Journal of Management Studies 32:3 May 1995
0022-2380

STRATEGIC GROUPS AND INTER-FIRM NETWORKS IN INTERNATIONAL HIGH-TECH INDUSTRIES

GEERT DUYSTERS

University of Limburg

JOHN HAGEDOORN

University of Limburg

ABSTRACT

Strategic partnering and the analysis of strategic groups are two issues which enjoy a growing interest from industrial economists as well as from strategic management scholars. This contribution focuses on two related topics in the discussion on strategic group formation. The first subject addresses the relevance of strategic groups for understanding industry heterogeneity. The other topic covers the question whether companies from particular strategic groups establish strategic links with each other, or whether intra-group rivalry leads to inter-firm cooperation across strategic groups. Although it appears neglected in the literature the possible linking of the analysis of strategic groups with corporate network studies could generate further understanding of the process of strategic group formation. The present contribution focuses on the international information technology industry in order to study the possible symmetry of the structure of strategic group formation and parallel inter-firm networks of strategic partnering empirically.

INTRODUCTION

Inspired by both theories of strategic management and industrial organization the analysis of strategic groups plays an important role in studies on industry structures and corporate strategies. In the traditional industrial organization literature sectors of industry and firms were to a large degree theoretically understood in terms of homogeneity. In later contributions alternative strategies influence market performance of companies allowing for a larger degree of industry heterogeneity. The introduction of behavioural aspects brings contributions from industrial organization, strategic management and business studies together as more attention is paid to heterogeneity and mobility barriers within industries. In that sense strategic group theory can be seen as a compromise between the traditional economics inspired literature and the more practically

Address for reprints: John Hagedoorn, MERIT, University of Limburg, PO Box 616, 6200 MD Maastricht, The Netherlands.

and behaviour-oriented literature on corporate strategy, see Barney and Hoskisson (1990), Aharoni (1993), and Fiegenbaum and Thomas (1993).

Generally, the concept of strategic groups is defined in terms of clusters of companies which pursue similar strategies with identical resources (see for instance, Harrigan, 1985; Hatten and Hatten, 1987). In contributions so far one finds rather different bases for possible group foundation. For instance, in McGee and Thomas (1986) a review of the literature demonstrates that at least 15 different sets of indicators are applied in fewer than 20 relevant studies. From surveys of empirical research on strategic groups in Thomas and Venkatraman (1988) and Ketchen et al. (1993) one can also deduct a large number of different indicators. These indicators range from straightforward size-classes and measures of the degree of vertical integration to multivariate indicators with different selections of a number of more or less familiar company characteristics.

Our contribution does not offer an extensive review of the state-of-the-art of strategic group analysis. The established understanding of strategic groups is already thoroughly discussed in the survey literature mentioned above and also found in most of the empirical studies that we briefly refer to below. Another review of the same body of literature, in particular in this journal, is, in our view, a clear example of 'carrying coal to Newcastle'. The objective of the present analysis is twofold. One goal is the assessment of the value of strategic group analysis for understanding the structure of heterogeneity in industries. In that context one has to find some evidence of the empirical relevance of strategic groups if one seeks to establish some understanding of corporate behaviour in between an industry equilibrium and idiosyncratic corporate behaviour that blinds our theoretical understanding of structures and processes. Contrary to many other contributions, we do not consider performance differences among strategic groups but we concentrate on the, in our opinion, more basic issue whether strategic groups can be found in terms of clusters of companies that share structural and behavioural corporate characteristics. Once we understand strategic group formation in a multivariate setting, we can continue with the second topic of this paper, i.e. the possible association of networks of strategic technology partnering with strategic group formation. As briefly discussed below, the older literature on strategic groups hinted at the possible mutual dependence of companies through inter-firm co-operation. In the literature from the past decade this relationship between strategic group formation and inter-firm linkages is largely neglected. Only in some recent contributions, briefly discussed below, the topic itself is put on the agenda again. In linking these two issues, our present contribution compares strategic group formation, or the structure of competition, with the structure of strategic partnering between firms.

As already indicated above, the abundance of reviews on strategic group analysis allows us to keep our discussion of the state-of-the-art in strategic groups analysis as short as possible. We continue with a short elaboration on the subject of the strategic space that defines the level of competitive positioning that one has to discern before strategic group analysis is further developed. Although not without theoretical implications our analysis is of an empirical nature, as we study the possible strategic group formation processes and the cohesion of group formation for the international information technology industry. This particular industry is chosen for several reasons, but its non-standard industry classification

character, the wealth of statistical material and company information, the relevance of international competition, and the 'tradition' of inter-firm co-operation are amongst the more important motives. Based on our findings we discuss both strategic group and network implications as well as some directions for further research.

SOME SUGGESTIONS FOR STRATEGIC GROUP ANALYSIS

In their critical assessment of the state-of-the-art in strategic group analysis Thomas and Venkatraman (1988) discuss a relatively long list of suggested directions for theoretical and empirical research. They recommend among other things a broader conceptualization of corporate strategy in order to capture the complexity of the strategy construct, stress the importance of cross-border competition and explain the necessity to analyse inter-firm competition from a perspective that surpasses traditional industry classifications. In addition to this, a particular interesting task mentioned in recent contributions is to provide an operationalization of corporate strategy going beyond one functional area, 'unfolding' the so-called 'strategic space' into several dimensions of strategic groups (see also Fiegenbaum et al., 1987; Fiegenbaum and Thomas, 1993). The complexity of such a strategic space is then caught in terms of levels of corporate control or company organization, components of strategic decisions and the dynamic aspects of changes in these dimensions. The step from the present state of analysis to such a more general framework could be too large to take at once, given the present state of theoretical understanding of industry heterogeneity. However, in a more straightforward interpretation of such a strategic space one can construct dimensions of strategic groups that reach from company structure variables to more strategic and behavioural variables that facilitate the understanding of possible industry heterogeneity as shown in strategic groups. This approach is quite compatible with an analytically and statistically multi-dimensional understanding of strategic group formation (see Kumar et al., 1990; Thomas and Venkatraman, 1988).

Given the increased internationalization of inter-firm rivalry this line of research should also go beyond national borders and include international markets in order to address multi-point competition at a global scale. Previously a substantial part of the work on strategic groups was concentrated on the identification of these groups within one national context. Besides some possible methodological insights based on these studies their benefits in terms of empirical results and/or theoretical spin-offs are increasingly becoming obsolete.

Apart from a broader international interpretation of markets it appears worthwhile to explore the phenomenon of strategic groups in relevant product markets replacing artificial or outdated product-based industry classifications. An important point to be made is that the abundance of statistical artefacts in official statistics is hardly a guarantee for relevant findings if competition takes place in markets that are only partly covered by such industry classifications. Also, as many companies compete in different markets, strategic group formation should not be identified in terms of companies' main economic activities, but in particular be related to their multi-market competitive positioning. All this is necessary

not so much to correct statistical mismatches with otherwise observable 'facts' but more specifically to catch as much as possible of the relevant characteristics of competition and the strategic space in which companies operate.

Support for a more inter-subjective or cognitive approach for the selection of dimensions of strategic groups, including the perception of strategic groups by the management of relevant companies, is found in some recent contributions (Pehrsson, 1990; Reger and Huff, 1993; Thomas and Venkatraman, 1988). We, however, think it is sufficient to link structural aspects of strategic groups to behavioural aspects that together build the necessary information for understanding the configuration of companies in industries. Also a 'popular' understanding of strategic groups itself does not necessarily generate additional objectifiable information that can contribute to the academic understanding of the subject.

A growing number of authors stress the importance of a theoretical explanation of the existence of strategic groups through a deductive instead of inductive approach (Barney and Hoskisson, 1990; Ketchn et al., 1993; Thomas and Venkatraman, 1988). In general it is argued that an inductive approach only gives some *a posteriori* empirical understanding of sectoral heterogeneity stressing intra-industry economic performance variance or otherwise structural differentiation. The present contribution focuses on the quality of strategic analysis for 'mapping' the strategic space in which a, possibly, differentiated population of firms is operating. For our purpose of exploratory research the analysis of strategic groups within a well-defined strategic space can serve as a useful analytical tool to detect heterogeneity of firms in an industry which is then linked to the analysis of the structure of inter-firm partnering.

OPERATIONALIZATION OF STRATEGIC SPACE

In this paper the industry in which companies operate is defined in terms of a set of product–market combinations in an international context extending beyond traditional industry classifications. Also, the group of companies that builds an industry is not restricted to those for which a particular activity is also a major or the only business. Consequently, companies can operate in different industries allowing for multi-point competition.

Within this general strategic space in which companies compete we can discern a number of dimensions of strategy. As mentioned above we understand these to lay on a continuum from structural variables to more strategic and behavioural variables. Also, the national background of companies could be a relevant aspect of the strategic space. Although competition is gradually becoming more international, the country of origin of companies could very well be an important characteristic of strategic groups because we can expect regional distance to play at least some role in group formation. If this is not the case or if country-specificity plays only a limited role it stresses the point made previously that strategic group formation has increasingly to be seen in a global perspective.

Structural company heterogeneity can be related to both size of companies and their degree of diversification. The former dimension refers to the inter-firm differences in capabilities to generate economies of scale, the latter indicates possible economies of scope for a multi-product firm or a more specialized status

for non-diversified companies. The dimension of diversification or width of corporate activities already takes an intermediary position in between structural and behavioural aspects of strategic groups because diversification not only reflects size, it also indicates a strategic intent to confront multi-market competition. Other characteristics of corporate behaviour reflect the crucial range of alternative strategies that can discriminate between groups of companies. In terms of general strategies these differences reflect broad categories of alternative strategic positioning, e.g. corresponding with Porter's (1985) generic strategies. Technology strategies, demonstrating different degrees of corporate commitment to innovation coinciding with dissimilarities in technological capabilities, seem most appropriate to discriminate between companies in high-tech sectors where differentiation or focus strategies are most relevant for competitive positioning.

Contrary to Fiegenbaum et al. (1987) and Pehrsson (1990) we stress that strategic group formation is not only emerging from similar strategies. We contend that company structure-related characteristics are important phenomena for understanding strategic group formation. If the company structural dimension is not included, the existing barriers that limit the range of behavioural autonomy are ignored. In that case a particular interpretation of strategic similarity of companies with different size-attributes – say a small niche-player and a large, diversified company that follows a focus strategy in only one of its many activities – would arbitrarily conclude a strategic resemblance that is nothing but a clear example of a crude statistical artefact.

STRATEGIC GROUPS AND NETWORKS OF STRATEGIC TECHNOLOGY PARTNERING

Although still largely neglected in the literature, it appears an interesting question whether strategic group affiliation affects the actual degree of interdependence between companies through partnerships. In Caves and Porter's (1977) seminal contribution there is frequent mention of mutual dependence and recognition of interdependence within strategic groups, which could indicate a possible relation between strategic groups and inter-firm collaboration, but this relation itself is not discussed. In Newman (1978) there is an element of co-operation through collusive behaviour and 'mutual dependence' in a cartel-like interpretation of strategic groups, see also Cool and Dierickx (1993). A number of recent contributions have more clearly put this topic on the agenda. Thomas and Carroll (1994) point out that a 'strong' definition of strategic groups implies networks of interacting firms. They criticize most of the present research for ignoring this aspect of strategic groups. Nohria and Garcia-Pont (1991) discuss the analysis of strategic groups in the context of the structure of inter-firm networks found in so-called 'strategic blocks'. Ketchen et al. (1993) point at the relevance of strategic alliances for defining strategic groups as they state that 'one criterion for defining configuration may be network or alliance membership' (p. 1307). Cool and Dierickx (1993) indicate that mutual dependence between companies within strategic groups implies that competition between groups should be larger than intra-group rivalry. In a similar way Nohria and Garcia-Pont (1991) express that inter-firm linkages within strategic groups could be positively connected, whereas those across strategic groups could be negatively connected. On the other hand, these

two latter contributions also suggest that competition within groups operating in more or less identical segments of their strategic space makes it harder to reach and preserve effective understanding through strategic linkages among strategic group members. In that context we can also refer to Hagedoorn (1993) who found that technological and market complementarity is a major motive for inter-firm partnering. Complementarity suggests that companies from one strategic group are not necessarily the most adequate partners for mutual dependence through strategic linkages.

Such elaborations lead us to the following two major issues to be studied. First, we will analyse strategic group formation in a multi-dimensional strategic space within international markets with a set of variables that follows from the directions for research outlined in the above. This first step is to be seen as a multi-dimensional operationalization of corporate strategy with an *a posteriori* understanding of groupings. The second issue we will study, after we have been able to construct strategic groups, is the relation of strategic groups with the structure of inter-firm networks of strategic partnering. Following the brief discussion above we assume that strategic groups are not reflected in identical networks of partnering companies through strategic alliances. Hence:

> *Hypothesis 1:* We can expect that strategic partnering density within groups is lower than extra strategic group partnering density.

In other words, we expect fewer pooling blocks (all firms from the same strategic group) than complementary partnering blocks (members from different strategic groups). More specific hypotheses about the relation between strategic groups and strategic partnering blocks can be formulated only once concrete strategic groups and their structural and behavioural properties are identified.

DESCRIPTION OF POPULATION, VARIABLES AND DATA

For the empirical analysis of strategic groups and patterns of strategic technology partnering we have chosen the international information technology industry with its three large sub-sectors, i.e. dataprocessing, telecommunications, and microelectronics. Basic arguments for choosing this industry are: the strong international character of competition; its multi-market competition between a large number of players; product–market combinations going beyond traditional sector classifications; and the relative abundance of reliable corporate indicators. For each of these sectors we analyse economic and technological data on structural and behavioural aspects of the major producers of which the vast majority comes from the triad: Europe (i.e. EC and EFTA countries), the USA and Japan. The data refer either to the period of the 1980s at large or to the second half of the 1980s, partly depending on the availability of consistent statistical material.

For the international information technology industry we constructed the following sub-sectors. Dataprocessing has a population of 25 leading companies: 12 US, 4 European, and 9 Japanese. The telecommunications industry comprises a population of 25 companies: 5 US, 12 European, 7 Japanese, and one miscellaneous. The microelectronics sector consists of 20 companies: 6 US, 3

European, and 10 Japanese; one company falls in the category of 'others'. (See also appendix 1.)

The data for the analysis are based on the MERIT-CATI data bank that holds information on a large number of indicators of corporate behaviour and performance, see appendix 2. As an indicator of size we have taken the average of corporate revenues that companies realized during the period 1986–90. We chose revenues as an indicator instead of the more frequently applied employment indicator to account for organizational differences and effects of quasi-integration. It is well known that Japanese companies have fewer employees than their US and European competitors due to the Japanese lean production practice and extensive customer–supplier networks. Therefore, size in terms of revenues, which roughly equals turnover, is in our opinion an appropriate indicator of economic magnitude to compare companies from different regions. Differences in corporate size in each sub-field of information technology are analysed by means of two indicators. The first indicator (SIZE) is the average total revenues of companies for the yearly average of the period 1986–90. The second indicator (DPSIZE, TELSIZE, SEMSIZE) is related to the dataprocessing, telecommunications, or microelectronics activities of these companies, i.e. their average revenues in each of these fields during the same period.

Other characteristics we include are related to corporate diversification and specialization patterns. By looking at the pattern of diversification we can say something about the width of the activities of companies in terms of their operations and general technical capabilities that possibly generate economies of scope, or whether they follow a strategy that concentrates their activities mainly in particular sub-fields of dataprocessing, telecommunications or microelectronics building on specialized capabilities. Diversification is first measured as the average number of information technology segments from a total of 20 segments in which companies were engaged during 1989. The degree of specialization is a different measure indicating the share of dataprocessing, telecommunications or microelectronics sales in total corporate sales during the period 1986–89. We apply principal component analysis to reduce our data set in order to arrive at one composite variable (DIV).

The technology strategy variable (TECH) is based on a number of innovation and technological strength-related indicators. The absolute innovative strength of companies is indicated by their number of sector relevant US patents, granted in the period 1980–88. We have taken US patents because we expect the US market to be the most advanced in terms of the combination of competition, openness and technological sophistication, in particular in information technology. The absolute number of patents granted was taken to have at least one indicator of absolute strength next to a number of more relative indicators. Also, we found that the correlation between R&D intensity, alliance-related variables and patenting intensity is extremely weak, whereas the correlation with the absolute number of patents is significant. An indicator of innovative capabilities and efforts from the innovation input perspective is the R&D intensity of firms, i.e. their total R&D expenditures as a percentage of total corporate sales during the period 1986–90. Apart from these two 'standard' innovation strategy indicators we will also include a measure that is related to the strategic technology partnering behaviour of firms in each sub-field during the 1980s. In order to

construct a combined indicator of strategic technology partnering behaviour of companies we apply principal component analysis once more, this time by combining two measures of technological strength as expressed in partnering behaviour. One of these measures indicates if the strategic technology alliances of companies in relevant sub-fields are primarily related to R&D or whether these alliances are more closely related to marketing and market entry activities. We include this indicator because Hagedoorn and Schakenraad (1994) found that, in particular in information technology, R&D-inclined strategic linkages are associated with improved company performance. The other partnering related measure indicates the degree to which the strategic partnerships of companies generate technology to their partners or absorb technology from them. We assume that the more a company generates technology to its partners the stronger the technological position of this company. All alliances that include licensing agreements, second-sourcing arrangements, OEM contracts, and research contracts indicate technology flows from one partner to another. The combined measure of these two ratios indicates the degree of technological strength of companies from a strategic technology partnering perspective.

The relationships between dimensions, variables and indicators of strategic groups are summarized in figure 1.

For the second topic, assessing the possible association of strategic groups with strategic partnering blocks, we take the number of registered inter-firm strategic technology alliances in the MERIT-CATI data bank as the unit of analysis, see

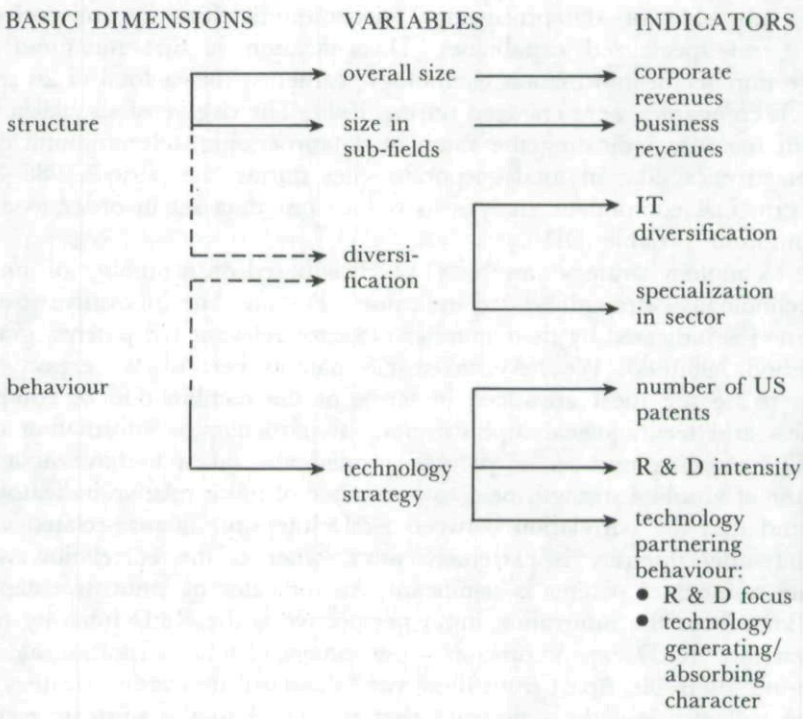

Figure 1. An overview of the applied strategic group indicators

appendix 2. We have taken all relevant inter-firm linkages established during the period 1985–89 plus those made before 1985 that were not already discontinued in 1985. A large number of studies (Hagedoorn, 1993; Mowery, 1988; Mytelka, 1991; Osborn and Baughn, 1990 – to mention but a few examples) suggest that technology partnering is concentrated in so-called high-tech industries and also that inter-firm partnering in these sectors has a strong R&D or technology-sharing orientation. Given the generally accepted high-tech character of the three information technology sectors studied in this paper, inter-firm partnering constituting strategic blocks will be analysed in terms of strategic technology alliances. See appendix 2 for further details.

We can assume independence between the technology strategy variable and the network indicator because of the difference between flow indicators of technology transfer, as part of an operational construct for strategy, and the stock of large numbers of alliances that are applied to reconstruct network block densities.

THE ANALYSIS OF STRATEGIC GROUPS

In the following we will apply a so-called multi-dimensional scaling (MDS) technique that enables us to identify groups of companies and interpret the 'rationale' of the formation for this grouping. MDS is a data reduction procedure comparable to principal component analysis and other factor analytical methods. One of the main advantages of MDS is that usually, but not necessarily, MDS can fit an appropriate model in two dimensions. MDS offers scaling of similarity data into points lying in an X-dimensional space. The purpose of this method is to provide co-ordinates for these points in such a way that distances between pairs of points fit as closely as possible to the observed similarities.

For the analysis of strategic groups we measure the resemblance of companies on the four variables listed in figure 1: overall size, size in relevant sub-fields, diversification, and technology strategy. For these four variables one would need a four-dimensional space in order to represent the scores on the various variables. Using the formula given below we can aggregate the Euclidean distance between companies on each dimension and represent the data in a (dis)similarity matrix that can be scaled by an MDS programme:

$$d_{ij}\left[\sum_{k=1}^{r} (X_{ik} - X_{jk})^2\right]^{1/2}$$

According to this procedure we first square the differences in co-ordinates dimension by dimension (k), add up the results, and take the square root of the total sum. Smaller distances between companies are then associated with more similar scores on the various characteristics. In order to facilitate interpretation the solution is given in two dimensions, provided that the fit of the model is acceptable. A stress-value indicates the goodness-of-fit of the configuration.[1]

With MDS-analyses there are in principle two complementary lines of interpretation, i.e. a dimensional as well as a neighbourhood interpretation. In the following only the latter interpretation – with small distance in the configuration indicating large similarity – is applied because the dimensional interpretation will generate hardly any results. To facilitate interpretation of the regional or national

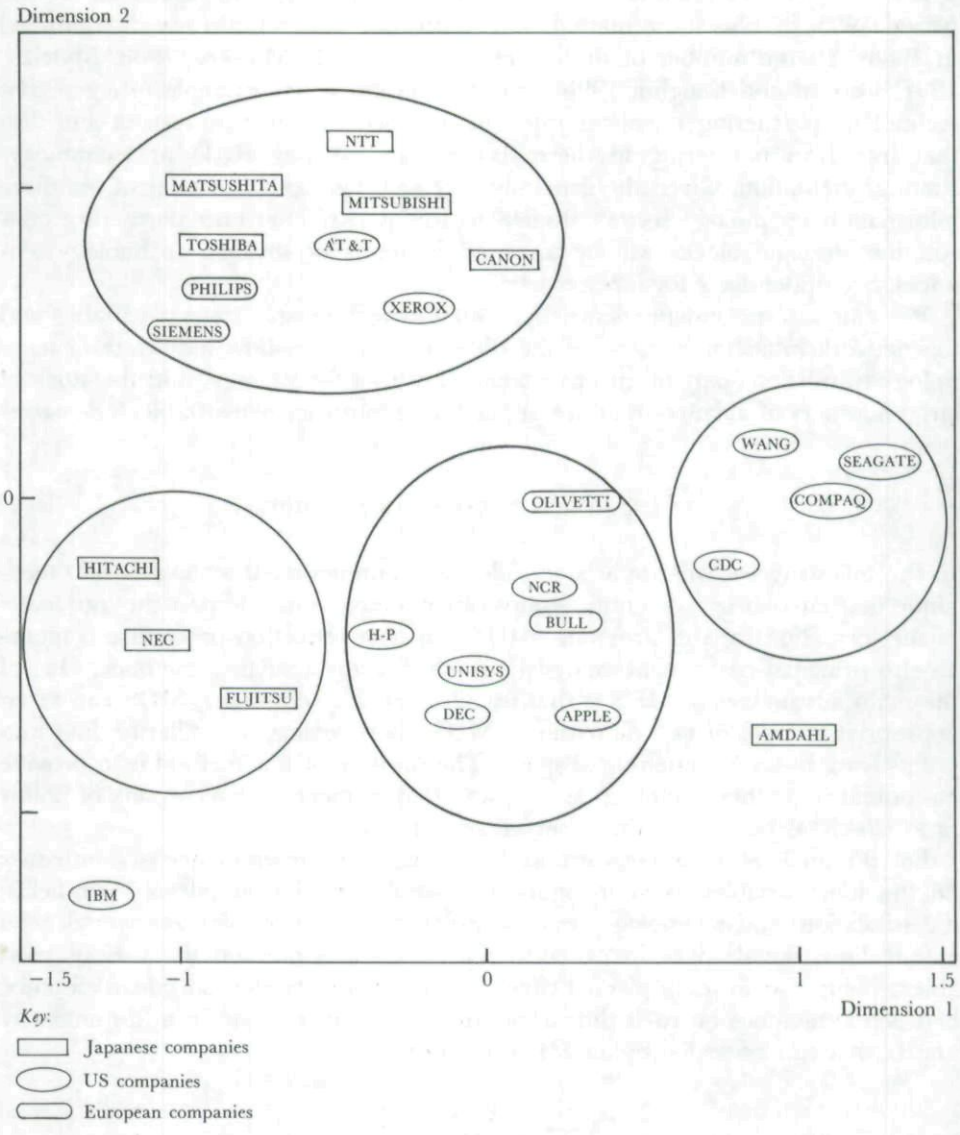

Figure 2. Strategic groups in the international dataprocessing industry

background of companies, in the figures Japanese firms are put in rectangles, American firms in flat ellipses, European firms in spherical ellipses, and companies from outside the triad in squares.

In figure 2 we can identify four groups of companies for the dataprocessing industry:

1. The first group contains large, diversified companies with only a modest interest in dataprocessing, i.e. the Japanese companies Matsushita, Toshiba, NTT,

Mitsubishi and Canon, the European electronic concerns Philips and Siemens, and two US companies, AT&T and Xerox.
2. Wang, Compaq, Seagate and CDC, four relatively small and specialized US dataprocessing firms, create a second strategic group.
3. Another regional 'cluster' is found for three technologically sophisticated large Japanese firms with a major interest in dataprocessing or closely related fields, namely Hitachi, NEC and Fujitsu.
4. Adjacent to both of these regional groupings we find a group of US and European dataprocessing companies, H-P, DEC, Unisys, Olivetti, NCR, Bull and Apple, that are somewhat 'found-in-the-middle', in the sense that their scores on size, diversification, and technology strategy are in between that of the other three groups mentioned above.

In addition, we observe two outliers, Amdahl, a US company recently acquired by Fujitsu and, more interestingly, IBM the by far largest yet rather specialized and technologically well developed company that seems to build a group of its own.

In the international telecommunications industry (see figure 3) we also find a number of groups of companies with different structural and behavioural characteristics:

1. The first strategic group consists of mostly diversified large companies with a minor interest in telecom. This cluster is of a 'triadic' character with the Japanese corporations Matsushita, Toshiba, Hitachi, Fujitsu and NEC; three European companies, Philips, GEC and Rockwell; and GTE and Motorola as US representatives.
2. Ericsson, Alcatel and Northern Telecom (NT) build a second group of specialized telecommunications firms with a rather strong position in the industry.
3. A third group of small telecom specialists, with no apparent advanced technology strategy, is dominated by the European firms, STC, Nokia, Matra, Sagem, Racal and Ascom; in this cluster we also find two Japanese firms, Ricoh and OKI, that are found to be very similar in their corporate characteristics.
4. Two leading IT firms, Siemens and IBM, form a different strategic group for which they share in particular their overall size and their level of technological sophistication.

As with the dataprocessing industry we find one company to take a very special place in the industry, in this case AT&T stands out as a separate 'group' distinguishing itself from others in terms of its size in telecommunications and its technological strength.

Although the pattern of group formation in the microelectronics industry (see figure 4) does not show either a particular 'outlier' nor a truly international group of firms, as is the case in the other two international sectors, the pattern of group differentiation is still somewhat similar in terms of combinations of size, diversification and technology strategies followed by companies operating in this field:

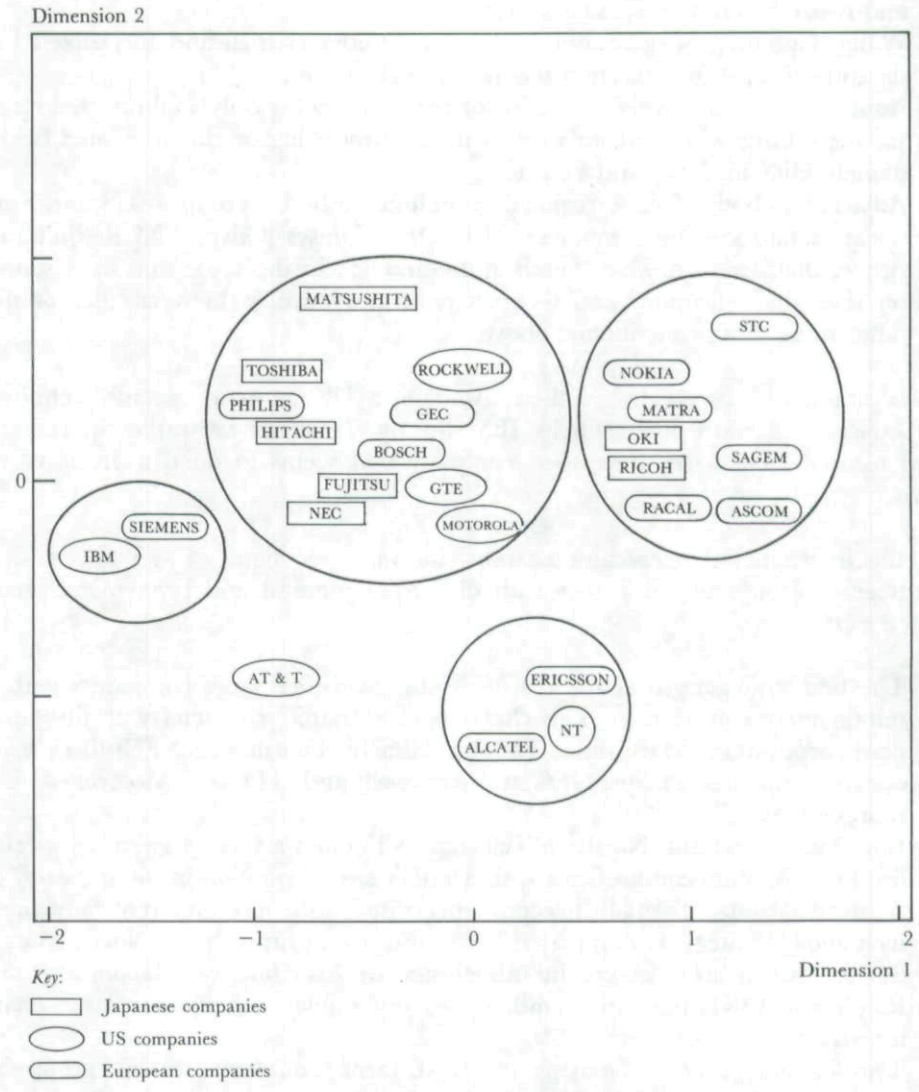

Figure 3. Strategic groups in the international telecommunications industry

1. At the bottom of figure 4 we see an Asian cluster, consisting of OKI, Sharp, Mitsubishi, Sony and Sanyo from Japan and Samsung from South Korea. These companies can be characterized as diversified electronics companies with minor interests in microelectronics and no strong commitment to a state-of-the-art level of technological sophistication.
2. AT&T and Phillips form a separate pair of two large, technologically sophisticated, companies with a relatively small interest in microelectronics.
3. In between these two groups we notice a group of five Japanese companies, i.e. NEC, Hitachi, Matsushita, Fujitsu and Toshiba, and Siemens from

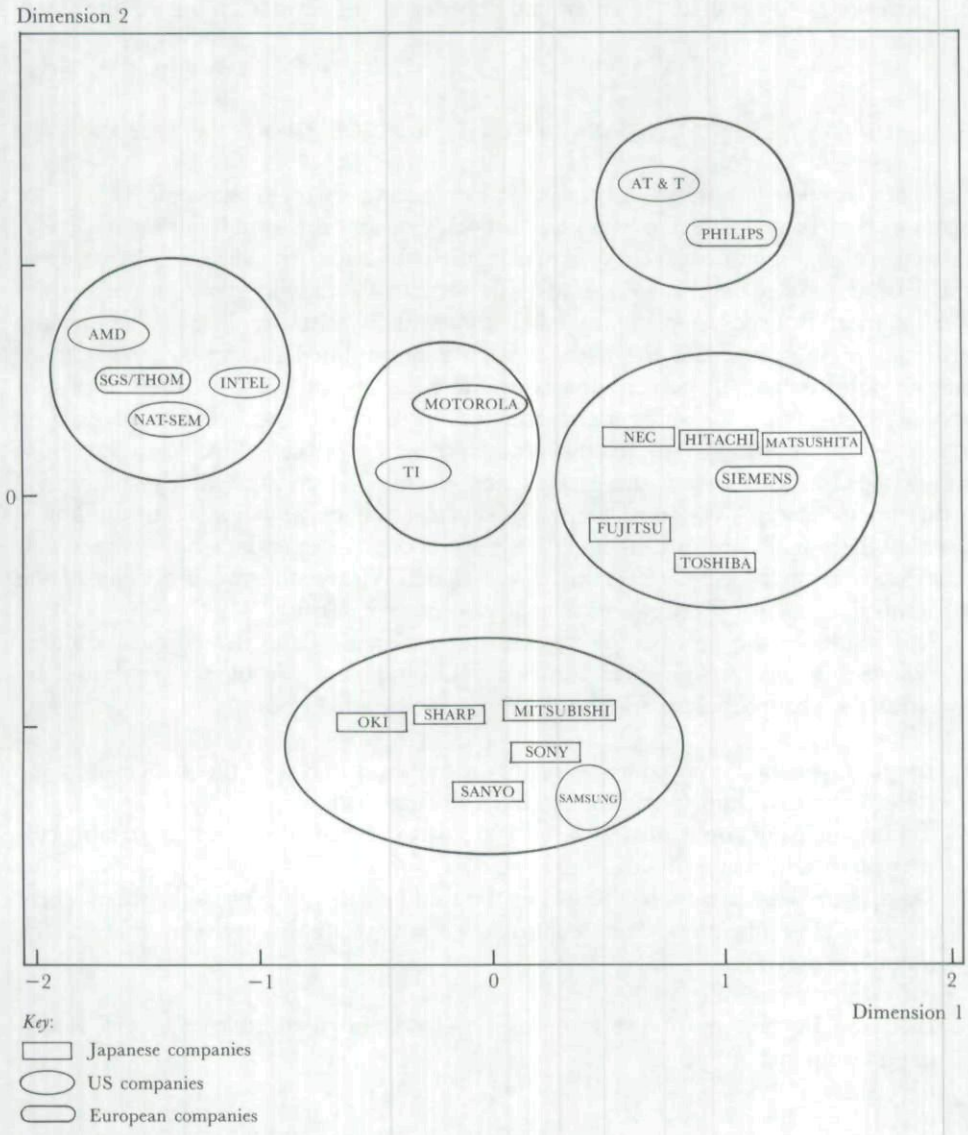

Figure 4. Strategic groups in the international microelectronics industry

Germany. All these firms are large, diversified and innovative companies.

4. A group of four small, specialized microelectronics companies is formed by AMD, Intel and National Semiconductors (Nat-Sem) from the USA and the European joint venture SGS/Thomson.
5. Two US companies are somewhat difficult to categorize: Motorola appears to share some characteristics with the fourth strategic group we identified; TI comes somewhat closer to the cluster of specialized microelectronics com-

panies. Both companies are, however, still quite different from these groups in terms of the size of the former and the degree of diversification of the latter company.

THE ANALYSIS OF NETWORKS OF STRATEGIC TECHNOLOGY PARTNERING

In order to detect patterns of strategic partnering through strategic blocks we apply a matrix permutation analysis.[2] To reveal the intra and inter-group relationships the original adjacency matrix, which describes the direct links between the various companies, is permutated in terms of strategic group membership. Permutation is used to bring together those firms that are located within the same strategic group. On the basis of such a permutated matrix we create a so-called 'density matrix', which describes the intensity of links between two sub-groups. Sub-matrix densities are calculated by dividing the number of existing alliances among sub-groups by the total number of possible links between those sub-groups. In this paper sub-groups are classified according to their strategic group membership. The next step is to reduce the density matrix to an image matrix where each group is assigned either a 0 or a 1 dependent on whether that particular group exceeds a certain cut-off value. We use the mean density of the full matrix as a cut-off criterion for each sub-matrix density.

The results of the network block densities for each of the three fields of information technology are given in tables I–III. In table I the blocks generated by the strategic group analysis for the dataprocessing industry are:

1. Large, diversified companies with only a modest interest in dataprocessing.
2. Relatively small and specialized dataprocessing firms.
3. Technologically sophisticated large firms with a major interest in dataprocessing or closely related fields.
4. Dataprocessing companies 'found-in-the-middle', in the sense that their scores on size, diversification, and technology strategy are in between that of the other three groups.
5. An outlier, Amdahl.
6. IBM the by far largest yet rather specialized and technologically well developed company.

Table I. Network block densities in the dataprocessing industry

Sub-matrix densities							*Image matrix**						
	1	**2**	**3**	**4**	**5**	**6**		**1**	**2**	**3**	**4**	**5**	**6**
1	0.03						**1**	0					
2	0.08	0.00					**2**	0	0				
3	0.19	0.08	1.00				**3**	1	0	1			
4	0.21	0.18	0.29	0.29			**4**	1	1	1	1		
5	0.33	0.00	0.33	0.14	–		**5**	1	0	1	0	–	
6	0.00	0.00	0.67	0.00	0.00	–	**6**	0	0	1	0	0	–

*Rule $y(i,j) = 1$ if $x(i,j) > 0.167$, otherwise 0.

Table II. Network block densities in the telecommunications industry

Sub-matrix densities						*Image matrix**					
	1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
1	0.64					**1**	1				
2	0.07	0.00				**2**	0	0			
3	0.15	0.42	0.04			**3**	0	1	0		
4	0.70	0.83	0.25	6.00		**4**	1	1	0	1	
5	1.20	0.00	0.00	1.00	–	**5**	1	0	0	1	–

*Rule: $y(i,j) = 1$ if $x(i,j) > 0.351$, otherwise 0.

Table III. Network block densities in the microelectronics industry

Sub-matrix densities							*Image matrix**						
	1	**2**	**3**	**4**	**5**	**6**		**1**	**2**	**3**	**4**	**5**	**6**
1	0.07						**1**	0					
2	0.00	1.00					**2**	0	1				
3	0.11	0.92	1.00				**3**	0	1	1			
4	0.58	1.13	1.13	2.67			**4**	0	1	1	1		
5	0.00	2.00	1.33	3.75	–		**5**	0	1	1	1	–	
6	0.50	1.50	0.67	1.75	2.00	–	**6**	0	1	0	1	1	–

*Rule: $y(i,j) = 1$ if $x(i,j) > 0.758$, otherwise 0.

In table II for the telecommunications companies there are five groups:

1. Diversified large companies with a minor interest in telecom.
2. Specialized telecommunications firms with a rather strong position.
3. Small telecom specialists, with no apparent advanced technology strategy.
4. Two leading IT firms, Siemens and IBM, sharing characteristics such as overall size and level of technological sophistication.
5. AT&T distinguishes itself from others in terms of its size in telecommunications and its technological strength.

In table III we find six groups in the microelectronics industry:

1. Diversified electronics companies with minor interests in microelectronics and no strong commitment to a state-of-the-art level of technological sophistication.
2. Technologically sophisticated companies with a relatively small interest in microelectronics.
3. Large, diversified and innovative companies.
4. Small, specialized microelectronics companies.
5. One company, Motorola, shares some characteristics with the fourth strategic group but it is of a larger size.
6. Lastly, TI comes somewhat closer to the group of specialized companies but it is more diversified.

In order to test the general hypothesis about the relevance of complementarity between partners, suggesting lower network densities for firms from the same strategic group than densities for complementary partnering blocks with members from different strategic groups, one simply has to consult the diagonal scores, i.e. the intra-block scores, and the other relevant combinations in tables I–III.

In the dataprocessing population (table I), with four groups and two outliers, two groups can be characterized as pooling blocks with above-average densities, two strategic groups have below-average densities. Four out of the six other relevant combinations also have an above-average network density although the density for the intra-strategic group networks is generally higher.

In telecommunications (table II), with four groups and one outlier, there are also two pooling blocks with above average densities and two strategic groups with little or no intra-group partnering. Here, three out of six combinations have an above average network density.

Table III demonstrates that of the four groups in microelectronics, ignoring the two outliers, three groups have a pooling tendency with above-average network densities. Also here we see that three out of six combinations demonstrate above-average network densities.

These figures show that both intra-strategic group partnering, suggesting pooling blocks, and inter-group partnering, suggesting primarily complementary blocks, are relevant. However, the network densities for intra-group partnering are somewhat higher than for the other combinations. So, the general hypothesis that partnering density within strategic groups is lower than the partnering density between strategic groups can be rejected.

Based on the analysis of strategic groups and the properties of different groups we can formulate two additional hypotheses about the expected network densities of complementary groups. In the above it was mentioned that technological and market complementarity are major motives for inter-firm partnering. In the strategic group analysis for the international information technology industry two different categories of firms feature clearly in each sector and they also differ significantly from each other and from the other groups. One of these strategic groups is that of the specialist firms that have specific traits in terms of technological sophistication or market niches that turn them into interesting partners for the other strategic groups. The other strategic group is that of the large diversified companies that due to their economies of scope and economies of scale are not only attractive partners for others but they also have the ability to choose partners from a wide variety of firms (Hagedoorn and Schakenraad, 1994). This suggests the following two hypotheses:

Hypothesis 2: Combinations of the group of specialist firms with other strategic groups will generate above-average network densities of inter-firm strategic technology partnering.

Hypothesis 3: Combinations of the group of large diversified companies with other strategic groups will also generate above-average network densities of inter-firm strategic technology partnering.

Table I generates the following results for the dataprocessing industry:

- For combinations with specialist firms (group 2) the majority of combinations, four out of five, show that network densities are below average.
- For both categories of large diversified industries (groups 1 and 3) the majority of combinations with other groups have an above-average network density, for group 1 the density of collaboration with one outlier is below average, for both groups the density of partnering with specialist firms is below average.

Table II for the telecommunications industry shows that:

- There are two groups of specialist firms (groups 2 and 3), for group 2 half of the combinations with other strategic groups have a below-average network density, for group 3 only one out of four combinations demonstrates an above-average density.
- For the group of large firms with a minor interest in telecom (group 1) two out of four combinations have an above-average density of strategic partnering.
- All combinations of the small group of large sophisticated companies (group 4), with the exception of the above-mentioned combination with specialist firms, are above average in their network density.

Lastly, from table III we learn that in the population of microelectronics firms:

- Combinations with specialist firms (group 4), with the exception of the combination of group 1, have high and above-average network densities.
- Apparently the group of large companies with a minor interest in this field and little technological sophistication (group 1) is not an interesting block for partnering as all densities are below average.
- The group of large technologically advanced companies with small interests in this sector (group 2) has above-average co-operation densities with most other groups with the exception of group 1.
- The group of large, diversified and innovative firms from group 3 has above-average network densities with three out of five combinations.

In other words, these results falsify the second and confirm the third hypothesis. With the exception of the microelectronics industry, specialist firms are in general not a major block of partners for other strategic groups. Apparently the group of large diversified companies with strong technological competencies is not only a major source of strategic partnering amongst themselves, this group is also to be seen as a complementary partnering group for most other strategic groups.[3]

DISCUSSION AND CONCLUSIONS

In the end, one of the questions we have to answer is not whether strategic groups can be empirically reconstructed, but whether they add something to our understanding of firm behaviour, corporate strategy and industry development. We have seen that the reconstruction of strategic groups in an international and multivariate setting generates interesting empirical results. The analysis of different strategic spaces in sub-fields of the international information technology industry demonstrates the possibility of grouping companies in a multi-dimensional setting of their structural and behavioural attributes. In the context of concrete competitor analysis it pictures the heterogeneity of industry structures and the variance in competitive positioning of companies. In that sense strategic group analysis in terms of categorization of companies enables us to present a 'mapping' of industries. Based on such statistical exercises the analysis of strategic groups can reveal the formation of groups of companies as well as indicate the role played by companies that are 'the odd ones out' and that do not fit within any strategic group. Further in-depth analysis of dimensional differentiation and the weighing of the importance of particular variables can contribute to our understanding of industry particularities. As far as further research is concerned, the introduction of a more dynamic perspective on changes in strategic groups can enrich our perception of transformations in industries.

Apart from this practical use in the context of the application of grouping techniques, the concept of a strategic group of companies *sui generis* has some, albeit limited, theoretical value for the understanding of industry heterogeneity. In their critical evaluation of strategic group analyses Barney and Hoskisson (1990) suggest that the group level of analysis should be abandoned altogether. However, in our opinion an attempt to expand the research agenda towards a mixture of understanding idiosyncratic, firm-specific, characteristics of companies and more general patterns in industries appears still worthwhile. At the firm level analysis the reconstruction of strategic groups can aid in isolating the idiosyncratic characteristics that create performance variance within larger groups of firms from the shared group characteristics. In that context it seems worthwhile to point at the dynamic and complex character of inter-firm competition where the dimensions of the strategic space and the 'rules of the game' do not only differ for separate industries but also change over time. For example, the process of internationalization of competition has different effects on a wide range of industries with both a time-related and a geographic component. Also, the dimensions of competition, say for technology-intensive industries *vis-à-vis* low-tech sectors and other product life-cycle related aspects, change both across industries and in time.

Resource-based-oriented approaches in strategic management could provide the wider context for the further understanding of the process of competition and corporate strategy. Behaviour aimed at creating innovative rents and competitive advantage to those companies that successfully pursue a disequilibrating strategy searching for competitive advantages, can create more useful insights to the process and structure of intra-industry competition. In that light it seems that the present attention paid to strategic groups as a cornerstone of strategic management-based analysis of industries is taking the matter somewhat too far. From a

theoretical perspective the concept can be seen only as one element amongst others in the attempt to further develop our understanding of homogeneity and heterogeneity in structures, strategies and performance of companies.

The recent growth in the attention paid to the link between inter-firm networking and strategic group participation merits further empirical and theoretical study. Our analysis of strategic groups and strategic partnering behaviour of firms, in a sector where inter-firm co-operation is so abundant, provides some mixed findings. Apparently both partnering within strategic groups and co-operation across different groups are relevant phenomena, in other words pooling blocks as well as complementary blocks play a role. Companies appear to weave a web of strategic partnerships around them with a wide variety of partners across the strategic space in which they are operating. The fact that intra-group partnering reaches somewhat higher levels of network density suggests that strategic partnering has some effect on the cohesion within strategic groups or vice versa. The present analysis, however, does not suggest the direction of causality in such a relationship.

Our analysis indicates that in particular strategic groups of diversified and technologically well developed companies build the core of the overall network of strategic technology partnering. Major characteristics of these companies are their international orientation, their economies of both scale and scope, and their technological strength. Their role is clearly one of a group of nodal companies, not only in terms of the density of their intra-group network but also in relation to other strategic groups. These large diversified companies are not only partners favoured by the other group members, they are also attractive partners for a wide variety of other companies. However, these networks of strategic partnering with companies from other strategic groups can also be re-interpreted in the sense that large diversified companies use their alliances with a number of companies through complementary partnering blocks to create leverage for their own technological and economic performance.

NOTES

[1] Stress values of the MDS solutions in this paper are very good:
- dataprocessing 0.04
- telecommunications 0.05
- microelectronics 0.05

[2] For a more extensive analysis of inter-firm networks in information technology and the positions taken by individual firms, see Hagedoorn and Schakenraad (1992) and Hagedoorn (forthcoming).

[3] For all the strategic groups with large, diversified firms that have a high degree of networking with other groups, the intra-group density is also above average; see group 3 in dataprocessing, group 4 in telecommunications, and groups 2 and 3 in microelectronics.

APPENDIX 1

Companies in the Population of Dataprocessing, Telecommunications, and Microelectronics Industries

	Dataprocessing	*Telecommunication*	*Microelectronics*
USA	Apple	AT&T	AMD
	AT&T	GTE	AT&T
	CDC	IBM	Intel
	Compaq	Motorola	Motorola
	DEC	Rockwell	Nat. Sem.
	H-P		TI
	IBM		
	NCR		
	Seagate		
	Unisys		
	Wang		
	Xerox		
Europe	Bull	Alcatel	Philips
	Olivetti	Ascom	Siemens
	Philips	Bosch	SGS-Thomson
	Siemens	Ericsson	
		GEC	
		Matra	
		Nokia	
		Philips	
		Racal	
		Sagem	
		Siemens	
		STC	
Japan	Amdahl	Fujitsu	Fujitsu
	Canon	Hitachi	Hitachi
	Fujitsu	Matsushita	Matsushita
	Hitachi	NEC	Mitsubishi
	Matsushita	OKI	NEC
	Mitsubishi	Ricoh	OKI
	NEC	Toshiba	Sanyo
	NTT		Sharp
	Toshiba		Sony
			Toshiba
Others		Northern Telecom	Samsung

APPENDIX 2

The Co-operative Agreements and Technology Indicators (CATI) Information System

The CATI data bank is a relational database which contains information on nearly 10,000 co-operative agreements involving some 3500 different parent companies. Systematic collection of interfirm alliances started in 1988. If available, many sources from earlier years were consulted enabling us to take a retrospective view. In order to collect interfirm alliances we consulted various sources, of which the most important are specialized journals which report on business events.

This method of information gathering which we might call 'literature-based alliance counting' has its drawbacks and limitations:

- In general we have only come to know those arrangements that are made public by the companies themselves.
- Newspaper and journals reports are likely to be incomplete, especially when they go back in history and/or regard firms from countries outside the scope of the journal.
- A low profile of small firms without well-established names is likely to have their collaborative links excluded.

Despite such shortcomings, which are largely unsolvable even in a situation of extensive and large-scale data-collection, we think we have been able to produce a clear picture of the joint efforts of many companies.

The data bank contains information on each agreement and some information on participating companies. The first entity is the inter-firm co-operative agreement. We define co-operative agreements as common interests between independent (industrial) partners which are not connected through (majority) ownership. In the CATI database only those inter-firm agreements are being collected that contain some arrangements for transferring technology or joint research. We also collect information on joint ventures in which new technology is received from at least one of the partners, or joint ventures having some R&D programme. Mere production or marketing joint ventures are excluded.

We regard as a relevant input of information for each alliance: the number of companies involved; names of companies (or important subsidiaries); year of establishment, duration and year of dissolution; field(s) of technology; modes of co-operation. Depending on the form of co-operation we collect information on equity sharing; the direction of capital or technology flows; the degree of participation in case of minority holdings; some information about motives underlying the alliance; the character of co-operation, such as basic research, applied research, or product development possibly associated with production and/or marketing arrangements.

The second major entity is the individual subsidiary or parent company involved in one (registered) alliance at least. We ascertain its nationality and we determine the main branch in which it is operating and classify its number of employees. In addition to this time-series for employment, turnover, net income, R&D expenditures and numbers of assigned US patents have been stored.

REFERENCES

AHARONI, Y. (1993). 'In search for the unique: can firm-specific advantages be evaluated?'. *Journal of Management Studies*, **30**, 31–49.

BARNEY, J. B. and HOSKISSON, R. E. (1990). 'Strategic groups: untested assertions and research proposals'. *Managerial and Decision Economics*, **11**, 187–98.

CAVES, R. E. and PORTER, M. E. (1977). 'From entry barriers to mobility barriers: conjectural decisions and contrived deterrence to new competition'. *Quarterly Journal of Economics*, **91**, 241–61.

COOL, K. and DIERICKX, I. (1993). 'Rivalry, strategic groups and firm profitability'. *Strategic Management Journal*, **14**, 47–59.

FIEGENBAUM, A. and THOMAS, H. (1993). 'Industry and strategic group dynamics: competitive strategy in the insurance industry, 1970–1984'. *Journal of Management Studies*, **30**, 69–105.

FIEGENBAUM, A., MCGEE, J. and THOMAS, H. (1987). 'Exploring the linkage between strategic groups and competitive strategy'. *International Studies of Management & Organization*, **18**, 6–25.

HAGEDOORN, J. (1993). 'Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences'. *Strategic Management Journal*, **14**, 371–85.

HAGEDOORN, J. (forthcoming). 'Strategic alliances in information technology among firms in Western industrialized nations'. In Peters, L.S. (Ed.), *International Issues in the Management of Technology*, vol. 10. Greenwich, CT: JAI Series on International Business Finance.

HAGEDOORN, J. and SCHAKENRAAD, J. (1992). 'Leading companies and networks of strategic alliances in information technologies'. *Research Policy*, **21**, 163–90.

HAGEDOORN, J. and SCHAKENDRAAD, J. (1994). 'The effect of strategic technology alliances on company performance'. *Strategic Management Journal*, **15**, 291–311.

HARRIGAN, K. R. (1985). 'An application of clustering for strategic group analysis'. *Strategic Management Journal*, **6**, 55–73.

HATTEN, K. J. and HATTEN, M. L. (1987). 'Strategic groups, asymmetrical mobility barriers and contestability'. *Strategic Management Journal*, **8**, 329–42.

KETCHEN, D. J., THOMAS, J. B. and SNOW, C. C. (1993). 'Organizational configurations and performance: a comparison of theoretical approaches'. *Academy of Management Journal*, **36**, 1278–313.

KUMAR, K. R., THOMAS, H. and FIEGENBAUM, A. (1990). 'Strategic groupings as competitive benchmarks for formulating future competitive strategy: a modelling approach'. *Managerial and Decision Economics*, **11**, 99–109.

MCGEE, J. and THOMAS, H. (1986). 'Strategic groups: theory, research and taxonomy'. *Strategic Management Journal*, **7**, 141–60.

MOWERY, D. C. (1988). *International Collaborative Ventures in US Manufacturing*. Cambridge, Mass.: Ballinger.

MYTELKA, L. K. (1990). *Strategic Partnerships in the World Economy*. London: Pinter.

NEWMAN, H. H. (1978). 'Strategic groups and the structure-performance relationship'. *Review of Economics and Statistics*, **60**, 417–27.

NOHRIA, N. and GARCIA-PONT, C. (1991). 'Global strategic linkages and industry structure'. *Strategic Management Journal*, **12**, 105–24.

OSBORN, R. N. and BAUGHN, C. C. (1990). 'Forms of interorganizational governance for multinational alliances'. *Academy of Management Journal*, **33**, 503–19.

PEHRSSON, A. (1990). 'Strategic groups in international competition'. *Scandinavian Journal of Management*, **6**, 109–24.

PORTER, M. E. (1985). *Competitive Advantage*. New York: The Free Press.

REGER, R. K. and HUFF, A. S. (1993). 'Strategic groups: a cognitive perspective'. *Strategic Management Journal*, **14**, 103–24.

THOMAS, H. and CARROLL, C. (1994). 'Theoretical and empirical links between strategic groups, cognitive communities, and networks of interacting firms'. In Daems, H. and Thomas, H. (Eds), *Strategic Groups, Strategic Moves and Performance*. New York: Elsevier Science, 7–30.

THOMAS, H. and VENKATRAMAN, N. (1988). 'Research on strategic groups: progress and prognosis'. *Journal of Management Studies*, **25**, 537–55.