and at explaining stock return components and other capital market indicators (Bhojraj, Lee and Oler 2003). Further researchers should investigate whether the GICS industry categories contribute additional insights into the industry boundary question.

The North American Product Classification System (NAPCS), under development since 1999 and nearing completion for 370 service-producing industries, will soon provide a hierarchical market- or demand-oriented complement to the supply-side NAICS (U.S. Census Bureau 2007). Eventually to be extended to manufactured goods, NAPCS codes will apply to identical products and services regardless of their originating industries. It will enable construction of three-mode networks linking firms to their products and industries, allowing fine-grained analyses of shifting industry boundaries as firms' product and service mixes change over time. Then, we should be able to assess not only whether firm and industry boundaries are porous and fuzzy, but also squishy.

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FOOTNOTES

1. These industry headings were: (1) *Forbes* Global 2000: Business Services and Supplies; Media; Semiconductors; Software and Services; Technology Hardware and Equipment; Telecommunications.(2) *Fortune* 500: Computer Peripherals; Computer Software; Computers, Office Equipment; Entertainment; Information Technology Services; Internet Services and Retailing; Network and Other Communications Equipment; Publishing, Printing; Semiconductors and Other Electronic Components; Telecommunications.(3) *Fortune* Global 500: Computer Services and Software; Computers, Office Equipment; Electronics, Electrical Equipment; Entertainment; Network and Other Communications Equipment; Semiconductors and Other Electronic Components; Telecommunications.

2. A three-dimensional MDS solution decreased the stress value to 0.152. But the incremental details are outweighed by the greater difficulty in displaying these results on a two-dimensional surface.

3. The stress value for the two-dimensional MDS solution is 0.229. A three-dimensional solution stress value decreases to 0.159. Although this third dimension clearly separates the AV-PERIPHERAL dyad from the large group at the right side of Figure 2, the structure is not easily displayed on a flat surface.

4. Values for these measures, obtained from Forbes and Hoovers, are for the fiscal year 2005.

Table 1. NAICS Subsectors and Industries in the Global Information Sector

Code	Industry Name	Abbreviation	N
334 Computer and Electronic Product Manufacturing			
33411	Computer and Peripheral Equipment	Computer	51
33421	Telephone Apparatus	TeleApp	23
33422	Radio, Television Broadcasting and Wireless	Broadcast	20
33429	Other Communications Equipment	Communic	24
33431	Audio and Video Equipment	AV	21
33441	Semiconductor and Other Electronic Components	Semicond	73
33451	Navigational Measuring Electromedical & Control Inst.	Navigat	16
33461	Manufacturing Reproducing Magnetic and Optical Media	Reprod	14
511 Publishing			
51111	Newspaper Publishers	News	17
51112	Periodical Publishers	Period	23
51113	Book Publishers	Book	16
51114	Directory and Mailing List Publishers	Directory	14
51119	Other Publishers	OthPub	1
51121	Software Publishers	Software	45
512 Motion Picture and Sound Recording			
51211	Motion Picture and Video Production	Movie	13
51212	Motion Picture and Video Distribution	MovieDist	4
51213	Motion Picture and Video Exhibition	MovieExh	2
51219	Postproduction Services and Other Industries	PostProd	3
51222	Integrated Record Production Distribution	Record	1
51223	Music Publishers	Music	7
515 Broadcasting			
51511	Radio Broadcasting	Radio	7
51512	Television Broadcasting	TV	27
51521	Cable and Other Subscription Programming	Cable	21
517 Telecommunications			
51711	Wired Telecommunications Carriers	Wired	55
51721	Wireless Telecommunications Carriers except Satellite	Wireless	58
51731	Telecommunications Resellers	TCResell	25
51741	Satellite Telecommunications	Satellite	27
51751	Cable and Other Program Distribution	CableDist	6
51791	Other Telecommunications	OtherTC	36
518 Internet Service Providers, Web Search Portals, and Data Processing Service			
51811	Internet Service Providers and Web Search Portals	ISP	19
51821	Data Processing Hosting and Related Services	DataProc	29
519 Other Information Services			
51911	News Syndicates	Syndic	3
51912	Libraries and Archives	Library	1

Table 2. Summary of Hierarchical Cluster Analysis of 275 GIS Firms

Firm Clusters' Main Industries	N	Prominent Firms
1. **MOVIEEX**	2	Regal Entertainment
2. **AV**	3	Maxtor, Philips
3. **BROADCAST**	8	Agilent, Matsushita, Qualcomm
4. news-tv	8	Daily Mail, Dow-Jones, Gannett, NY Times, Singapore Press
5. teleapp-communic-semicond	7	Alcatel, Cisco, Ericsson, Lucent, Nortel
6. **TV**	7	DirecTV, Fuji TV, Tokyo Broadcasting
7. **PERIOD**	3	Primedia, VNU
8. **WIRELESS**	14	Comcast, EchoStar, Portugal Telecom, Sprint-Nextel, Telus
9. semiconductor-teleapp-communic	10	Intel, Nokia, Motorola, Sanyo, Siemens, Sumitomo
10. **SEMICONDUCTOR**	39	Kyocera, Mitsubishi, Taiwan Semiconductor, Texas Instruments
11. satellite-wireless-wired-othertc--tcresell-dataproc	17	Bell Canada, CBS, France Telecom, KDDI, NTT, Telecom Italia
12. wired-othertc	17	China Unicom, Reuters, Telecom Indonesia, Telenor, Vodafone
13. movie-tv	10	Disney, News Corporation, Time Warner, Viacom, Vivendi
14. cable-tv	12	BSkyB, Liberty Global, ITV, Washington Post
15. **COMPUTER**	19	Acer, Benq, Bull, Dell, Hewlett-Packard, Hitachi, SanDisk
16. computer-semiconductor	12	Canon, LSI Logic, Nvidia, Oki, Samsung, Toshiba
17. book-period	11	Axel Springer, McGraw-Hill, Pearson, Reader's Digest
18. satellite-tcresell-wired-wireless	6	AT&T, BellSouth, Hellenic Telecom, Qwest, Telstra, Verizon
19. tcresell-wireless-wired	21	Alltel, Carso Global, China Netcom, Pakistan Telecom, Turkcell
20. **DATAPROCESS**	12	Atos, EDS, First Data, NCR, Unisys, Xerox
21. software-computer-reprod	14	Apple, Fujitsu, Microsoft, Oracle, SAP, Seagate, Sony, Sun
22. **SOFTWARE**	17	Adobe, Autodesk, Avaya, CA, Infosys, Intuit, Siebel, VeriSign
23. **ISP**	5	Belgacom, Google, Yahoo
24. **DIRECTORY**	3	Dex, Dun & Bradstreet
25. **NAVIGATIONAL**	7	Lexmark, Ricoh, Scientific-Atlanta
26. **OTHPUB**	1	Seat-Pagine

Table 3. Analyses of Covariance for Accounting-Based Measures

Independent Variables[a]	Dependent Variables for 2005 Fiscal Year: Net Income	Total Assets	Long-Term Debt	Total Liabilities	ROA	ROI
Standardized β* for diversified-industry clusters:						
11. satellite-wireless- wired-othertc-tcresell-dataprocess		0.32**	0.32**	0.48*		
19. tcresell-wireless-wired	-0.36*	0.20†			-0.58***	-0.58***
12. wired-othertc	-0.46***	0.42***	0.17*	0.23**	-0.38**	-0.41**
18. satellite-tcresell-wired-wireless				0.20*		
16. computer-semiconductor					0.18*	
17. book-period	-0.26†					
Coefficients of Determination:						
R^2 with clusters	0.266	0.610	0.510	0.600	0.241	0.208
R^2 without clusters	0.198	0.575	0.494	0.572	0.158	0.146
F ratio for R^2 difference	7.26***	7.00***	3.74*	5.39**	6.67***	7.09***
df difference	3	3	2	3	3	2
N of cases	(273)	(272)	(265)	(269)	(219)	(209)

[a] Other independent variables in each equation are firm age, logged number of employees, and 32 dummy-coded NAICS industries.
† p ≤ .10 * p ≤ .05 ** p ≤ .01 *** p ≤ .001

Table 4. Analyses of Covariance for Market-Based Measures

Independent Variables[a]	Market Cap	Earnings Per Share	Dividend Per Share	Dividend Yield	Beta
	Dependent Variables for 2006 Fiscal Year				
Standardized β* for diversified-industry clusters:					
11. satellite-wireless- wired-othertc-tcresell-dataprocess		0.43***	0.27*		
19. tcresell-wireless-wired	0.19†				
12. othertc-wired	0.22*				
17. book-period	-0.50***			0.30*	
14. cable-tv			0.26*	0.25*	
5. teleapp-communic-semiconductor					0.22**
Coefficients of Determination:					
R^2 with clusters	0.473	0.183	0.248	0.358	0.331
R^2 without clusters	0.433	0.140	0.203	0.327	0.308
F ratio for R^2 difference	8.62***	10.90***	6.25**	5.50**	6.77**
df difference	3	1	2	2	1
N of cases	(263)	(242)	(245)	(245)	(232)

[a] Other independent variables in each equation are firm age, logged number of employees, and 32 dummy-coded NAICS industries.
† p ≤ .10 * p ≤ .05 ** p ≤ .01 *** p ≤ .001

		Newspapers	
		1	0
TV	1	*a* 17	*b* 17
	0	*c* 7	*d* 242

		Semiconductors	
		1	0
Wireless Telecoms	1	*a* 3	*b* 55
	0	*c* 70	*d* 148

Figure 1. Example Computations of Jaccard Similarity Coefficients for Two Pairs of Industries

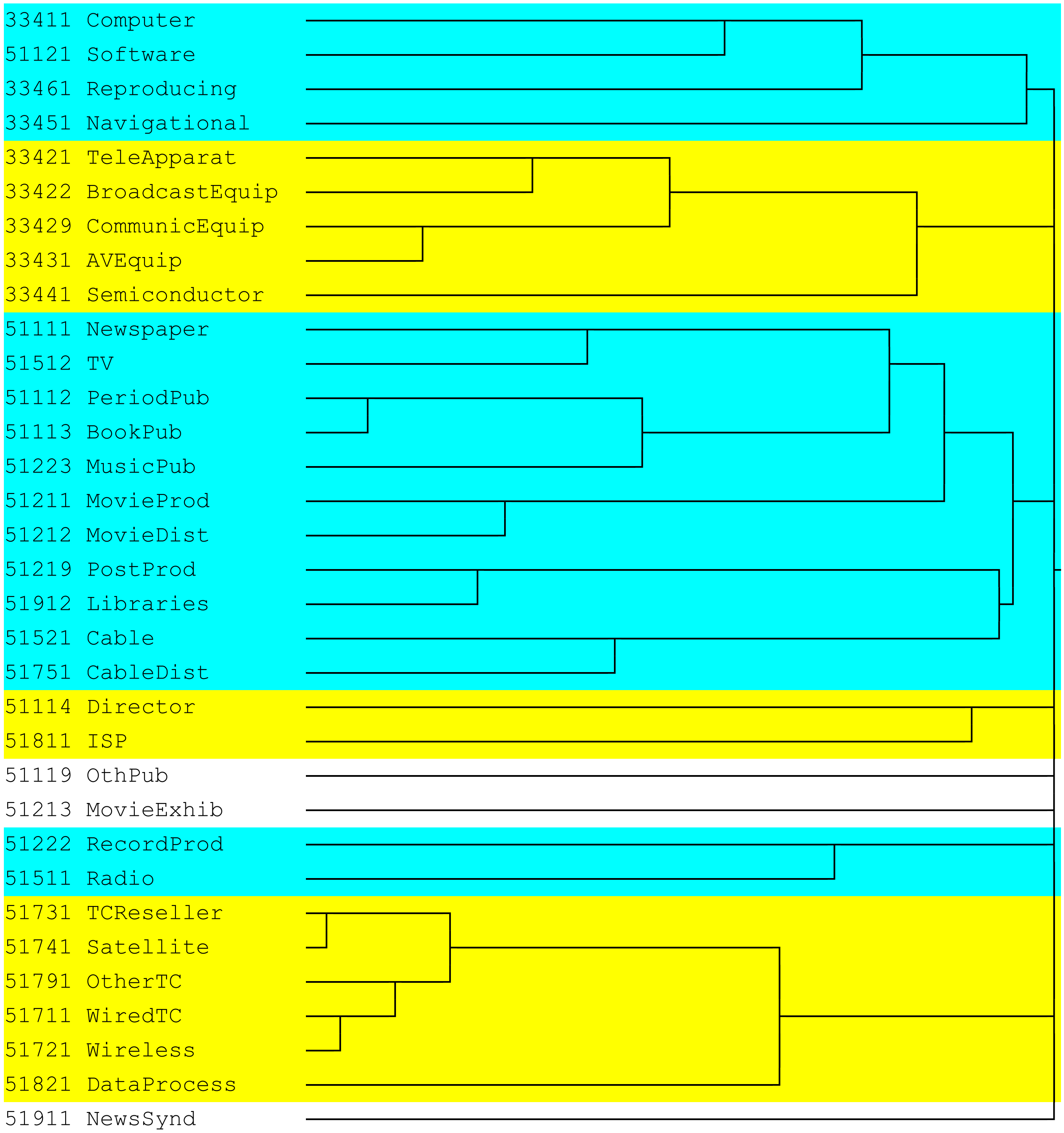

Figure 2. Dendogram from Hierarchical Cluster Analysis of 33 Industries (Ordinal Scale)

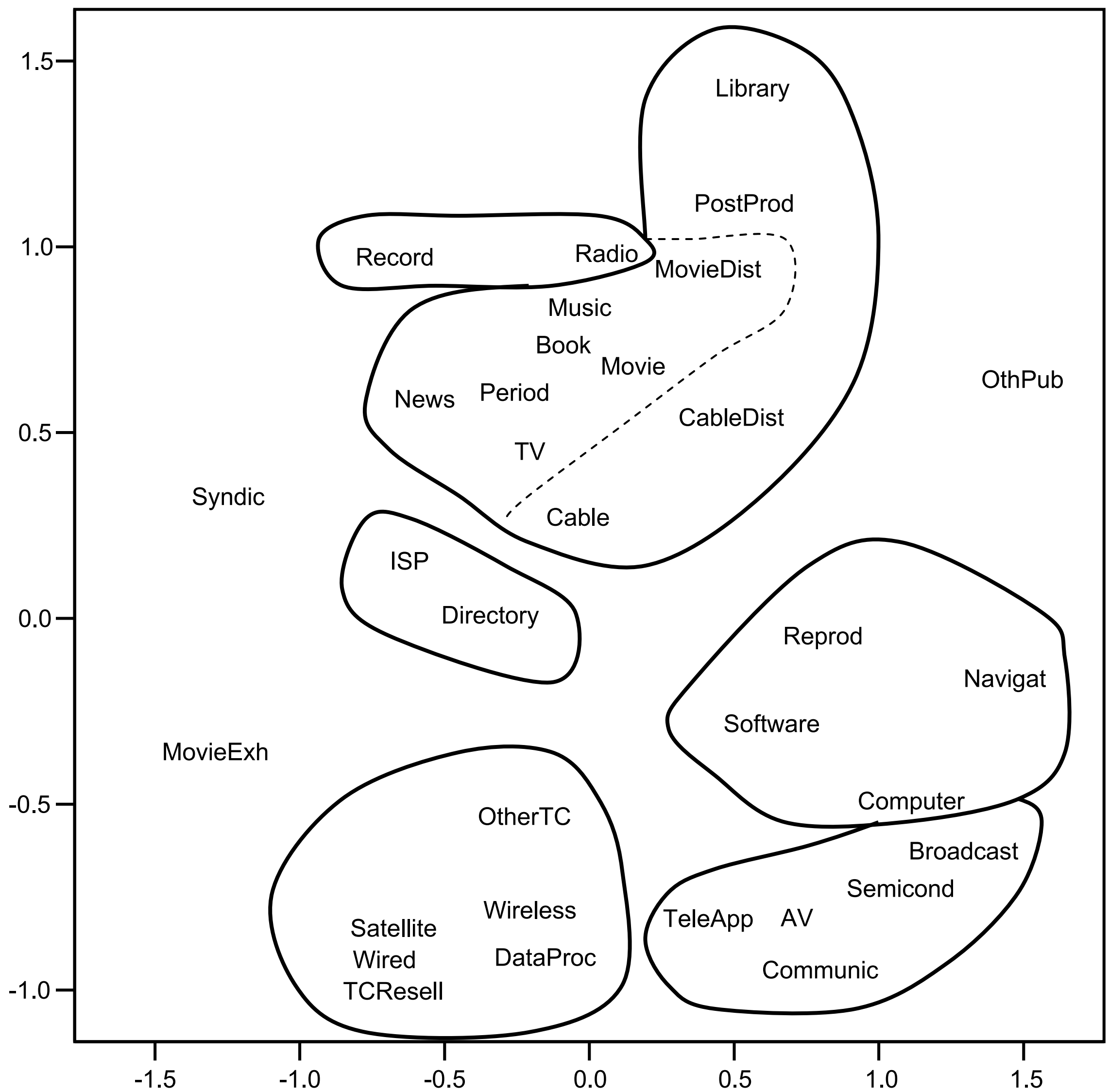

Figure 3. Multidimensional Scaling of Jaccard Coefficients among 33 Industries

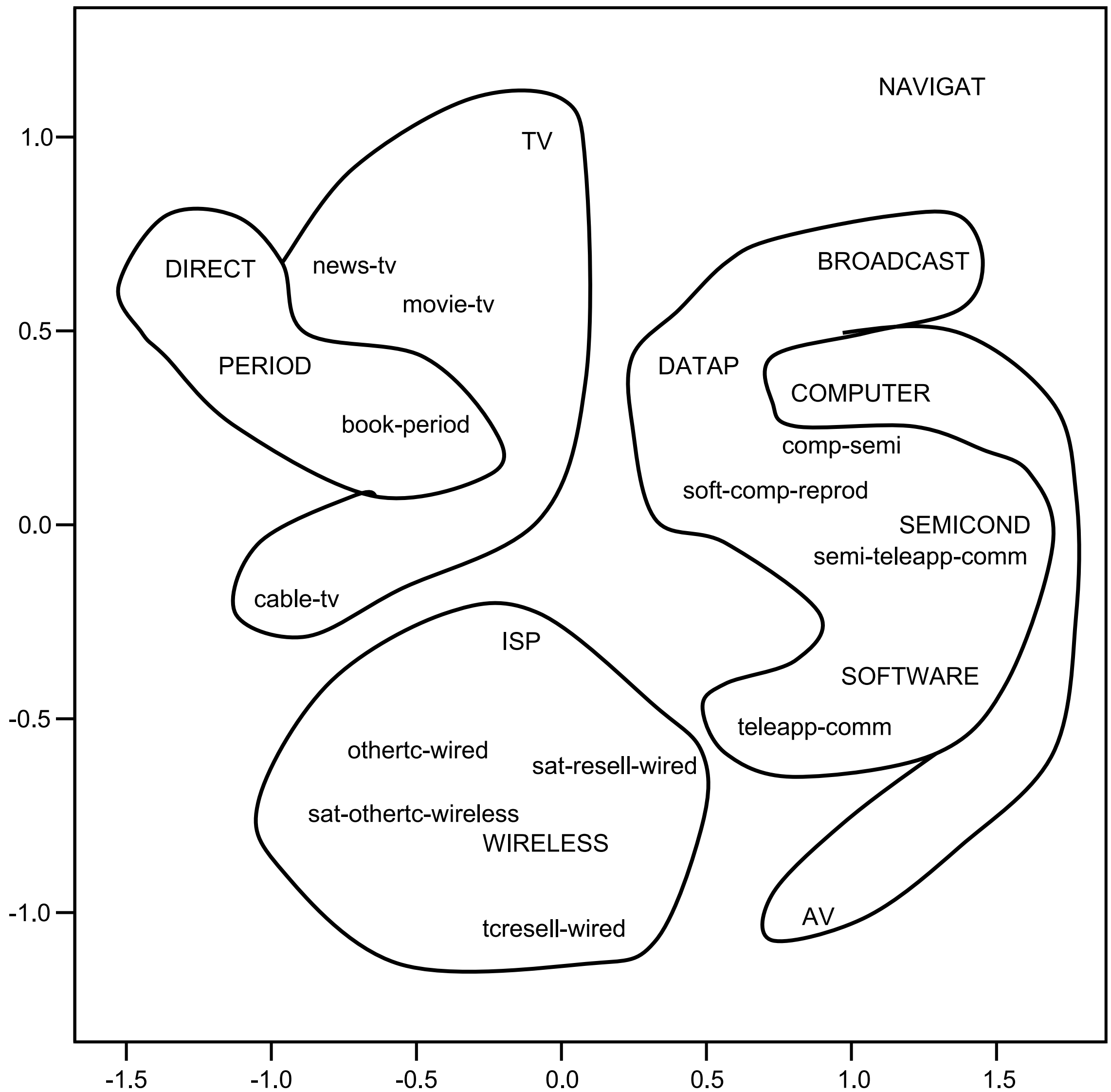

Figure 4. Multidimensional Scaling of Weighted Path Distances among 24 Firm Clusters

This paper describes the fuzzy boundaries between support verb constructions (SVC) with ter â€œhaveâ€ and dar â€œgiveâ€ and causative operator verb (VopC) constructions involving these same verbs, in Brazilian Portuguese (BP), which form a complex set of relations: (i) both verbs are the support verb of the same noun (SVC); (ii) dar is the standard (active-like) SVC while. ter is a converse (passive-like) SVC; and (iii) dar is a VopC, operating on a ter SVC. In this paper we have systematicallyâ€¦ CONTINUE READING. And so the boundary between agents and forces is fuzzy in the enchanted world; and the boundary between mind and world is porous, as we see in the way that charged objects can influence us. I have just been referring to the moral influence of substances, like black bile. But a similar point can be made about the relation to spirits. The porousness of the boundary emerges here in various kinds of â€œpossessionâ€â€”all the way from a full taking over of the person, as with a medium, to various kinds of domination by or partial fusion with a spirit or God. Here again, the boundary between self and oth The aquifer boundary conditions are fuzzy and create ambiguities to the solution of the problem. Since the aforementioned problem concerns differential equations, the generalized Hukuhara (gH) derivative was used for total derivatives, as well as the extension of this theory concerning partial derivatives. The case studies proved to follow the generalized Hukuhara (gH) derivative conditions and they offer a unique solution.Â In this article, the solution to the fuzzy second order unsteady partial differential equation (Boussinesq equation) is examined, for the case of an aquifer recharging from a lake. In the examined problem, there is a sudden rise and subsequent stabilization of the lakeâ€™s water level, thus the aquifer is recharging from the lake. Personal boundaries are the limits and rules we set for ourselves within relationships. A person with healthy boundaries can say â€œnoâ€ to others when they want to, but they are also comfortable opening themselves up to intimacy and close relationships. A person who always keeps others at a distance (whether emotionally, physically, or otherwise) is said to have rigid boundaries. Alternatively, someone who tends to get too involved with others has porous boundaries. Common traits of rigid, porous, and healthy boundaries. Rigid Boundaries. Porous Boundaries. Healthy Boundaries. Avoids intimacy an (2010: 52) note that soft spaces and fuzzy boundaries represent a â€˜â€˜deliberate attempt to insert new opportunities for creative thinking, especially in areas where public engagement and cross-sectoral consultation has seen entrenched oppositional forces either slowing down or freezing out most forms of new developmentâ€™â€™. They suggest that soft spaces are often informal and appear to be dened in ways that are purposely â€˜uidâ€™ and â€˜fuzzyâ€™ in the sense that they can be modied and (re)designed eortlessly to reect dierent interests and challenges.Â We will begin with a discussion of planning, â€˜fuzzy spacesâ€™ and porous borders, and then will study this issue empirically by using the dual-methodology dened above.