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Inter-firm partnerships for generic technologies—the case of new materials[1]

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Abstract

In this contribution it is shown that networks of inter-firm technology cooperation in new materials are dominated by a number of leading multi-national companies. The increase of the number of cooperative agreements in the past decades has led to a complex configuration of inter-firm partnerships in which the generic character of new materials is reflected in the inter-sectoral pattern of alliances.

1. Introduction

In recent years a substantial number of studies and other publications on strategic alliances and inter-firm technology cooperation have been published; see Hagedoorn and Schakenraad [1] for an overview. In this paper we attempt to contribute to the empirical understanding of these phenomena with an analysis of strategic partnering in one particular field of technology. We will discuss some important features of inter-firm cooperation in the field of new materials technology, such as historical patterns in inter-firm technology cooperation and the configurations of concrete inter-firm linkages.[2] Two issues are central to this paper:

- we will demonstrate that inter-firm technology cooperation in new materials has increased in recent years, and
- we will analyse the relevant industry structural aspects of strategic technology partnering in networks of cooperating firms.

We have chosen the field of new materials because this field of technology can be characterized as generic, which due to its inter-sectoral background and state of early evolution appears an interesting field of inter-firm cooperation.

Before giving a short outline of this paper we will first briefly define these 'new materials'. Following Cohendet *et al.* [2] we prefer to understand new materials as 'new and improved materials', thereby broadening the scope to a relatively large set of 'high tech' materials. Throughout this paper we will take the groups of materials mentioned below to define the field of new materials:[3]

- electronic, magnetic and optical materials, in particular for the microelectronics and

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information technology industry, which largely comprise the group of so-called functional new materials;

- technical ceramics, i.e. materials that are formed at high temperature (± 800°C) from compounds containing, for example silicon, carbon, oxygen, nitrogen, aluminium, beryllium, titanium, boron;
- powder metallurgy, which not only applies to powder-producing operations in metals, but also to aggregation and sintering in ceramics;
- fibre-strengthened composite materials, made of two or more substances where the properties of the composites are superior to those of the individual components;
- technical plastics—chemical materials a number of whose combined properties satisfy particular requirements such as weight, modulus of rigidity, tensile strength, impact strength, melting point, elasticity, chemical inertness etc.
- new materials such as special metals and alloys, in particular serigraphic compounds, aluminium-lithium alloys and amorphous metals.

In this contribution we limit inter-firm cooperation to the analysis of technology cooperation, i.e. those forms of inter-firm collaboration for which joint development of new technologies and or agreements aimed at improved innovative performance are at least part of the agreement. In that context we define strategic alliances as those agreements that focus on a long-lasting effect on the product-market positioning of the participating companies.

In the following sections we will first present some historical developments of inter-firm cooperation in new materials in order to show how this phenomenon has gradually increased and how cooperation is distributed across different sub-fields of new materials. In the next section we will examine the relation between the size of firms, as a proxy of industry structure, and patterns of strategic partnering. A central exercise in this section is the study of patterns of inter-firm agreements for new materials with a multi-dimensional scaling technique and cluster analysis. It is also possible to identify the major cooperating companies, their position in international networks and their specific linkages to other companies.

2. Some general patterns of inter-firm technology cooperation in new materials

A general trend in the yearly introduction of new cooperative agreements in new materials as found in our Cooperative Agreements and Technology Indicators (CATI) data bank is given in Fig. 1. So far we have been able to collect information about approximately 700 agreements in new materials. Nearly 90% of these agreements have been established since 1980. During the past two decades there has been a gradual increase in new agreements up to the mid-1980s, with a sudden jump to over 100 new agreements per year in 1986 and 1987. In the most recent years we witness some levelling off in the increase of new agreements. Although it is still difficult to offer a complete

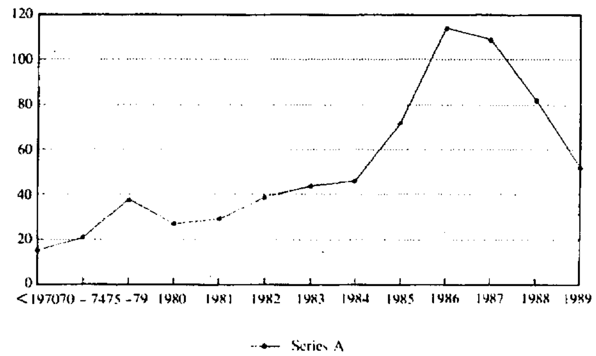

Fig. 1. The development of technology cooperation agreements in new materials; numbers of new agreements, yearly, 1989 first 9 months only. Source: MERIT–CATI data bank.

explanation for this 'stagnation', which is also found in other fields of technology [6], it could be that companies are becoming somewhat more concerned about the costs and benefits of alliances and take a slightly more careful attitude towards the formation of alliances. This somewhat more cautious behaviour could affect the number of new alliances.

In Fig. 2 we see the distribution of technology cooperation agreements in a number of sub-fields of new materials. Technical ceramics is the largest group of new materials, as far as inter-firm cooperation is concerned, with a share of over 25%, followed by technical plastics, and electronic, magnetic and optical materials. Fibre-strengthened composite materials, powder metallurgy and special metals and alloys make up the three smaller groups of new materials in our database. A more detailed overview of trends for each sub-field is presented in Appendix 2. There we note that, with the exception of special metals, very few agreements were forged in the years before 1974. In those 'early' years most agreements were related to special metals and powder metallurgy. In the second half of the 1970s electronic materials and technical ceramics (both over 26%) and powder metallurgy (over 20%) took a large share of all agreements in new materials. This distribution changed considerably during the first half of the 1980s when

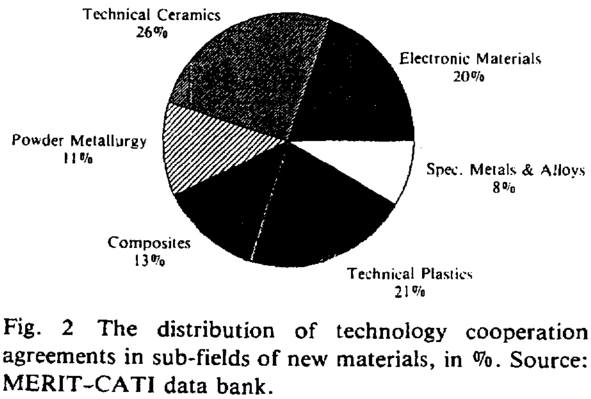

Fig. 2 The distribution of technology cooperation agreements in sub-fields of new materials, in %. Source: MERIT-CATI data bank.

technical plastics (over 25%) and electronic materials (over 20%) were major fields of cooperation. Since 1985 over 70% of all alliances in new materials have been found in what have become the three major areas of cooperation: technical ceramics (over 30%), and technical plastics and electronic materials (each about 20%).

3. Industry structure and technology cooperation in new materials

As with so many new fields of technology or new industries it is difficult to find reliable statistical information on emerging industrial structures. Due to its generic character, the somewhat unclear definition of the field itself and its close ties to a number of established industrial sectors, this is particularly true for new materials. Nevertheless, a number of features of the industrial structure related to new materials emerge from the growing body of literature on this new field of industrial activity.[4] In many sub-markets of new materials large, diversified and integrated materials companies appear to be able to play a major role, in particular in high volume markets due to the effects of economies of scale. On the other side of the spectrum, small and medium sized companies can play a role in some low volume niche markets, such as in specialty materials, and in those design-oriented areas where small research-intensive firms can play a leading role as innovators.

In technical ceramics the industry structure is characterized by, on the one hand, medium sized and large companies diversifying from traditional ceramics and, on the other hand, a number of large, diversified and often vertically integrated companies from the (petro-) chemicals, steel, electronics and the automobile industries. For electronic materials the leading companies are particularly the large, diversified electronic companies that produce these materials for their captive consumption, as well as a small number of chemicals producers. In technical plastics and composites the group of large chemical companies play a prominent role, also because many of these firms have recently acquired smaller specialized downstream firms in order to capitalize on the higher value of finished products. In powder metallurgy and special steels a number of traditionally leading steel companies are the most important producers. Many of these companies are gradually diversifying towards multi-materials manufacturers that produce complex alloys, composites, ceramics and the like. In other words, the impressionistic literature on this subject suggests that the industry structure of new materials is to a large extent dominated by many leading multinationals that originate from a small number of related industries such as electronics, chemicals, automobiles, steel and machinery.

If such a multi-sectoral and diversified industrial structure with a dominance of large companies really exists for new materials, we might expect to find this general pattern reflected in the structure of strategic partnering. In particular, if this field of new materials is emerging from a diverse number of industries, on both the user and the supplier side, we can expect a variety of major cooperating companies from different sectors.

A first impression of the relevant industry structure according to the size-distribution of cooperating companies in new materials is given in Table 1. There we introduce a classification of size classes which is somewhat different from ordinary classifications but which we expect to be useful in particular in the international context (see also Hagedoorn [9]). Here, we take firms with up to 500 employees to be small companies, companies with 500 to 5000 employees as medium-sized, those with between 5000 and 50 000 employees as large companies, and very large companies as those employing over 50 000 people. As shown in Table 1 nearly 700 companies in our data bank are engaged in technology cooperation in new materials. About one-third of these companies are relatively small. Both medium-sized and large companies each reach about a quarter of all companies and over 15% of this population belongs to the group of very large companies with over 50 000 employees. It has to be stressed that this distribution of cooperating companies is fairly different from the ordinary distribution of size classes in manufacturing in most advanced capitalist economies, as it is well known that in most countries over 95% of the total population of companies in manufacturing employ less than 500 people.[5]

TABLE 1. Distribution of companies with cooperative agreements in new materials

Company size	Companies in size category		Share with two or more alliances
	No.	%	
≤500	227	33.2%	14.1%
500–5000	167	24.4%	18.0%
5000–50 000	183	26.8%	50.8%
>50 000	107	15.6%	72.0%
Total	684	100.0%	33.9%

Source: MERIT–CATI data bank.

In Table 1 we also present information on firms that are cooperation-oriented in the sense that they have more agreements than the odd one which might have been established occasionally. From Table 1 we learn that on average one-third of the cooperating companies have at least two alliances. In the groups of small and medium-sized firms only 14% and 18% of the population respectively have these two or more agreements. Over half of the group of large companies and nearly two-thirds of the group of very large companies have two or more agreements. All in all, the figures from Table 1 suggest that there is little doubt that there is a positive relation between the degree of cooperation by companies and their size.

In order to take the analysis somewhat further, in particular to an understanding of networks of collaborating firms in new materials, we will apply a number of analytical techniques. First, a non-metric multi-dimensional scaling (MDS) technique will be used to give an overview of the network structure.[6] We already introduced such an MDS technique in previous work [1, 6]. Second, a cluster analysis will be applied to detect groupings of collaborating firms. Third, we will present a more structural analysis of network density and ranking orders for the group of most cooperating firms. The emphasis in the following will be in particular on changing networks during the 1980s.

MDS solutions are presented for two periods: 1980–1984 and 1985–1989. For the first period (1980–1984) we have taken alliances established in that particular period plus those alliances made before 1980 that were not already discontinued in 1980. For the second period, the years since 1985, we follow the same procedure; we have taken all alliances forged in that period and added those alliances from the earlier period which were not already discontinued in 1985.

During each period alliances of subsidiaries and divisions are assigned to the parent company. Also within each period, the still existing alliances of companies taken over by others or partnerships made by merging companies will be assigned to the acquiring company or the new corporation. For an explanation of company codes we refer to Appendix 3.

The same similarity data were used for a cluster analysis. The objective of this analysis in our study is simply to cluster firms into groups on the basis of the numbers of alliances between them. The result is a series of clusters comprising intensely cooperating companies. The particular technique employed here is called hierarchical cluster analysis (see Everitt [11]). Clusters are formed by grouping firms into small but highly cohesive clusters, a procedure which is repeated in several rounds until all firms are members of a single cluster. The basic characteristic of hierarchical clustering is that once a firm is a member of a cluster, it remains part of that cluster. As the term suggests, each cluster is embedded within a larger cluster. At the one extreme, the 'network' can be seen as comprising 45 clusters which all contain only one firm, while at the other extreme the network can be seen as one cluster having all 45 firms in it. It is obvious that we are interested in some intermediate level of clustering. We show a summary of the results in Table 2 and discuss them together with the MDS solutions.

The structure of cooperation in new materials technologies in the two periods is illustrated in Figs. 3 and 4. These two-dimensional pictures are the result of the non-metric scaling procedure described above. The goodness-of-fit values for both periods amount to 0.01 and 0.05, which are generally seen as acceptable values; values lower than 0.02 are accepted as excellent. On the basis of these values we can picture two-dimensional solutions; for substantially higher stress-values, three- or more dimensional solutions would be required.

To improve interpretation it is possible to draw lines between companies. We have drawn lines between every pair of companies for which the number of strategic links exceeds some threshold value. A very thick solid line indicates very strong cooperation (four strategic alliances or more), thick lines indicate that three alliances were registered, normal lines stand for moderate cooperation (two agreements), while dashed lines represent one strategic link. The position of companies which are not connected to other companies through lines, however, is by no means merely peripheral: rather, their agreements are spread over companies not belonging to the top 45 of the most collaborating firms.

Cluster analysis applied to the links between the 45 most collaborating companies in the first half of the eighties results in five completely isolated clusters: a Swedish and a German cluster, one American and two largely Japanese groups (see Table 2 and Fig. 3). The six Swedish companies, located at the upper right-hand, have forged alliances to engineer

TABLE 2. Results of cluster analysis of cooperation in new materials in two periods

1980–1984 (Fig. 3)	Five largely geographically concentrated clusters: • a Swedish cluster (Nyby, Asea, Volvo etc.) • a German one (VW, Daimler, Flick etc.) • two isolated Japanese clusters around Mitsui and Mitsubishi • a largely US cluster separated in two sub-groups, one with Corning ELF and Toray, another with TRW, GTE, IBM, etc. • the Ferruzzi–Hercules couple
1985–1989 (Fig. 4)	Three predominant blocks: • a Swedish/German block (ABB, Volvo, VW, Daimler, Flick etc.) • a U.S. block (IBM, TRW, GTE, Litton, Chrysler, Du Pont, Ford etc.) • a miscellaneous block, consisting of four groups: – a largely Japanese cluster with Nissan, Kawasaki, Mitsubishi, Nippon Steel, Asahi, Ishika-Wajima, Hitachi and BP – a second mainly Japanese cluster with Mitsui, Allied-Signal, Kyocera, Enimont, Arco, Toshiba – a quartet with Sumitomo, Toray, BASF, Degussa – a U.S./European group: with Thomson, Saint Gobain, Corning, Hoganas and GE

ceramics for engines (Volvo and Asea) or to cooperate on ferrochrome (Volvo, Scandust, Boliden and SKF). Asea and Nyby agreed to develop a powder products manufacturing process and created a joint venture for their powder products. In the neighbourhood of the Swedish cluster we find seven German companies which were partners in a thermomechanical ceramics programme in the mid-1980s, where ceramics engineering firms, motor manufacturers and parts suppliers cooperated in order to replace metals and alloys in engines.

On the left-hand side of Fig. 3 we find a cluster containing amongst others 10 American firms, such as IBM, Du Pont and Celanese, all of which participated in the so-called Optical Circuitry Cooperative, created in 1984 and discontinued in 1986. One of its primary goals was to apply materials R&D in super optical computers. The other, smaller half of the cluster is centred around the Japanese company Toray. This firm has tied up with Du Pont and ELF for fibres, and it has a joint venture with Corning Glass Works in the field of basic materials for the silicon industry.

A careful look at the 'Japanese' block at the bottom of Fig. 3 reveals two isolated clusters, each of them concentrated around one large conglomerate. The first one, Mitsubishi, together with Fuji Electric, Fujitsu, Kawasaki, Ishika-Wajima and Nissan's subsidiary NAE, created a research corporation to perform R&D on advanced composites and alloys, e.g. used to reduce the weight of rocket-motor casings. Mitsubishi also made investments in Asahi Glass Co. The second conglomerate, Mitsui, teamed up with Toshiba and Allied for amorphous metals and it formed GEM Chemicals Ltd. with GE Plastics. Its partners in Alumax Inc. are Amax and Nippon steel, and finally, Mitsui's subsidiary Kanto Denka Kogyo cooperates with Hoganas from Sweden on the technical development and marketing of magnetic oxide powders.

The only remaining 'cluster' is the Hercules–Ferruzzi combine. In 1982 Ferruzzi's Montedison and Hercules of the U.S. created a joint

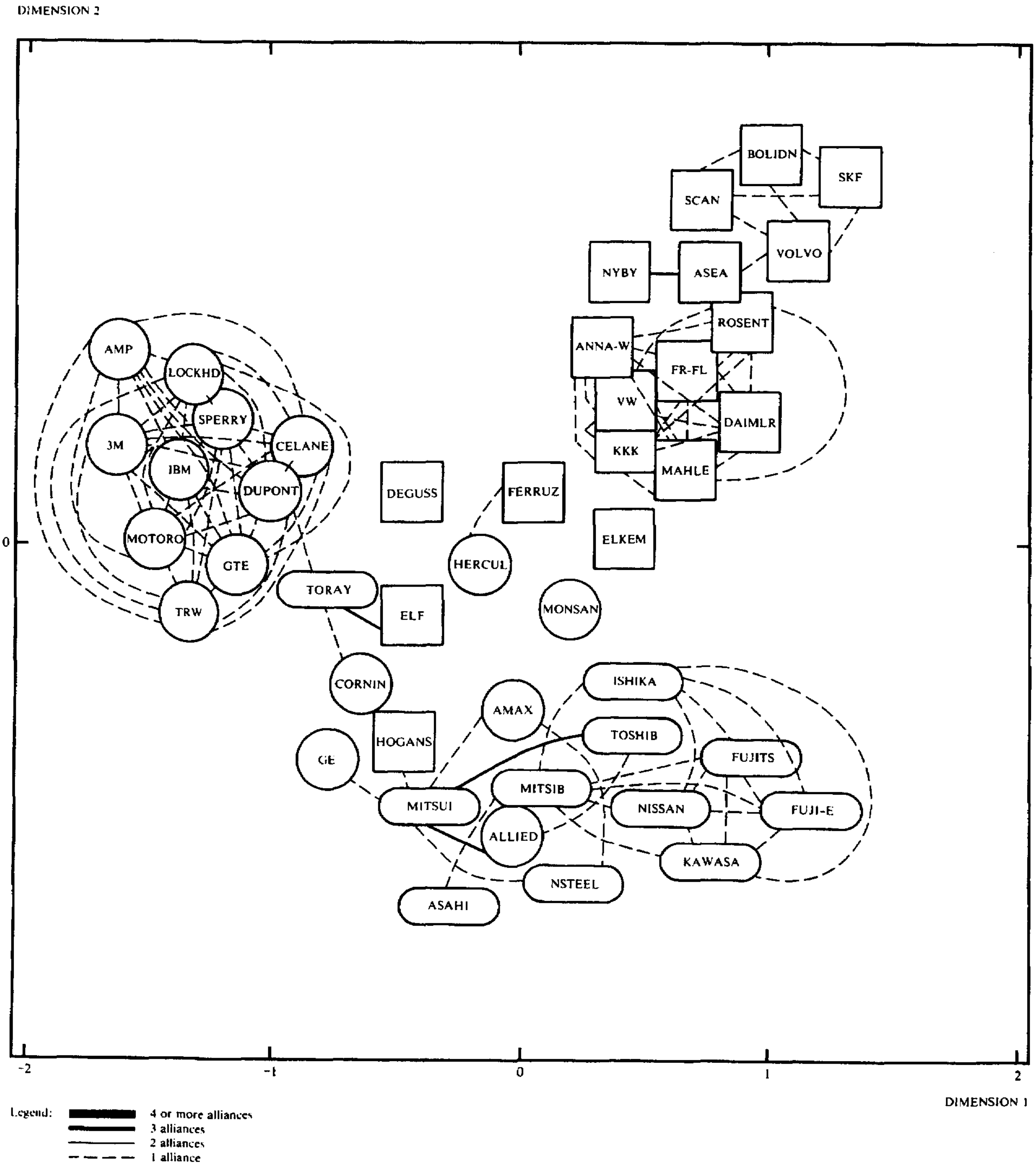

Fig. 3. The structure of strategic technology partnering in new materials technologies, 1980–1984.

venture, Himont, to handle some chemicals fibres and composites businesses. In 1987 Ferruzzi decided to buy out its partner and put Himont in a new, large joint venture with state-owned ENI, called Enimont.

Turning to the next period we still see the Swedish, German, American and Japanese blocks but they have become more or less interlocked (see Fig. 4). Cluster analysis reveals three predominant blocks: a Swedish/German, an American and a miscellaneous group with four sub-groups, often concentrated around Japanese companies.

The 10 members of the recently abandoned Optical Circuitry research venture mentioned before occupy the upper right corner of the picture and together with Litton, Chrysler and Ford represent an American cluster.[7] Three of its former members, IBM, Du Pont and Hoechst Celanese gained access to other clusters. IBM teamed up with Toshiba (for large-scale colour LCD technology) and invested in a small promising fibre optics company, named PCO, majority owned by Corning Glass Works. Du Pont, Litton, Chrysler and Kraus-Maffei (a firm of the Flick concern) together with others established a research centre for composite materials technology. Du Pont continued its link with Toray and started a joint venture with Mitsubishi for the production of a key material for polyamide products. Hoechst Celanese signed a tripartite agreement with BASF and Toray to exchange carbon fibre technology.

Especially due to efforts of Volvo and Flick, the previously isolated Swedish and German groups mingled during the second half of the 1980s. Volvo, VW and four other car makers created a research group aimed at pre-competitive R&D on ceramics and fibre optics. Volvo, SKF, Boliden, Sandvik, Kemanobel (majority owned by Flick) joined ABB Cerama. Volvo Flygmotor started a research program with Ishika-Wajima for tungsten-reinforced super-alloys.

The miscellaneous block at the bottom of Fig. 4 can be split into four sub-groups; see also Table 2 for the results of cluster analysis. First of all, there is a predominant Japanese cluster with Nissan, Kawasaki, Mitsubishi, Nippon Steel, Asahi Glass, Ishika-Wajima, Hitachi and BP. Here a very popular item for collaboration is ceramics, e.g. ceramics for diesel and gas turbine engines, catalytic converters, compounds, and refractory bricks. The second cluster appears to be dominated by Mitsui and Toshiba and has Allied-Signal, Kyocera, Enimont and Arco as its members. Resins, catalysts and special metals are also frequently occurring topics for collaboration. Next, we find a small, yet heterogeneous, group with Sumitomo, BASF, Toray and Degussa, working on high tech biomaterials, magnets and fibres. Finally, an American–European group can be distinguished with Thomson, Saint-Gobain, Corning, Hoganas and GE cooperating on subjects such as glass fibres and ceramics.

Looking at the network as a whole it is obvious that many of the well-known multinational companies from a small number of industrial sectors such as chemicals, electronics/information technologies, steel, transportation and machinery play a leading role in strategic technology cooperation. In particular we notice the strategic positions of ABB, Volvo, Flick, Du Pont, IBM and a number of Japanese conglomerates. Analysis of separate sub-fields of new materials, not presented in this paper, would reveal that for each sub-field a number of large, but somewhat less diversified, companies and a group of specialized companies also play a role of significance.

After these impressions of networks for new materials and the changes in these networks we will elaborate on these networks in a more structural way. To give an indication of the stability over time of the top 45 of most cooperating firms in new materials, we computed a rank correlation coefficient. It appeared that 29 firms belonging to the top 45 in the first period were still present at the top in

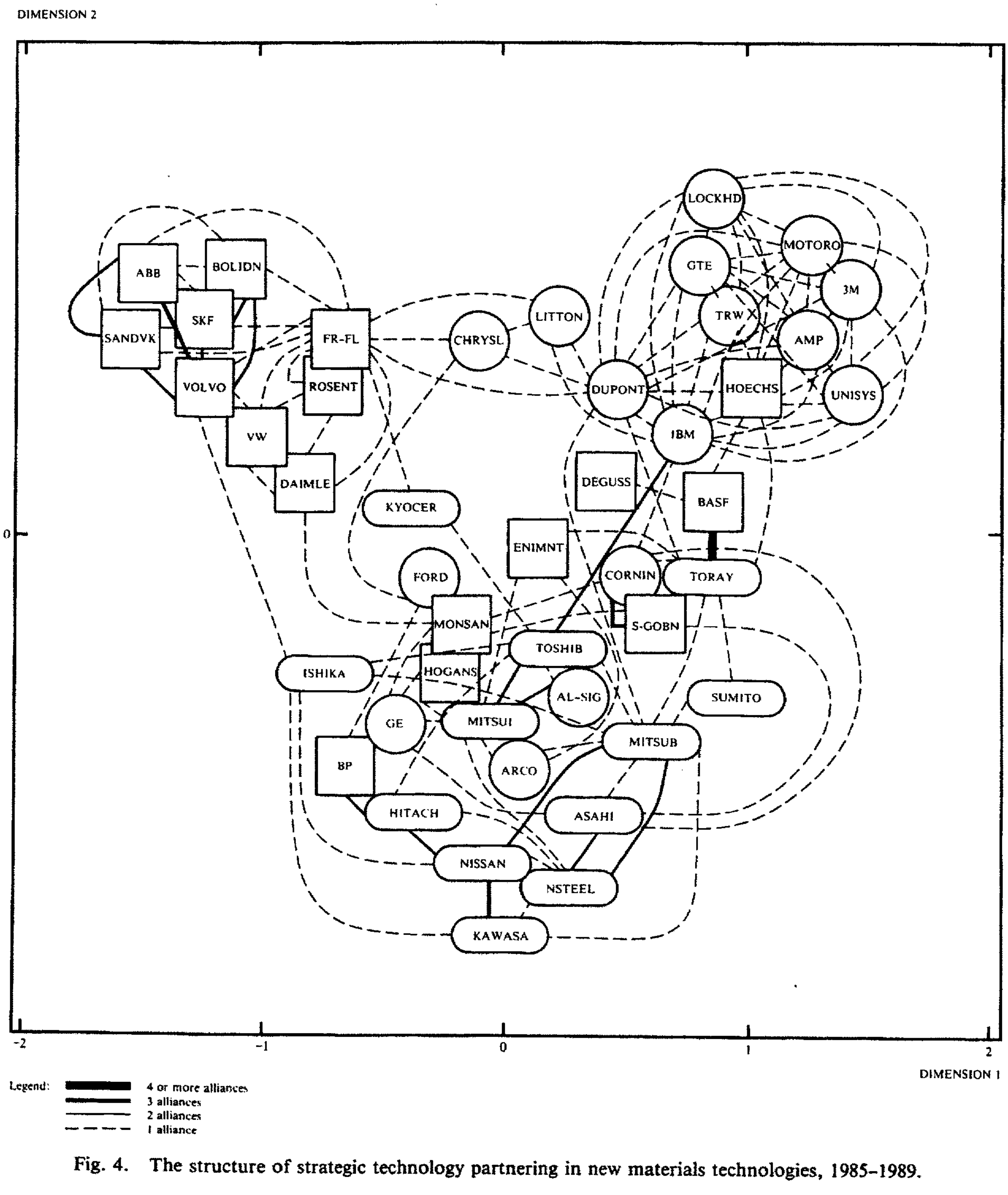

Fig. 4. The structure of strategic technology partnering in new materials technologies, 1985–1989.

TABLE 3. A comparison of some network aspects for the top 45 most cooperating firms in new materials

MDS stress value		Network density		Rank correlation 1980-84 and 1985-89		
1980–1984	1985–1989	1980–1984	1985–1989	n	(% of 45)	r
0.01	0.05	10%	12%	29	66%	0.38*

* Not significant at 0.05 level.

the next period. However, the correlation between their rankings turned out not to be significant (see Table 3). In other words, although the proportion of 'stayers' was rather high (nearly 70%) considerable shifts took place within their ranking.

To uncover some aspects of structural centrality of a network we also computed a network density index. This index is defined as the ratio of the actual number of lines (k) to the possible number of lines $n(n-1)/2$, where n denotes the number of points in the network. The network density in new materials technologies increased slightly from 10% in the first half of the 1980s to 12% in the second half (see Table 3). This means that in the years starting with 1985 only 12% of all theoretically possible links between the 45 firms were empirically observed. In other words, one cannot describe technology cooperation in new materials in terms of an intensive and dense network, which is largely due to the variety of sub-fields of new materials with companies from a very diffuse background.

Finally, in Table 4 one can find the top 10 of the most collaborating firms and their number of links in two periods. Corning leads the list for new materials during the first half of the 1980s with 11 links; Mitsubishi leads the second half with 26 links. It is clear that these top-collaborating companies are amongst the leading firms in chemicals, information technologies and equipment manufacturing. The most striking feature of the comparison of the first with the second half of the 1980s is the predominant role that Japanese companies appear to be taking. As we can see there were no Japanese companies amongst the leading 'cooperators' in new materials during the first half of the 1980s. This situation, however, has changed dramatically during the second half of the 1980s when four Japanese joined the group of most cooperating companies, being well represented in the top of Table 4. Furthermore, all the leading companies of the first half of the 1980s were U.S. firms; in the second half of the past decade we find 'only' four U.S. companies among the top 10 of cooperating firms in new materials.

TABLE 4. A comparison of the top 10 of firms with most strategic links for new materials

Position	1980–1984		1985–1989	
1	Corning	(11)	Mitsubishi	(26)
2	Celanese	(10)	Nippon S.	(23)
3	Du Pont	(10)	Corning	(21)
4	GTE	(10)	Du Pont	(21)
5	AMP	(9)	Toshiba	(21)
6	IBM	(9)	Toray	(20)
7	Lockheed	(9)	Fr.Flick	(18)
8	3M	(9)	Volvo	(17)
9	Motorola	(9)	Hoechst	(16)
10	Sperry	(9)	ABB	(14)
	TRW	(9)	IBM	(14)
			3M	(14)

Source: MERIT-CATI data bank.

4. Conclusions

Our analysis of trends and patterns in inter-firm technology cooperation in new materials has demonstrated amongst other things that this phenomenon apparently gained in importance during the last couple of decades, although its growth has somewhat levelled off during the last couple of years. This trend reflects the importance that strategic partnering is playing in corporate behaviour in changing industry structures as influenced by technological development. In new materials this development is in particular shown in technology cooperation in a number of sub-fields such as electronic materials, technical ceramics and technical plastics.

Although new materials can be described as an emerging core technology with a generic character, it is clearly embedded in a number of adjacent fields of technology, such as information technologies, chemicals and mechanical engineering. Strategic partnering by leading companies from a number of industries reflects the intra-sectoral character of this technological area. It can be expected that this inter-firm cooperation is part of the strategies of many firms to cope with the present technological changes through inter-firm cooperation which creates a piecemeal strategic response to these complex transformations.

If we consider the pattern of inter-firm partnering in new materials, it emerges that there is not yet a true globalization of strategic partnering. The network of worldwide cooperation demonstrates a low level of density, although it is increasing, and most of the clusters we found are of 'regional' character. Nevertheless, partnering in new materials is also characterized by a dominant appearance of large, multi-national companies which illustrates the international and, to a certain extent, worldwide character of strategic partnering. This scene of international alliances is governed by firms from the U.S.A. and Europe, with an increasing importance for the role being played by Japanese companies.

Acknowledgement

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Notes

[1] This paper is one of a series of papers in a research project on 'Inter-company Cooperation and Technological Development' at MERIT. This research focuses on the empirical analysis of changes in industry structures and global trends in different modes of inter-firm agreements in a large number of fields of technology. It also addresses theoretical questions in this field of research as well as methodological issues concerning applied network and multivariate analysis of strategies and industry structures. Empirical analysis is based upon the CATI database which contains information on several thousands of worldwide cooperative agreements and the companies involved.

[2] Our findings are partly based on our CATI data bank which, at present, contains information on nearly 10 000 cooperative agreements in a large number of technologies and several thousands of participating companies (see also Appendix 1).

[3] The following overview is based in particular on Cohendet *et al.* [2], Royal Swedish Academy of Engineering Sciences [3], Roobeek [4] and van den Berg *et al.* [5].

[4] This general description of the industry structure is largely based on information from Cohendet *et al.* [2], OTA [7] and van Tulder and Junne [8].

[5] We expect that our data bank has a certain bias in the sense that we lack information on cooperation in which smaller and less well-known companies are participating.

[6] MDS is a data reduction procedure comparable to principal component analysis and other factor analytical methods (see also Kruskal and Wish [10]). One of the main advantages of MDS is that it can fit an appropriate model in fewer dimensions than can factor analytical methods. This increases the possibility of facile interpretation of two-dimensional pictures. MDS offers a scaling of similarity data into points lying in an X-dimensional space. The purpose of this method is to provide coordinates for these points in such a way that distances between pairs of points fit the observed similarities as closely as possible. 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.

The total number of strategic partnerships between two companies is taken as a measure of similarity between those two companies. A large similarity, as found in a similarity matrix, indicates intensive cooperation. These similarity matrices are not reproduced in this paper. Unfortunately our MDS software can only analyse similarity matrices to a maximum of 45 rows, which means that each analysis is restricted to a maximum of 45 companies with the largest numbers of strategic partnerships.

[7] In comparison with the previous period some formal changes have taken place: Hoechst acquired Celanese and renamed it Hoechst Celanese; Sperry merged with Burroughs into a new corporation called Unisys.

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Appendix 1: The Cooperative Agreements and Technology Indicators (CATI) information system

The CATI data bank is a relational database which contains separate data files that can be linked to each other and provide (des)aggregate and combined information from several files. So far information on nearly 10 000 cooperative agreements has been collected. Major sources for our data bank are newspaper articles, books dealing with the subject and, in particular, specialized technical journals which report on business events as well. This method of information gathering has its drawbacks and limitations:

- in general only those agreements that companies make public are published;
- newpaper and journal reports are likely to be incomplete, especially when they go back in history and/or regard firms from countries lying outside the scope of the journal;
- a low profile of small firms without well-established names is likely to have them excluded;
- another problem is that information about the dissolution of agreements is generally not published.

Despite these shortcomings, which are largely unsolvable, we think we have been able to produce a data bank which enables us to perform empirical research which goes beyond case studies or general statements.

Our data bank contains information on each agreement and some information on companies participating in these agreements. First of all, we define cooperative agreements as common interests between independent partners which are not connected through (majority) ownership. In the CATI information system only those inter-firm agreements are being collected that contain some arrangements for transferring technology or research. Joint research pacts, second-sourcing and licensing agreements and research corporations are clear-cut examples. 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.

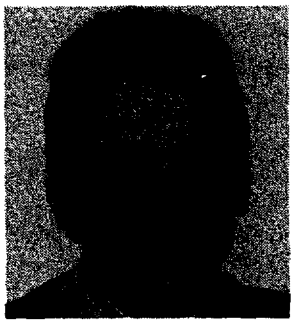
Appendix 2: Technology cooperation agreements in sub-fields of new materials[a]

	Electronic materials	Technical ceramics	Powder metallurgy	Composites	Technical plastics	Special metals and alloys	Total
1974	6 16.7% 4.4%	3 8.3% 1.7%	7 19.4% 8.9%	5 13.9% 5.4%	5 13.9% 3.4%	10 27.8% 17.2%	36 100.0% 5.2%
1975–1979	10 26.3% 7.4%	10 26.3% 5.6%	8 21.1% 10.1%	4 10.5% 4.3%	2 5.3% 1.4%	4 10.5% 6.9%	38 100.0% 5.5%
1980–1984	38 20.5% 28.1%	32 17.3% 18.1%	28 15.1% 35.4%	30 16.2% 32.6%	49 26.5% 33.3%	8 4.3% 13.8%	185 100.0% 25.9%
1985–1989	81 18.9% 60.0%	132 30.8% 74.6%	36 8.4% 45.6%	53 12.4% 57.6%	91 21.2% 61.9%	36 8.4% 62.1%	429 100.0% 62.4%
Total	135 19.6% 100.0%	177 25.7% 100.0%	79 11.5% 100.0%	92 13.4% 100.0%	147 21.4% 100.0%	58 8.4% 100.0%	688 100.0% 100.0%

[a]Data are presented for four sub-periods and for 1974–1989 as a whole. In each case the first value shows the absolute number of agreements recorded, the second indicates the percentage this represents of all agreements recorded in that sub-period, and the third the percentage it represents of all agreements in the materials sub-field concerned over the entire period studied.
Source: MERIT–CATI data bank.

Appendix 3: List of company codes

Code	Company's full name	Country	Code	Company's full name	Country
3M	Minnesota Mining & Mfg. Co. (3M)	U.S.A.	HOGANS	Hoganas A.B.	Sweden
ABB	ABB Asea Brown Boveri A.G.	Switzerland	IBM	Int. Business Machines Corp. (IBM)	U.S.A.
ALLIED	Allied Corp.	U.S.A.			
AMAX	American Metal Climax (AMAX)	U.S.A.	ISHIKA	Ishika-Wajima Harima Co. Ltd.	Japan
AMP	AMP Inc.	U.S.A.	KAWASA	Kawasaki	Japan
ANNA-W	Anna Werke	F.R.G.	KKK	Kuhnle, Kopp & Kausch A.G.	F.R.G.
ARCO	Arco (Atlantic Richfield Co.)	U.S.A.	KYOCER	Kyocera	Japan
ASAHI	Asahi Glass Co.	Japan	LITTON	Litton Industries Inc.	U.S.A.
ASEA	Asea A.B.	Sweden	LOCKHD	Lockheed	U.S.A.
BASF	Basf A.G.	F.R.G	MAHLE	Mahle	F.R.G.
BOLIDN	Boliden A.B.	Sweden	MITSUB	Mitsubishi Corp.	Japan
BP	British Petroleum	U.K.	MITSUI	Mitsui & Co.	Japan
CELANE	Hoechst Celanese Corp.	U.S.A.	MONSAN	Monsanto Co.	U.S.A.
CHRYSL	Chrysler Motor Corp.	U.S.A.	MOTORO	Motorola Inc.	U.S.A.
CORNIN	Corning Glass Works	U.S.A.	NISSAN	Nippon Steel Corp.	Japan
DAIMLR	Daimler-Benz A.G.	F.R.G.	NSTEEL	Nippon Steel Corp.	Japan
DEGUSS	Degussa A.G.	F.R.G.	NYBY	Nyby Uddeholm Powder A.B.	Sweden
DUPONT	Du Pont de Nemours	U.S.A.	ROSENT	Rosenthal A.G.	F.R.G.
ELF	Elf Aquitaine	France	SANDVK	Sandvik A.B.	Sweden
ELKEM	Elkem A/S	Norway	SCAN	Scandust	Sweden
ENIMNT	Enimont SpA.	Italy	SKF	SKF	Sweden
FERRUZ	Ferruzzi SpA.	Italy	SPERRY	Sperry	U.S.A.
FORD	Ford Motor Co.	U.S.A.	SUMITO	Sumitomo Group	Japan
FR-FL	Friedrich Flick Industrie KGaA.	F.R.G.	S-GOBN	Saint-Gobain S.A.	France
FUJITS	Fujitsu Ltd.	Japan	THOMSN	Thomson S.A.	France
FUJI-E	Fuji Electric	Japan	TORAY	Toray Industries Inc.	Japan
GE	General Electric Co. (GE)	U.S.A	TOSHIB	Toshiba Corp.	Japan
GTE	General Telephone & Electric (GTE)	U.S.A.	TRW	Thompson Ramo Woolridge Inc.	U.S.A.
HERCUL	Hercules	U.S.A.	UNISYS	Unisys Corp.	U.S.A.
HITACH	Hitachi Ltd.	Japan	VOLVO	Volvo A.B.	Sweden
HOECHS	Hoechst A.G.	F.R.G.	VW	Volkswagen A.G.	F.R.G.



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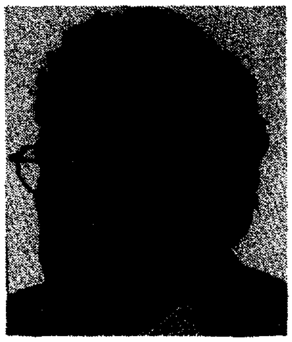

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Les associations entre entreprises dans le domaine des technologies génériques—le cas pour des nouveaux matériaux

RÉSUMÉ

Dans cet article, on montre que les réseaux de coopération en technologie entre entreprises dans le domaine des nouveaux matériaux se trouvent dominés par un nombre de sociétés multinationales de pointe. La croissance dans le nombre de contrats de coopération dans les dernières décades a mené à une configuration complexe des associations entre entreprises dans laquelle le caractère générique des nouveaux matériaux se voit réfleté en la structure inter-sectorielle des associations.

Partnerschaften für generische Technologien zwischen Firmen—im Falle von neuen Materialien

ABRISS

In diesem Beitrag zeigt man, dass Netzwerke der technischen Zussammenarbeit zwischen Firmen im Falle von neuen Materialien von mehreren führenden multi-nationalen Firmen beherrscht werden. Die Zunahme der Anzahl der zusammenwirkenden Vereinbarungen in den letzten Jahrzehnten hat zu einer komplexen Gestaltung der Partnerschaften zwischen Firmen geführt, wobei der generische Charakter der neuen Materialien im zwischensektorischen Muster der Arbeitsgemeinschaften gespiegelt wird.

Asociaciones entre empresas para las tecnologías genéricas—el caso de los materiales nuevos

RESUMEN

En esta contribución se demuestra el hecho de que las redes de cooperación tecnológica entre empresas están dominadas por las empresas multinacionales de primera importancia. El aumento en el número de acuerdos de cooperación en las últimas décadas ha conducido a una configuración compleja de asociaciones entre empresas en las que el carácter genérico de los materiales nuevos se ve reflejado en el reparto entre sectores de estas asociaciones.