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THE SMALL WORLD OF GERMANY AND THE DURABILITY OF NATIONAL NETWORKS

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The globalization of financial markets and the concomitant restructuring decisions of firms challenge the historical legacy of national systems of governance. German corporate ownership patterns and restructuring events in the 1990's are examined here in this light. The results show that ownership links among German firms constitute a "small world" that has consequences for understanding mergers and acquisitions. Ownership links form closely-knit clusters of firms that are nonetheless highly connected across the network as a whole. Restructuring events fall squarely in the center of this structure. Despite increasing global competition, the German small world tends to replicate itself. To illustrate this robustness, potential disruptions to the observed German network are simulated. This simulation shows that the properties of the small world remain intact even when ownership ties are changed. These findings suggest that a more global economy in Germany need not lead to the dissolution of the ownership structure, but rather may be associated with a deepening of network ties.

THE internationalization of capital poses a significant challenge to national systems that structure the financing and governance of large corporations. Countries have historically developed dramatically different means of raising capital for economic enterprises. Systems of governance in a country reflect the historical bargains struck by la-

bor, the state and holders of capital regarding who gets to own and control the economic assets.

These national systems are challenged by the globalization of capital and the related restructuring strategies of domestic firms.¹ If one departs, as we do in this article, from the view that these systems are static reflections of institutional pressures or cognitive beliefs, the immediate question is how can national ownership patterns endure in the face of strategizing economic actors. The vulnerability of these systems is highlighted when they are understood as networks in which firms, financial intermediaries, and other economic institutional actors are embedded. A striking feature of national ownership networks—as we show for the case of Germany—is that they are very sparse. In sparse

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¹ As recently as the 1980s, the great proportion of capital was derived from national savings, even for developing countries. Increasingly, however, international capital flows augment national sources for investment (see Feldstein and Bacchetta 1991).

networks, observed ties between firms represent only a small proportion of all possible links. Surely, with such low network densities, these national systems should be fragile structures subject to rapid erosion.

We argue here that the opposite is true—that a few ownership ties can still generate substantial structure in a network and have a powerful effect in creating an enduring national structure for the coordination of economic behavior. This argument derives from the notion of a “small world” that presents far more order and stability than that suggested intuitively by network sparseness. A small world is a network in which many dense clusters of actors are spanned by relationships that act as conduits of control and information (Milgram 1967; White 1970). Thus, despite the overall low density of ties, the members of a network are linked with each other across clusters through a relatively small number of intermediaries. It is possible, to paraphrase an old quip, to get “there from here” in only few steps: The number of paths between any two randomly chosen actors is rather small. Indeed, this observation is central to a wide range of sociological models, such as Coleman’s (1990) association of social capital with “closed” networks, Granovetter’s (1973) theory of weak ties, Burt’s (1992) structural holes, and studies of social class (e.g., see Domhoff 1967).

The dynamic properties of small worlds provide insight into the durability of national structures of firm ownership as sparse networks. These properties are best understood by comparing the observed network with a randomized network (i.e., a random graph) that has the same number of nodes and same number of relationships per actor as the observed. Simulations by Watts (1999), for fairly general families of networks, show that as an increasing proportion of existing ties are replaced with randomly generated links, the global connectivity among actors increases much more rapidly than the degree of clustering is reduced. The network becomes more globally connected, but the clusters of densely interconnected members persevere. There is, in other words, structural stability in small worlds despite the low density, even when a substantial number of paths are changed.

Thus, the dynamics of a small world permit economic actors to strategize, and yet the small-world structure still tends to be replicated. This duality of action and structure (Giddens 1984) in the process of structuration contradicts the intuition that strategizing actors will disrupt social structure. In fact, the inherent durability of the network structure itself may have a strong stabilizing property, as actors may intuit the structural constraints on their actions.

The conservative properties of a small world caution us from inferring too much from the globalization of capital and the restructuring of equity ownership. In the context of small-world structures, the persistence of national systems of power is not inconsistent with the growing penetration of global capital markets. Networks are composed of entrepreneurs whose probable intents are to preserve their structural autonomy and cohesion. Globalization, we claim, is always a localized affair. National networks not only mediate global and local forces but also provide specific actors with the resources and opportunities to preserve the national structure of ownership.

We argue that ownership networks are prevalent in national economies and, although typically quite low in density, are nonetheless important influences on acquisition events. We adopt the small-world model of Watts and Strogatz (1998; Watts 1999) as a way of understanding how sparse networks can have a surprising degree of structure. The ownership patterns and globalization trends in Germany provide the background to our analysis—with a special focus on the 1990’s.

BACKGROUND

Over the past decade, there has been increasing interest in national models of corporate governance (for representative studies, see Berger and Dore 1996; Boyer and Freysenett 2000; Hamilton and Biggart 1988; Kogut 1993; Soskice 1990). These systems are often presented as static descriptions that determine the behavior of firms. This observation, however, is only half the story; these systems emerged from specific national conditions and were shaped by strategies of economic actors who created institutions to

equilibrate the conflict among social classes and business interests. The institutional bargains struck among influential actors express the pivotal role played by power in the creation of markets for firm ownership and financial control (Fligstein 1996).

A nation's institutional resolutions of ideological and economic conflicts influence the pattern and distribution of ownership ties among the largest corporations. Countries therefore differ substantially in the degree to which corporate institutions own each other. For example, in the United States, populist hostility to big business led to aggressive restrictions on the ability of financial institutions and corporations to control public enterprises (Fligstein 1990; Roe 1994). In the United States and United Kingdom, pension fund managers, mutual funds, and individual shareholders are the primary owners of large corporations (Useem 1996). In contrast, cross-holdings among firms were a common form of control in France, even after the first wave of nationalizations by the state after World War II (Houssiaux 1957). In Germany, banks and large corporations have dominated the ownership of large firms, although labor has been unusually successful in forcing the state to provide it with a voice (Juergens, Naumann, and Rupp 2000; O'Sullivan 2000). Also, in Japan, corporations, banks, and insurance companies hold corporate shares.² Families also can own large percentages of corporations.

When corporations and families develop widespread cross-holdings, the common ownership links among firms constitute a network that can extend across a substantial portion of the national economy. Shareholding is a stronger form of corporate control than board membership (e.g., Burt 1983; Haunschild 1993; Pennings 1980), which direct ownership can obviously influence. A tie of common ownership is a special kind of interorganizational relationship and arguably represents most directly the claims on control over a firm's decisions. Intuitively, common ownership links are powerful influences on restructuring by acquisition because acquisition events shift the distribu-

tion of ownership in the economy and must be sanctioned by current shareholders. And when a shareholder is another organization, the power to sanction or enable an event is highly concentrated in a single institution whose financial results are likely to be affected.

Kogut, Walker, and Anand (forthcoming) show statistically that the diversification decisions by large companies are strongly influenced by the national context. Their additional case studies suggest that acquisition opportunities are located in national *chains* of intercorporate relationships. Sets of institutional players combine to determine (but not decide) which paths of expansion are feasible given the current structure of holdings. Ownership links obviously also have an informational component. Thus, because ownership ties indicate both the presence of control and the availability of information, a firm's location in a network of institutional owners may partly determine its diversification opportunities.

The boundary of the feasible region set by the structure of the ownership network becomes apparent as aggressive firms try to forge their own expansion paths. These attempts to alter the established structure may cause incumbent institutional forces to make adjustments and accommodations. Davis and Stout (1992) argue that in the United States the large gains to be made by restructuring (what they call the "money on the table") generated pressures that broke up existing relationships among owners and board directors. Accompanying this change was the growing dominance of institutional investors, who brought with them new ideas about corporate governance and shareholder value (Useem 1996).

The expansion of these ideas based on the American experience, along with an increased interest of American institutional investors in foreign markets, is seen as a challenge to national systems on a global basis. Thus, van Wolferen (1990) describes the painful give-and-take in Japan between its national institutions and global pressures for reform. The popular book by Albert (1993) is a European's fretting over how the penetration of the American obsession with short-term profit potentially may damage the principles of "Rhine" capitalism. With the

² See Lincoln, Gerlach, and Takahashi (1992) for Japanese data and network structure. The German case is described below.

rise in foreign-owned equity, the short-term incentive to restructure along the lines of American capitalism is believed by many to cause fundamental changes in these economies.

The argument that national structures of ownership matter for economic choices is complicated by the observation that these networks have very low densities. It is not obvious how such networks can produce stable national patterns that are able to endure over time. In this regard, it is instructive to look at the many studies that have focused on interlocking directorates.³ The studies of interlocking ownership present anything but clear evidence for the effects of network structure on economic behavior. The most striking statistic is that these networks are characterized by low density. Scott (1997:122, 149) reports the density among the largest 250 firms to be .038 for Germany, .034 for the United States, and .017 for the United Kingdom. For his sample, Gerlach (1992:158) found density to be .041 for Japan. These densities are so low as to suggest that any pattern of relationships might be more random than conducive for any kind of network-wide coordination.

Because they failed to find dense networks, many authors (e.g., Useem 1984) have backed away from arguing that ties among firms lead to coordinated action. Rather, they suggest that action is related to the generalized context of a managerial class that adheres to a common ideology. Further, Palmer (1993) finds that interlock ties that are broken through accidental events are only infrequently reconstituted, suggesting that motivation for coordinated action is unlikely to be primary. Some studies show that structural impediments to action can be overcome ("money talks"), although these studies are still sensitive to the roles played by institutional contexts and owners (Davis and Stout 1992). There are also numerous studies showing that interlocks matter for the diffusion of ideas (e.g., Haunschild

1993), even if financial motives remain important (Palmer et al. 1995).

It therefore seems inconsistent to claim that markets are politically and socially constructed, and at the same time to note that network structures among market participants appear to be sparse and thus fragile. One way to resolve this inconsistency is to appeal to law and to the state as active political influences on market formation (Fligstein 1996; Roe 1994). Clearly, the historical record of many countries, Germany included, shows the strong hand of state regulation on markets. Changes in governmental institutions and regulatory environments are often the product of negotiations between the state, capital, labor, and other interests. Firms, like other actors, seek to acquire institutional changes that favor their strategies. As Zey and Swenson (1999) have shown for the United States, alterations in tax laws that were desired by corporations subsequently led to restructuring.

Regardless, shifts in legal and fiscal policies, even if designed under the influence of corporations, only establish a framing by which paths are rendered feasible or infeasible; they rarely dictate who gets to own whom. We can view the preservation and evolution of markets as arising out of these institutional framings *and* the structural conditions that permit economic actors to exercise control. Once institutional changes are made, the structural opportunities are altered as well. Firms jockey to implement their strategies, such as restructuring and acquisition. But who buys and who is bought depend upon differential ownership claims and access to financial resources embedded in on-going structural relationships.

Restructuring decisions involving acquisitions require the joint decisions of the current owners to sell and the new owners to purchase. To a great degree, acquisitions are a matching process between sellers and buyers who are located in a network of ownership relations. A firm's location in such a network indicates the constraints on and resources available for restructuring. In this sense, different locations in the ownership network imply that firms differ in their access to social resources (Lin 2000). Network structure is thus a critical force that

³ This focus partly reflects the restriction on ownership holdings by corporate and financial firms in the United States, a restriction that is generally absent in most other countries. For a recent review, see Mizruchi (1996).

links the strategic action of firms to enduring national systems of ownership and control.

SMALL WORLDS

One way to characterize the structure of sparse networks, such as shared ownership, is the "small world." Small-world analysis arose out of the work of mathematical graph theorists, such as Rapoport and Horvath (1961), who were interested in the probabilities that a message, a disease, or anything that could be communicated between individuals, would reach them at varying distances from the source in a network of relationships. Milgram (1967) conducted an insightful experiment that observed the mobilization of existing ties by asking individuals to send a letter to an unfamiliar addressee. The popular notion that we are all connected (on average) at a social distance of no more than six persons is based on this research (see the John Guare play, *Six Degrees of Separation*). White (1970) analyzed a Milgram small world in networks where actors optimized search processes. Granovetter's (1973) idea of the strength of weak ties follows logically from this perspective; agents seek new information through others (i.e., weak ties) who are outside their immediate set of contacts.

Watts and Strogatz (1998) formalize the small-worlds idea using graph theoretic notions for networks with low density. They suggest that the small-world phenomenon occurs when actors in a sparse network are highly clustered but at the same time are connected to actors outside their clusters by a small number of intermediaries. Watts and Strogatz show how such a network structure can develop. They start with a sparse network composed of clusters that are marginally linked to each other and then "rewire" a proportion of ties, thereby creating new ties, each between actors chosen at random in the network, perhaps close to the original tie, perhaps far away. At lower levels of rewiring—less than 1 percent of the paths changing—global connectivity remains relatively low. But when about 1 percent of the paths are rewired, the network begins to exhibit small-world characteristics—clusters remain and high connectivity across these clusters

emerges (Watts and Strogatz 1998:441). Interestingly, even when 10 percent of the paths are rewired, clustering remains strong. This result implies that when connectivity increases, as ties within clusters are replaced with ties that span them, clustering can still remain strong, even in large, highly dispersed networks.

THE NATIONAL SETTING

The ownership network in Germany provides a useful and important setting for examining the small-world model. The German ownership structure has its origins in the great wave of entrepreneurship that swept Western Europe in the later half of the 1800s. Germany was one of the first countries to develop large diversified firms. Although German firms did not experience a merger wave with the intensity of that in the United States, acquisitions among German firms were frequent even prior to World War I. Moreover, because of investments in research and development, German firms diversified through internal growth and the development of new products. As a result, at the turn of the century, large German companies were more diversified than their American counterparts (Kocka and Siegrist 1979).

It is impossible to understand the patterns of German ownership of large corporations without focusing on the powerful role played by financial institutions. The rapid industrialization of Germany required immense financial resources. The state and banks cooperated on this front to finance these large investments. It was the German example of bank financing that gave rise to Gerschenkron's (1962) thesis of late capitalist development. The power of the bank was strengthened by the convention of issuing stock as bearer's shares. Since possession, rather than registration, marked ownership of these shares, individuals deposited them with banks. In doing so, they often gave the banks the rights to vote on their behalf (the so-called *Depotstimmrecht*). Thus, banks often voted their own shares, *plus* those of their customers.

Though the power of the banks fluctuated throughout the twentieth century (with particular weakness after the great inflation of

the 1920s), banks have remained central actors as owners of German firms and as sources of finance. There are three major banks, along with regional banks (some with large state participation), plus many savings and cooperative banks.

It is important to underscore that firms in Germany arose out of regional networks that varied in their properties. In these networks, local banks played important roles, as did state and city governments—especially for medium-sized firms (or *industrielle Mittelstand*). Whereas the largest firms sought capital from national and sometimes international markets, the regional economies consisted of powerful links between local banks, governments, and firms (Herrigel 1996:118–123; also see Deeg 1999). Moreover, labor in Germany has been well represented inside the firm through work councils and in the supervisory boards of public firms through the rights to co-determination.

The power of the major banks has periodically been a cause for public scrutiny. Already by 1910, Riesser published his study on the power of German banks.⁴ However, German industry consolidated greatly during the Weimar period as part of the Rationalization Movement that associated size with efficiency (Brady 1933). In the late 1920s, the German government commissioned the *Enquete Ausschuss* (investigating committee) to examine bank power, as well as the creation of trusts during the post-war period of rationalization. Though many of these trusts were broken up after World War II (such as the chemical trust), banks remained important actors. Prowse (1995) cites the statistics from a 1979 commission report on monopolies, in which 41 firms had banks as owners that held more than 25 percent of voting rights. In the 56 public stock companies for which combined bank ownership was greater than 5 percent, these banks held over 57 percent of the voting rights, on average. The power of banks and other shareholders has persisted to recent times. Prowse (1995) also reports that of the 41 large non-financial corporations in 1990, the top five

owners held on average 41.5 percent of equity. Moreover, 25 percent of the largest 310 nonfinancial firms had a majority owner in 1991.⁵

This structure did not change through the mid-1990s. Beyer (1999) concludes that management-controlled firms with dispersed owners were not prevalent in the German ownership network even as recently as 1993. His network analysis among large German firms shows a structure in which firms are located in hierarchical pyramids under a dominant firm or in long ownership chains. A recent report of the Monopoly Commission in Germany shows that of the largest 100 firms, a controlling interest in the equity of 51 was held by 39 large firms. To complicate the picture, of these 39 firms, 28 also were recipients of controlling interests (Hoepner 2000:9).

However, cracks appeared in the banks' (and the insurance company Allianz's) control over German companies in the 1980s and 1990s. Gorton and Schmid (1996) found that affiliation with a bank improved the profitability of firms in the 1970s. However, there was no effect on profits in the 1980s. A detailed study by Edwards and Fischer (1993) found that the influence of German banks was overstated, that the debt/equity ratios of German banks was not higher than those among comparable countries. Still, other studies have shown that banks own the financial intermediaries in Germany and that there has been only a modest increase of equity-derived financing compared with bank loans (Schmidt, Hackethal, and Tyrell 1999).

Lending weight to the arguments that ownership networks in Germany are shifting is the claim that global pressures have been building to force Germany to change, largely through the accumulation of German shares by American institutional investors. Thus, a 1996 report by the California state pension fund, CalPERS, reports that:

Germany has recently been experiencing an economic slowdown causing many people to reassess the old ways of doing business. . . . [T]he growth and liquidity of the inter-

⁴ Also see the study by Wellhoener (1989), which shows considerable banking influence in some but not all large firms for the period of Riesser's study.

⁵ This statistic might well be an artifact of the prevalence of the holding company in Germany, in which a parent company is listed as an owner of independently-incorporated affiliates.

national capital markets . . . has made the cost of German capital harder for German executives to ignore and caused more companies to begin looking toward cheaper international sources. As German corporations attempt to access the international capital markets, they are finding that the US and UK institutional investors that are the predominant source of this capital have certain expectations of management. (CaLPERS 1996)

Consequently, it appears that German ownership patterns are poised for the financial revolution that took place in the 1980s in the United States.

DATA

GERMAN FIRMS AND OWNERS

The time frame for this study is from 1993 to 1997. We measure German ownership relationships in 1993 and the acquisition events for 1994 through 1997 to avoid confounding the effects of events on the pattern of ownership itself. These effects were indeterminate since we have no data on the distribution of the shareholdings of target firms post-acquisition.

Our data come from a handbook compiled by the Frankfurter Allgemeine Zeitung GmbH. (1995), which gives broad financial data on the top industrial, financial, and insurance companies in Germany. These companies include public stock companies (*Aktiengesellschaft*), limited liability companies (*Gesellschaft mit beschränkter Haftung*), and limited partnerships. In addition to financial data, the handbook also reports owners who own more than 5 percent of a firm's assets. This information was derived from public financial statements and reports filed with government offices.

To reduce the complexity and scale of the analysis without necessarily reducing its substance, we examined the largest 500 non-financial corporations, the 25 largest banks, and the 25 largest insurance firms as of 1993 reports. This modest narrowing of the available data produced a sample of 550 firms that could be engaged in some form of merger and acquisition activity. These firms were owned by 684 institutions, including other nonfinancial corporations, banks, in-

surance companies, individual shareholders, cooperative organizations, families, state governments, the German national government, and non-German firms.

The identification a company's owners is complicated by reporting practices. In some cases, the Frankfurter handbook simply listed the approximate number of anonymous shareholders. We did not include these owners in our analysis as they appeared to be dispersed and, of course, could not be identified. More important is the treatment of holding companies, a relatively common form of institutional ownership which is far more prevalent in Germany than in other industrial countries, including France (see Kogut et al. forthcoming). Holding companies raise the problem of how to treat affiliated firms that are listed as companies but which belong to a holding-company structure. We adopt the practice used in the Frankfurter handbook of recording a firm as owned by the holding company, along with other owners if it was a joint venture or a less than fully-owned entity.

RESTRUCTURING EVENTS

The data on restructuring events come from the Securities Data Corporation archive on mergers and acquisitions. From 1994 to 1997, there were 101 acquisitions, including both sides of the transaction, involving the top 550 German corporations, banks, and insurance companies. There were obviously a much larger number of transactions involving these firms and smaller firms, however, we are not concerned with such events in this study. The acquisitions we examine are either purchases of an entire corporation ($N = 38$), of a corporation's subsidiary ($N = 48$), or of a joint venture in which a large firm held a stake ($N = 15$). We do not differentiate among these types of acquisition, because all of them entail the same questions about the influence of ownership chains.

METHOD

CONSTRUCTING THE NETWORK OF OWNERSHIP TIES

An ownership tie is a tie between two firms through a common owner. These links for all

the firms in our sample compose an affiliation network (for a discussion and listing of previous studies of this kind, see Wasserman and Faust [1994, chap. 8]). Analyzing such networks has a broad tradition and differs slightly from the more commonly studied relational networks that focus on *direct* ties between actors. The ownership network among the 550 German firms is simply their affiliation matrix. In many ownership networks such as this not all firms will be connected. It should also be clear that firms can be linked by more than one owner. In our method, multiple common owners between firms result in only one tie.

Using the affiliation network, we constructed a distance matrix among the firms. The distance between two firms is the smallest number of owners linking them. Thus if companies A and B share an owner and companies B and C share an owner, the distance between A and C equals two (see Appendix A).

IDENTIFYING SMALL WORLDS

To be a small world in the sense of Watts and Strogatz (1998), a network must exhibit a short average distance, or path length, between actors and a high degree of clustering. The average path length, called L , is simply the average of all geodesics (shortest path length between two actors in the network) taken from the distance matrix. The degree of clustering is indicated by a clustering coefficient, called C . This coefficient represents the extent to which firms that are directly connected to a focal firm are also directly connected to each other. It is calculated by observing, for each firm, how many of the firms that are tied to it are also tied to each other and dividing this number by the number of possible ties in the set. For example, if Daimler Benz is connected to 10 other firms by 1 ownership link and 8 of these firms are also directly tied to each other, then C_i for Daimler would be 28 (the number of pairwise ties between the 8 firms) divided by 45 (the number of possible ties among all 10 firms in Daimler's set) or .62. The network clustering coefficient is then the average C_i for all the firms.

Intuitively, one might assume that clustered graphs would be characterized by long

average path lengths. But this assumption can be wrong, as Watts and Strogatz (1998) show. Their method, already discussed briefly, is to start with a connected network with high degree of clustering and a high average path length and, in a simulation, to rewire a proportion of the ties. When the proportion of ties rewired in this fashion equals 1, a new network is created. Watts and Strogatz call this new network a "random network" for purposes of comparison with the highly structured original. In contrast to the original network, the random network has a low degree of clustering and a small average path length. Notably, as the network moves from a structured to a random graph, changes in path length and clustering are not linearly related. The average path length decreases much faster than clustering does. In other words, both the clustering coefficient and path length converge to the random values, but at different rates. This difference explains why assuming a negative linear relationship between global connectivity and the degree of clustering can be incorrect in many cases. These cases are small worlds; they demonstrate high clustering and short distances among actors network-wide, even though the network is sparse.

The concept of the random network is useful in that it provides a basis for identifying whether empirical networks demonstrate small-world properties. Watts and Strogatz (1998) provide limiting values for the average path length and the clustering coefficients of random networks with n actors and an average of k relationships per actor. These limiting values are $\ln(n)/\ln(k)$ for the average path length and k/n for the clustering coefficient. For a network to be a small world, its average path length is close to $\ln(n)/\ln(k)$, but its clustering coefficient is substantially greater than k/n .

RESULTS OF THE SMALL-WORLD ANALYSIS

Table 1 shows how much the firm ownership structure in Germany resembles a small world. The table presents the parameter values for the ownership network connecting firms and the values for the network of owners themselves, as they are linked through their equity holdings in the firms. In each

Table 1. The Small World of Firms and Their Owners: Germany, 1993 to 1997

Variable	Firms	Owners
<i>Density</i>		
Density for all firms ^a	.01	.01
Average number of links for all firms	3.56	2.02
Density for network of connected firms ^b	.02	.01
Average number of links for connected firms	6.59	3.23
<i>Clustering</i>		
Clustering coefficient of connected firms	.84	.83
Clustering coefficient of a random graph with same size and number of links per firm for connected firms	.022	.008
<i>Path Length</i>		
Average path length among connected firms	5.64	6.09
Expected average path length in a random graph of firms with same size and number of links as connected firms	3.01	5.16

^a Total number of firms = 538.

^b Number of connected firms = 291; number of owners = 429.

case we distinguish between parameters calculated for the overall network, which includes unconnected firms or owners, and parameters calculated for the connected firms or connected owners only. We focus primarily on the latter. The results reveal a small -

world pattern for both firms and their owners. Both firm and owner networks are highly clustered and at the same time are connected through relatively short average path lengths globally, compared with the random graph benchmarks.

Table 2 compares these results to three other networks analyzed by Watts and Strogatz (1998). The film actors network is an affiliation network of actors connected by participation in the same films; the power grid network represents links between generators, transformers, and substations in the western United States; and *C. Elegans* is the completely mapped neural network of a worm. The first four columns for German firms repeat the statistics of Table 1. The next 2 columns provide critical statistics, showing for all five networks that the actual and random average path lengths are quite similar, while the ratios of clustering coefficients are considerably different. The last column shows this most clearly: The small-world effect is evident and strong for German networks connecting firms through owners and connecting owners through firms.

MERGERS AND ACQUISITIONS

Table 3 presents the results on buyers and targets. There are two central observations. First, buyers and targets are clustered to about the same degree as firms on average (shown in Table 1). Because the clustering coefficient is high (approaching 1.0) among the buyer and target firms, it is tempting to claim that their "cliques" must be filling in.

Table 2. How Small Is Germany's Small World: A Comparison

Network	Path Length		Clustering		Actual-to-Random Ratio for:		
	Actual	Random	Actual	Random	Length	Clustering	Length/ Clustering
Film actors network ^a	3.65	2.99	.79	.001	1.22	2,925.93	2,396.90
Power grid network ^a	18.70	12.40	.08	.005	1.51	16.00	10.61
<i>C. Elegans</i> network ^a	2.65	2.25	.28	.05	1.18	5.60	4.75
German firms, connected	5.64	3.01	.84	.022	1.87	38.18	22.46
German owners, connected	6.09	5.16	.83	.008	1.18	118.57	100.48

^a Data come from Watts and Strogatz (1998). See text above for descriptions of these networks.

Table 3. The Small World of Buyers and Their Targets: Firms in Germany, 1993 to 1997

Variables	Buyers	Targets	Overall Firms (Connected)
Average number of links per firm	5.15	3.82	3.56
Clustering coefficient	.89	.84	.84
Average shortest path to another firm (for connected firms)	5.39	5.49	5.64

But this need not be the case. Buyers and their targets need not belong to the same cluster. Second, there are on average slightly fewer links connecting buyers and targets to other firms in the network than there are links connecting the other firms to each other (5.39 or 5.41 compared to 5.64 for connected firms). This finding indicates that the firms involved in the restructuring events are more likely to be brokers in the overall network.

There is another way to address the issue of who is doing the acquiring and how acquisitions relate to cluster membership. We ask: Are there owners who frequently act as brokers? And if so, are they more centrally located in the network of owners than the average owner is? In other words, do the more central owners in the network increase the centrality of their positions by brokering acquisition events? To calculate owner centrality, we calculated the point centrality for each owner (see Freeman 1979). We then simply compared the average point centrality of the owners who link acquisition events to the average centrality of owners in the overall network.

Table 4 presents statistics for the sample of pairs of firms in the network that are involved in acquisition events and the full sample of firm pairs. First, these results show that the average number of links in the network tying buyer and target together is lower than the average number of links tying firms in the overall population of connected firms. So the firms involved in the acquisition events are clearly tied more closely in the network. This finding is consistent with the results in Table 3 and indicates either more direct facilitation of the acquisition event through the ownership chain or a shorter search path.

Second, it is apparent that acquisitions reinforce the existing network structure of ownership. The evidence lies in comparing the average centrality of the owners in the chains linking buyers and targets and the average centrality of the “more central” firms in general. By “more central” here, we mean owners in the general population that are located on at least one path between two firms. The brokering owners have almost double the centrality of the general owner population (.038 vs. .020). So acquisition events are in a sense making the network more centralized. But they are not reducing the extent to which clustering occurs.

SMALL WORLDS AND ACQUISITION BROKERS

The evidence on centrality shows that brokering owners facilitate the restructuring and replication of the German network. This result is not surprising when we recall that ownership ties provide directly the power to decide who buys what. To investigate these brokering owners in greater detail, we present them with some of their characteris-

Table 4. Path Length and Owner Centrality for Acquisition Events and the Overall Population of Connected Pairs: Firms in Germany, 1993 to 1997

Variable	Acquisition Event Subsample	Overall Population of Connected Pairs
Average number of links in each chain	3.29 (for buyer/target pairs)	5.64 (for all connected firms)
Average centrality of owners	.038 (for owners brokering acquisition events)	.020 (for all connected owners)

Table 5. Descriptive Statistics of Owners in Chains Linking Buyers and Targets: Firms in Germany, 1993 to 1997

Owners	Industry	Number of Chains with an Event	Mean Level of Connection	Owner Centrality
Allianz	Insurance	2	1.5	.028
Bayerische Hypotheken und Wechselbank	Banking	1	2.0	.005
Brigitta Erdgas und Erdoel	Oil and Gas	2	4.0	.042
Commerzbank	Banking	1	2.0	.017
Deutsche Bank	Banking	4	2.0	.089
Dresdner Bank	Banking	2	2.0	.073
Dyckerhoff	Glass	8	4.0	.040
E. Schwenk Baustoffwerke	Construction	9	4.0	.034
Esso	Oil and Gas	1	3.0	.007
Federal Republic of Germany	Government	1	1.0	.056
Kaufhof Holding	Retail	1	2.0	.003
Münchener Rückversicherung	Insurance	1	1.0	.005
Ruhrgas	Oil and Gas	3	4.0	.064
Siemens	Electronics	2	4.0	.018
Veba	Oil and Gas	2	4.0	.099
Vermögensverwaltung	Holding company	3	3.6	.008
WestLB Girozentrale	Banking	3	3.0	.022
Wintershall	Oil and Gas	2	4.0	.095

tics in Table 5. We report the number of chains each firm belongs to, the average distance of the owner from the acquisition event, and the centrality of each owner. Using these data, we can confirm or deny our claim at the micro-level that brokers can be characterized as located on short path lengths and within dense clusters.

It is clear that most of these brokers fall generally into two industries: financial services (seven banks and insurance companies) and oil and gas (five companies) with the remainder in other categories (one glass firm, a construction firm, a retail firm, an electronics firm, a holding company, and the Federal Republic of Germany). Starting with the remainder, two of these owners—Dyckerhoff and E. Schwenk Baustoffwerke—are by far the most prevalent in the ownership chains, with eight and nine chains, respectively. However, these are clearly outliers given their industries and high levels of connectivity (four links for each). Vermögensverwaltung is a holding

company with an average number of chains of 3.6 and an average distance from the events of three links. The FRG and Kaufhof Holdings have only one chain each but are quite close to the acquisition events they broker (one and two links away, respectively).

The financial services group, composed of some of the largest and most powerful banks and insurance companies in Germany, has an average point centrality of about half that of the oil and gas group (.034 compared to .061) but is much closer to the acquisition events (about two links as opposed to four links away). The groups are involved in about the same number of chains (13 for financial services and 10 for oil and gas). One might ask whether these two groups broker different types of events. For example, it is logical to assume that the oil and gas firms are involved in oil and gas acquisitions. Yet an examination of the data shows that this is not the case. The businesses of targets whose acquisitions are brokered by oil and gas firm

owners range from internet services and software companies to firms involved in manufacturing and shipping. Likewise, owners of financial services broker acquisition events involving companies in machinery, insurance, coal mining, real estate, and interestingly, oil and gas, among others.

To relate these findings to broader debates in network studies, consider two opposing definitions of network structure (each labeled "social capital") that have been proposed by Coleman (1990) and Burt (1992). Coleman's measure is based on the relative density of relationships within groups of actors, which leads to analyzing a network as blocks of similarly positioned actors that are more or less "inbred." In this view, higher density means greater social capital in the sense that actors have multiple channels for information transmission and the exercise of control. In an alternative view, Burt (1992) argues that brokering positions in a network, which he characterizes as filling structural holes, represent a kind of social capital. The hole is a structural opportunity for the broker who facilitates the flow of resources and information between otherwise disconnected actors.

The concept of networks as small worlds integrates these two views of social capital. Watt's (1999) definition of a clustering coefficient technically incorporates both the ideas of structural holes and of cohesion. A structural hole is often defined as $\sum_k (1 - \sum_j P_{vj} P_{vk})$, where j and k are actors that are both directly tied to the firm. Thus, a structural hole implies that the clustering coefficient for a specific firm equals 0, since there are no ties among the firms that are tied to it. On the contrary, a high clustering coefficient indicates a high degree of cohesion.

Our findings suggest that the two types of social capital—cohesion and brokering opportunities—are not structurally inconsistent. Their coincidence can be illustrated by imagining the logic behind the spanning of new relationships across clusters as the network develops, consistent with the arguments of Watts (1999). In Watts's models, the network begins with clusters that then become connected over time. Small worlds in Watts's models are developed through the establishment of bridging ties chosen ran-

domly. It is very likely that ties bridging clusters in real networks are highly motivated, probably by the potential for financial control. A bias toward replicating structure, which would surely be expected in any setting where norms and sanctions are prevalent, would further strengthen our results. We have therefore a result that reflects the importance of a broker, as in Burt's (1992) theory, that acts to preserve ownership clusters, as in the sense of Coleman's (1990) emphasis on dense cliques. As a result, the network changes but along the lines of its historical structure. Walker, Kogut, and Shan (1997) find exactly this result that biotechnology networks evolve to reinforce Coleman-like cliques.

THE DURABILITY OF OWNERSHIP NETWORKS

We began with the claims that (1) a firm's or owner's position in a network influences acquisition patterns by conditioning structural opportunities for acquiring resources, and (2) that the small world is an important way to understand the network of resources: sparsely populated with ties, and yet both clustered and globally connected. This claim is especially appropriate for Germany in the 1990s as it adjusts to global economic pressures and the opening of its capital markets to foreign firms. Germany underwent a wave of restructuring in the late 1980s and 1990s, partly in reaction to the European Union initiatives, partly as a consequence of Germany's reunification, and partly in response to a changing world economy. Yet, despite this restructuring, the pattern of acquisitions is associated with existing ownership chains. This trend indicates not the fragmentation of but the persistence of the historical ownership structure.

In a period of rapid turbulence, the role of ideology clearly is a tool for influencing changes in the structure of markets. Here, we see the pivotal importance of how politics shapes markets (Fligstein 1996). Indeed, there are current signs that major changes are underway, even though German firms still display extensive interfirm ownership links. In particular, there have been serious attempts to change the ownership holdings in Germany (Ziegler 2000). In part, German

banks themselves desire these changes. They face inherent problems of conflicts of interest in their evolution into investment banks because they still hold considerable shares in potential buyers and targets. In this regard, German banks are following a change in strategy that was made by American banks (with important institutional differences) in the 1980s and 1990s (Davis and Mizruchi 1999).

Not surprisingly, strategizing actors use the ideology of the imperative of globalization. For example, Deutsche Bank incurred a conflict of interest in advising Krupp, a steel company, (via their subsidiary, Morgan Grenfell, located in London) regarding its hostile takeover attempt of Thyssen, another metals company, in which Deutsche Bank held shares. Subsequently, Deutsche Bank tried to merge with Dresdner Bank, its historic rival, partly to consolidate its overseas investment bank activities. Rolf Breuer, head of Deutsche Bank, noted that:

Rhineland capitalism, which . . . has assured the success of the German economy for 50 years, has reached its limits and should be reformed. The principal reason for this change is globalization that imposes on all national structures to change in order to remain competitive in the world environment.⁶

This ideological representation of market forces is not simply posturing, for restructuring requires alterations in the political and fiscal regulation of German financial markets. One of the major issues for the banks is to avoid massive taxation if they choose to sell their holdings. Indeed, there appears to be “money on the table,” as many of the firms dependent upon central owners are underperforming in the market, thus suggesting their vulnerability to divestment (Hoepner 2000). The recent legislation of the Schroeder government to provide tax relief for corporate restructuring (called the Eichel-Plan after the Minister of Finance) promises to repeat the 1990’s American experience changing tax laws to facilitate the

massive corporate restructuring (see Hoepner [2000] for an analysis of the German case, and Zey and Swenson [1999] for the American case).

Amidst these challenges to the current structure of cross-holdings in ownership, it would be instructive to know if the German national system, as reflected in its small-world structure, should easily collapse.⁷ As a simple baseline, consider the case where ties are reassigned randomly without sensitivity to issues of power and control. We want to test the durability of the national pattern of ownership in Germany. Thus, if we deprive owners of specific strategies, a proportion of which would certainly reinforce the existing structure, is the current network structure vulnerable to rapid erosion, or can a bit of that structure still endure? This is a pivotal question because in the coming years, as global forces impinge more strongly on the German economy, owners will clearly sell their stakes, firms will be acquired, and new ownership links will be forged.

To explore the robustness of the German ownership structure, we simulated degrees of change to the network. The simulations were performed for 20 levels of network change. The levels of change were chosen to reflect the logarithmic scale of Watts and Strogatz (1998) and ranged from altering 1 path to altering 192 paths in the affiliation matrix. At each level of change, we ran 100 simulations, randomly choosing ties to alter, and calculating the new clustering coefficient and average path length between connected firms. We then averaged these statistics across the 100 runs for that level of network change to create average statistics.

Thus, at the lowest level of change—one path—each simulation run identified at random an existing relationship between two firms, broke that tie, and added a tie between two other firms, also chosen at random. The clustering coefficient and average path length were then calculated. This process was repeated 100 times, and the mean

⁶ Interview, “Rolf Breuer estime que la Deutsche Bank peut s’imposer sans fusionner,” (Rolf Breuer believes that Deutsche Bank can succeed without a merger) *Le Monde*, May 31, 2000 (translated by the author).

⁷ Again, recall that the national system is also anchored in other institutions, such as the representation of labor in work councils and supervisory boards. See Jurgens, Naumann, and Rupp (2000) on this point.

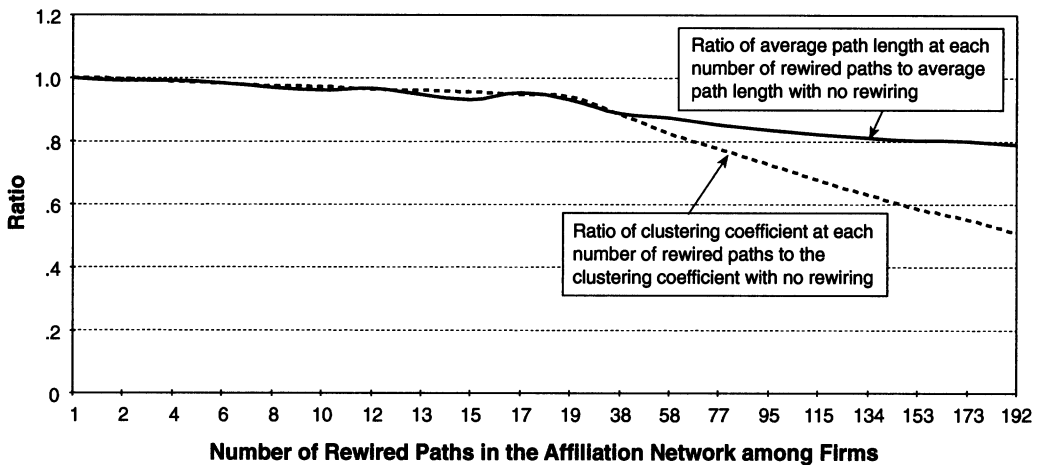


Figure 1. Results of Simulated Changes in Firm Ownership through the “Rewiring” of Ties in the Affiliation Network: Firms in Germany, 1993 to 1997

clustering coefficient and average path length were computed across all 100 simulations.

Figure 1 summarizes the results. As the amount of network change increases, both the average path length and the clustering coefficient drop, consistent with Watts’s (1999) small-world concept. However, the extent of this drop differs between the two network characteristics. The average path length decreases slowly, so that even with 192 paths rearranged, the path length has dropped less than 20 percent from its original value. The clustering coefficient exhibits a different pattern. The clustering coefficient shows the same smooth decline as the average path length until roughly 19 paths are altered. After this point, the coefficient’s rate of decline increases. As shown in Figure 1, even with 192 paths altered, the clustering coefficient equals about .42, roughly one half its value of .84 in the original network. However, the coefficient still remains quite high compared with the random value of .022 (see Table 2).

The simulation results suggest that a massive reallocation of ties would be necessary to significantly erode the small world of German firm ownership as this structure is substantially preserved even after 192 rewirings of owner relationships. This is a little less than twice the number (101) of acquisition events we observe between 1994 and 1997, roughly one-quarter of which

were structure-preserving in the sense of involving two firms that were already connected.

Moreover, these simulations understate the self-preserving characteristics of networks. The relative stability of small worlds implies that a structure of connected cliques can persist even as a fairly sizeable number of ownership links occur randomly. *The obvious strategies of exploiting brokering opportunities and of developing cliques are both consistent with the small-world structure and are not excluded from the randomized approach.* In fact, randomization is perhaps the least favorable general rule for preserving the small world, certainly as Watts (1999) represents it, because randomization includes both those new links that reinforce the small world and those that degrade it. Of course, it is possible, for example, that Allianz might disappear as a node should its holdings be randomly distributed. This would clearly have an effect. But then we should ask by what logic can we foresee such an event *given* Allianz’s position in the existing structure of relationships? Even if it decided to sell all holdings, it is likely that some would be sold to related partners. Hence, a randomization of ties is a strong test of network durability. For this reason, we are reasonably confident that the simulation results provide conservative evidence for the robustness of the small world of ownership in Germany.

The initial structure of an ownership network may vary widely across countries depending on a range of factors that limit or promote the connectedness of firms through shared ownership.⁸ As capitalist institutions are realized in a country with a growing economy, the small world of firm ownership should appear. If the initial network structure is fragmented based on sectoral, financial, regional, or family clusters, the small world emerges when brokers enter to exploit restructuring opportunities as capital becomes available. If the initial structure is more centralized, as in a relatively small economy dominated by powerful brokers, the small world is developed as the economy expands and ownership becomes more widely distributed.

How small worlds are developed as market and regulatory institutions change is a question strongly related to understanding the capitalist model. Although the question is clearly beyond the scope of this paper, our simulation results suggest that, absent regulation that destroys the network itself (e.g., through prohibiting the co-ownership of firms), the small world should be robust to shifts in the policies and structures of supporting institutions. The plasticity of these institutions in response to political and economic forces, such as globalization, may therefore alter specific ownership ties, as for example industries are de- or re-regulated. But these changes should not eliminate the small-world structure and the role of powerful firms in brokering restructuring events.

National networks also reflect cognitive templates that influence the strategic action of economic actors who heed the distributional consequences of power and control. Networks are composed of clusters in the first place because they reflect the preferences of actors and the distribution of power in a historically given economic and social structure. In some capitalist economies, for

example, network formation may reflect certain technological beliefs (such as the convergence of technologies) or adherence to status rules (Podolny 1993). Thus, we expect that new links form through the application of unobservable rules that influence network structures in dynamic ways. Also, investor understandings are undoubtedly influenced by financial and governmental institutions as well as by shifts in markets and technologies.

For these reasons, globalization itself may be a less powerful force than currently thought. Globalization may have the observed impact of fostering restructuring, yet it may not significantly disturb the historical structure of the domestic ownership network. Hence, the small-world effect acts as a powerful focal point of convergence for economic action. Power, very much in the sense of Giddens (1984), is self-preserving because actors sense that structure is fairly robust, even in the face of random disturbances. Certainly, national networks can decay, as Davis and Misruchi (1999) observed for the United States; yet certain nodes remain more critical than others. As Padgett and Ansell (1993) noticed in their study of Florence and the Medici family, the potential for robust action by well-positioned actors does not require extensive cross-holdings or a high density of relationships.

CONCLUSION

It is ironic that globalization is experienced and manifested as a national phenomenon. Global economic forces—the mobility of capital, trends in trade and direct investment, the diffusion of capitalist ideas—impinge on individual countries through their institutions of ownership and power. Given differences among countries in these institutions, each country should respond differently to the same external pressures. But this hypothesis is not consistent with the evidence on the low densities of firm ownership networks in the major developed nations. Low density implies a lack of connectivity and therefore the impossibility of organized action at the country level. Without organized action in a country, the network of ownership and power loses its meaning as a national filter of global pressures.

⁸ These factors may include the early presence of large firms with capital to invest, the availability of regional as opposed to central sources of capital, regulatory sanction of cross-holdings, the distribution of investment across the sectors of production, as well as political forces for or against the concentration of ownership (e.g., see Khanna and Palepu [2000] on group structures in emerging markets).

Thinking about networks in terms of small worlds resolves this conundrum. The small-world effect implies that a high level of connectivity can exist across a low-density network. And the persistence of closure in links around each firm, shown by our simulation, revitalizes the notion that clusters of ownership do matter. The analysis of ownership ties in Germany not only reveals a structure that guides acquisition decisions but also identifies brokers associated with the reinforcement and replication of national systems.

Our results linking restructuring events to the network of owners in Germany is an example of how the importance of the small-world concept can be demonstrated empirically. We found little evidence of sectoral influence in relating the ownership network to acquisition events. Nor did we find a predominance of financial organizations at the center of the network. Owners that were central in restructuring events came from a variety of industries, indicating that the re-

peated use of network position may be mostly related to specific strategic interests.

Networks of corporate control in other countries are likely to have similar structural characteristics as well as well-positioned firms. Seen in this light, the global economy consists of many national small worlds composed of country-specific institutions responding to the economic forces of global integration. Globalization is a force that impinges on all countries, but its effects are mediated by these small worlds of ownership within national economies that demonstrate surprising perseverance.

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APPENDIX A: CONSTRUCTING THE NETWORKS AND THE DISTANCE MATRICES

Ties between firms based on common owners compose an affiliation network. Its obverse is the network among owners connected by firms. Here we discuss the construction of the distance matrix among firms below.

The ownership network among the 550 German firms we studied can be used to create the distance matrix for the network in which distance represents the shortest number of owners linking any two companies. For example, consider a network that has four firms and five owners. We want to create a distance matrix that indicates how many owners link each pair of firms. We start with the matrix **A**, which lists the four firms in the rows and the five owners in the columns. The number 1 indicates that the owner owns this firm; a 0 indicates no ownership:

$$\mathbf{A} = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}.$$

In matrix **A**, the firm in the first row shares an owner with the firms in rows two and four. We see this by (Boolean) post-multiplying the matrix by its transpose. The matrix multiplication creates matrix **B** that now lists the four firms along the rows and along the columns:

$$\mathbf{B} = \begin{bmatrix} 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{bmatrix}.$$

To calculate indirect links, we post-multiply this matrix by its transpose to arrive at matrix **C**:

$$\mathbf{C} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}.$$

To capture the history of these calculations, we create a symmetrical distance matrix, matrix **D**, that has the following properties: $d_{ii} = 0$, since firms have zero distance to themselves; $d_{ij} = 1$, if $b_{ij} = 1$, since 1 indicates a common owner; $d_{ij} = 2$, if $b_{ij} = 0$ and $c_{ij} = 1$, since it takes another firm to link firms i and j in the ownership chain.

$$\mathbf{D} = \begin{bmatrix} 0 & 1 & 2 & 1 \\ 1 & 0 & 1 & 2 \\ 2 & 1 & 0 & 1 \\ 1 & 2 & 1 & 0 \end{bmatrix}.$$

(Continued on next page)

(Appendix A continued)

This process is continued until all firms are connected.

A network and distance matrix was constructed in the same way for our German sample of owners connected by firms. In many empirical cases such

as ours, not all firms will be connected. If two firms are not connected through any other firms, then d_{ij} is set to a nominal value to indicate this fact. It should also be clear that firms could be linked in chains of more than one owner.

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