UNDERSTANDING THE RATIONALE OF STRATEGIC TECHNOLOGY PARTNERING: INTERORGANIZATIONAL MODES OF COOPERATION AND SECTORAL DIFFERENCES

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Interfirm strategic alliances appear to have become more important as a part of (international) business. In this contribution an attempt is made to clarify our understanding of the motives that lead firms to cooperate in their innovative efforts. Going beyond general theoretical statements and case studies, attention is paid to both sectoral differences in the motivation for partnerships as well as to contrasts in interorganizational features of technology cooperation. Based on a large sample of alliances the analysis reveals some major differences regarding the research orientation of contractual arrangements and organizationally complex alliances.

INTRODUCTION

The aim of this article is to shed some light on the question 'why companies cooperate in their efforts to innovate.' This basic question regarding the rationale behind technology cooperation is relevant to our understanding of both practical issues in strategic management as well as to theoretical knowledge of the organizational boundaries of the modern firm. In general when these boundaries to the firm are analyzed they are defined in terms of vertical relationships of economic exchange from one company to another. Technology cooperation frequently surpasses this particular arena of economic exchange and enters into a field of relatively long-term strategic considerations regarding lateral relationships between companies. The economic rationale behind the existence of certain boundaries to a firm affecting cooperative behavior is expected to be different for operational considerations, largely related to cost minimizing behavior, and long-term strategic perspectives of interfirm positioning. It is in this general perspective of the boundaries to a firm defining the domain of both vertical and horizontal interfirm relationships as well as in short-term and in long-term perspective of cooperation that we will elaborate upon the question introduced above.

So far a few theoretical contributions have been made that have put this subject on the agenda. In particular transaction cost economics inspired contributions (Williamson, 1985; Teece, 1987) have theorized interfirm partnering as an economic phenomenon in between market transactions and hierarchies. In general these transaction cost economics inspired contributions appear to concentrate on vertical, customer–supplier relations and discuss them in rather general theoretical terms or analyze concrete developments in case studies from which generalizations are difficult to make.

We will attempt to take the analysis one step further and study a large 'sample' of over 4000 strategic technology alliances in a number of industries. We emphasize empirical understanding of the motives of firms to engage in strategic
technology partnering, i.e., interfirm cooperation for which a combined innovative activity or an exchange of technology is at least part of their agreement. The strategic character of the agreement relates to the expected long-term effects of the agreement on the product–market positioning of at least one of the partners. The motives of firms to engage in strategic partnerships are placed against both the organizational setting of partnerships, in particular contractual arrangements and complex modes of organization, and the industrial context which is expected to affect the pattern of motives for strategic alliances.

In the following we will first present an overview of the motives for firms to enter into alliances as found in the literature and discuss the different interorganizational alternatives there are to establish these partnerships. These sections are followed by a brief explanation of the data and the method applied to collect the material that we analyze. The main results are discussed in the section where we verify the hypotheses that are formulated in the first two sections.

AN OVERVIEW OF MOTIVES FOR STRATEGIC (TECHNOLOGY) ALLIANCES

A growing body of recently published studies contains some information on motives that are thought to lead companies to cooperative efforts. In most of these studies motives are discussed in very general terms and only in a small number of papers have motives for cooperation been a major object of study. This brief survey of main reasons provides a general categorization of motives following a somewhat linear interpretation of the innovation process from developing science and performing R&D down to market entry and the joint introduction of new products. (See also Table 1.) This simple, linear depiction of the innovation process enables us to present a condensed impression of the spectrum of concrete motives as found in the literature for the various phases of the innovation process as it is affected by interfirm cooperation.

The first group of motives one finds in the literature are those related to the sharing and further advancement of research and the restricted diffusion of some basic scientific and/or technological knowledge amongst participating companies. Some motives within this group are clearly related to concrete research activities, be it basic or applied research; others can also be associated with some general endeavor at the technological or scientific frontier of particular fields of technology, i.e., sharing the state-of-the-art. Some motives are related to the increased complexity and intersectoral nature of new technologies and the cross-fertilization of scientific disciplines and fields of technology. Here it is the growing interrelationship between, for instance, subfields of chemistry, physics, and electronics; computer science and process technologies; materials science, electronics, and chemistry that build the necessity for close collaboration between companies. Even as many very large and diversified firms might still lack some competence in a number of scientific and technological fields, cooperation creates the necessary complementary technology inputs enabling these companies to capitalize on economies of scale through joint efforts. In the same domain of arguments we find motives that stress the necessity for companies to monitor the evolution of technologies in order to assess technological synergies, near-future results of general scientific knowledge and relevant complementarities of technologies. Here also, the central argument is that no company will have an all-embracing competence in every field of technology and therefore a concrete evaluation of possible synergies might at some stage of a particular technological trajectory warrant a joint undertaking with another company. A number of more specific motives, mentioned in the literature, are the reduction, minimizing and sharing of the uncertainty which is inherent to performing R&D. Many studies refer to the reduction of risk in R&D as a major motive for shared activities; we, however, suggest it is more appropriate to think of this sharing of R&D in terms of reduction of uncertainty. It is well known that risk can be defined as the probability of occurrence of an event with a given probability distribution of the size of the event. Uncertainty, on the other hand, is associated with the unknown likelihood of an event when there is no probability distribution. It is probably this unknown likelihood of success in research that leads some companies to combine their efforts in order to create economies of scale and/or scope that will
Table 1. An overview of motives for (strategic) interfirm technology cooperation

<table>
<thead>
<tr>
<th>I</th>
<th>Motives related to basic and applied research and some general characteristics of technological development:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased complexity and intersectoral nature of new technologies, cross-fertilization of scientific disciplines and fields of technology, monitoring of evolution of technologies, technological synergies, access to scientific knowledge or to complementary technology:</td>
</tr>
<tr>
<td></td>
<td>Reduction, minimizing and sharing of uncertainty in R&amp;D:</td>
</tr>
<tr>
<td></td>
<td>Reduction and sharing of costs of R&amp;D:</td>
</tr>
<tr>
<td>II</td>
<td>Motives related to concrete innovation processes:</td>
</tr>
<tr>
<td></td>
<td>Capturing of partner's tacit knowledge of technology, technology transfer, technological leapfrogging:</td>
</tr>
<tr>
<td></td>
<td>Shortening of product life cycle, reducing the period between invention and market introduction:</td>
</tr>
<tr>
<td></td>
<td>OECD (1986a), Mariotti and Ricotta (1986).</td>
</tr>
<tr>
<td>III</td>
<td>Motives related to market access and search for opportunities:</td>
</tr>
<tr>
<td></td>
<td>Monitoring of environmental changes and opportunities:</td>
</tr>
<tr>
<td></td>
<td>Internationalization, globalization and entry to foreign markets:</td>
</tr>
<tr>
<td></td>
<td>New products and markets, market entry, expansion of product range:</td>
</tr>
</tbody>
</table>

facilitate their search processes to expand to a wider field of research activities or expand their competence. Closely related to the previous argument is the motive of reduction and sharing of costs of R&D. The key-argument for this motive is the increase in costs of R&D in a large number of fields of technology. This motive is frequently mentioned in addition to the motive of the basic uncertainty of innovative processes. Examples given in the literature are costs of research in high-tech industries and the costs of advanced system design such as in telecom and aerospace.

The second group of motives is more closely related to concrete innovative projects in a joint activity of two or more companies. In such a joint operation one (or both/all) partner(s) can be motivated by the possibility of secretly capturing some of the capabilities, knowledge or technologies of partners. Then, joint activities are merely a cover-up for an attempt to quickly absorb some innovative capabilities from others. In that case at least one partner has a 'hidden agenda' for its evolvement in the joint project. On the other hand, an agreed technology transfer of one partner to another can also be a motive for interfirm cooperation. This technology transfer can equip one partner or both partners to leap-frog their competitors. The other set of motives in this group is slightly neglected in the literature. Only a few publications mention the reduction of the total period of the product-life cycle and the contraction of the period between invention and market introduction as a motive for technology cooperation.

The third group of motives is associated with
a combination of market access and technology development through a combined effort of companies. An argument in favor of cooperation is found in the opportunities for market entry through a joint monitoring of environmental changes in combination with developing new products or processes. At a more international level combining some activities of two (geographically) separated firms for particular markets favors internationalization and globalization of companies that lack the economic control, competence or experience to follow such a strategic move independently. Finally, interfirm agreements are mentioned in the literature for their ability to create new markets and products, to provide market-entry and to expand the product range of both partners.

All in all, the literature appears to generate a wide range of motives for interfirm technology cooperation varying from a narrow research oriented argumentation to a market access objective. In this contribution we will assess the diversity of motives that play a role in interfirm strategic technology partnering, given certain sectoral differences that obviously could influence the motivation of firms to collaborate. In particular the technology intensity of different sectors of industry can be expected to affect the motivation of companies participating in strategic alliances. In that context we can formulate:

Hypothesis 1: It is expected that the technology intensity of sectors is reflected in the research orientation of the strategic technology alliances affecting different sectors, i.e., strategic technology partnering in so called high-tech sectors is strongly related to R&D cooperation, whereas in medium and low-tech sectors research is not a dominant feature of partnering and market access objectives prevail.

If we consider the applied or basic character of this research intensity of strategic technology partnering, we can expect it to be probably of an applied nature. Following Harrigan (1985) we assume corporate basic research to be of little relevance to interfirm technology cooperation. The argument is that either basic research is more or less a free good, for instance provided by a technological infrastructure, or if it is an essential corporate activity as in R&D intensive industries, it comes close to a company's corporate core and as such it is not a desirable subject for collaboration. See also Teece (1987). This leads us to formulate:

Hypothesis 2: Regardless of the research intensity of industrial sectors, basic research is not expected to be an important motive for strategic technology partnering.

INTERORGANIZATIONAL MODES OF STRATEGIC TECHNOLOGY PARTNERING

Strategic technology partnering does not only reflect differences in the motivation of partners or variation in its sectoral distribution, it also comes in a number of interorganizational modes of governance. These distinct modes of organization for interfirm partnering can have a differentiated impact on the character of technology sharing, the organizational context and the possible economic consequences for participating companies (Auster, 1987; Buckley and Casson, 1988; Contractor and Lorange, 1988; Hagedoorn, 1990a; Harrigan, 1985; Osborn and Baughn, 1990; Root, 1988). We suggest a contrast between different organizational modes of cooperation with relatively strong modes of interorganizational governance such as joint ventures, research corporations and minority investment on the one hand, and contractual arrangements such as joint R&D agreements, technology exchange agreements, customer-supplier relationships and one-directional technology flows on the other.

We refer to joint ventures and research corporations as combinations of the economic interests of at least two separate companies in a 'distinct' firm; profits and losses are usually shared according to equity investment. Minority equity investment, especially those made by a large company in a smaller 'high tech' company, can be understood as a case of cooperation, which in the long run could affect the technological performance of at least one 'partner,' in particular if such minority sharing is coupled with research contracts.

Joint R&D agreements refer to joint research pacts and joint development agreements which establish joint undertaking of R&D projects with shared resources. Technology exchange
agreements cover technology sharing agreements, cross-licensing and mutual second-sourcing of existing technologies. Under the heading of customer-supplier relationships we have joined those categories of agreements through which contract-mediated collaboration in either production or research is established. These customer-supplier relationships can be divided into a number of forms of partnership such as coproduction contracts, comakership relationships, and research contracts that regulate R&D cooperation in which one partner, usually a large company, contracts another company, frequently a small specialized R&D firm, to perform particular research projects. Finally, there are unilateral technology flows such as second-sourcing and licensing agreements.

As already mentioned above we define as strategic technology alliances those interfirm cooperative agreements which are aimed at improving the long-term perspective of the product market combinations of the companies involved. These strategic technology partnerships differ from other partnerships such as cost-economizing agreements which we think are more associated with control of either transaction costs or operating costs of companies. In case both strategic and cost-economizing arguments for partnering appear possible, either because it is not feasible to differentiate between the cost or the strategic argument or because partners can be expected to have alternating motives as a consequence of the character of the agreement, we consider such agreements of a mixed character.

Although there is no strict correlation between organizational modes of cooperation and their strategic or cost-economizing content, we think some modes of cooperation are more strategically motivated whereas others tend to be more oriented towards cost-economizing. (See Table 2.) Based on previous research we estimate that e.g., R&D joint ventures and research corporations, joint R&D agreements and equity investments are for over 85 percent strategically motivated (Hagedoorn and Schakenraad, 1990b). Compared to this, only a small portion of the technology exchange agreements, one-dimensional technology flows and customer-supplier relationships are expected to be strategically motivated, with the exception of a subgroup within the latter mode, i.e., research contracts, which we assume to be at least partly strategically motivated.

The distinction between strategic technology alliances and nonstrategic partnerships enables us to concentrate our empirical investigation on those interorganizational modes of cooperation that are, at least partly, strategically motivated. Within this group of strategic technology alliances we can differentiate between those modes of governance that are interorganizational stronger modes of cooperation and more 'simple' contractual arrangements. The literature on this subject (Berg, Duncan and Friedman, 1982; Harrigan, 1985; Osborn and Baughn, 1990) suggests that alliances which are organizationally most interdependent, i.e., joint ventures, are to be seen as complex organizations that are difficult to manage. Companies can be expected to engage in such strategic alliances if they see a long-term perspective and the broader benefits of such an agreement that they wish to capitalize on through a jointly owned firm. Also, due to its particular organizational and corporate identity as a partly separate firm this mode of cooperation applies to a relatively broad spectrum of company objectives and its scope is expected to be multidimensional. In other words, despite their joint ownership structure and their dedicated area of operation complex interorganizational modes of partnering cover a large share of the normal business activities of companies. On the other hand, contractual arrangements such as R&D pacts, technology exchange, relevant customer-supplier relations and forms of one-directional technology transfer have a more one-dimensional perspective and are exclusively aimed at technological achievement. The perspective of these particular modes of joint technological development and technology sharing is probably of a short-term character, irrespective of the possible overall long-term effect on participating companies (Hagedoorn, 1990a; Harrigan, 1985; Osborn and Baughn, 1990). Thus:

_Hypothesis 3: Strategic technology alliances characterized by complex interorganizational modes of cooperation, such as joint ventures, are motivated by both market and technology-mediated objectives; contractual strategic technology alliances are primarily aimed at short-term technological achievement._
Table 2. The assumed relation between modes of technology cooperation and their strategic content

<table>
<thead>
<tr>
<th></th>
<th>Joint ventures, research corporations</th>
<th>Joint R&amp;D</th>
<th>Technology exchange</th>
<th>Direct investment</th>
<th>Customer - supplier relationships</th>
<th>One-directional technology flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost economizing</td>
<td>–</td>
<td>–</td>
<td>+++</td>
<td>–</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Mixed strategy</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Long-term positioning</td>
<td>++++</td>
<td>+++</td>
<td>–</td>
<td>+++</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

—little or negligible relevance, + indication of growing relevance.
METHOD OF DATA COLLECTION

Our research is based on the MERIT-Cooperative Agreements and Technology Indicators (CATI) data bank, a relational data bank, with information on nearly 10,000 technology cooperation agreements involving some 3500 different parent companies.

After a pilot-project in 1986-87 systematic collection of interfirm technology alliances started in 1988. If available, many sources from earlier years were consulted enabling us to take a retrospective view. For all sectors of industry or fields of technology in our data bank we have information on cooperative agreements from at least as early as 1980 up to 1989; for some sectors we have been able to collect information on a longer period going back to the 1970s or beyond. In order to collect information on interfirm alliances and their parents we consulted various sources, of which the most important are newspaper and journal articles, books dealing with the subject, and in particular specialized technical journals which also report on business events. A small group of students trained by us assisted in gathering information and 'feeding the computer'.

This method of information gathering which we might call 'literature-based alliance counting' has its drawbacks and limitations, such as inadequacy of certain sources, low profile of certain companies, bias in favor of Anglo-Saxon sources, and underestimation of certain modes of cooperation, such as licensing. Despite these 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. This enables us to perform empirical research which goes beyond case studies or general statements. Some of the weaknesses of the data base can easily be evaded by focusing on the more reliable parts, such as strategic technology alliances ignoring cost-economizing partnerships, as done in the present paper.

The data bank contains information on each agreement and some information on companies participating in these agreements. The first entity is the interfirm cooperative agreement. We define cooperative agreements as common interests between independent (industrial) partners which are not connected through (majority) ownership.

In the CATI data base only those interfirm agreements have been collected, that contain some arrangements for transferring technology or joint R&D. Joint research pacts, second-sourcing and licensing agreements are clear-cut examples. We also collected information on joint ventures in which new technology is received from at least one of the partners, or joint ventures with one or more R&D programs; mere production or marketing joint ventures are excluded. In other words, our analysis is primarily related to technology cooperation. We are discussing those forms of cooperation and agreements for which a combined innovative activity or an exchange of technology is at least part of the agreement. Consequently, partnerships are omitted that regulate no more than the sharing of production facilities, the setting of standards, collusive behavior in price-setting and raising entry barriers, although all of these may be side-effects of interfirm cooperation as we define it.

In this paper 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 of the agreement, field(s) of technology and/or industry, modes of cooperation, equity sharing, the degree of participation in case of minority holdings, the character of cooperation, such as basic research, applied research, or product development possibly associated with production and/or marketing arrangements. Of particular interest to the present contribution is that we also collected information on motives underlying the alliance.

For each agreement that we collected we interpreted the motives with a list of catch words, i.e., an extensive inventory based on motives we found in the literature and in our previous research. Appendix I provides the classification of motives for which Table 1 gives a compact version of motives found in the literature. In addition to this each of these motives can be related to their strategic impact. As already explained, we make a distinction between cooperative agreements which are aimed at the strategic, long-term perspective of the companies involved and those agreements which we think are more associated with the control of either transaction costs or operating costs of companies. In case both general motives appear possible, either because it is not feasible to differentiate between
the cost or the strategic argument or because partners can be expected to have alternating motives as a consequence of the character of the agreement, we have marked such agreements as being of a mixed character. The present analysis only covers those agreements that we have marked as strategic or as being of a mixed character, leading to total of 4192 strategic technology alliances made during the eighties.

In our assessment of the strategic implications of cooperative technology agreements each of them will be valued according to the list presented in Appendix 1. For many agreements there are several motives to be found of which some will be more strategic and others more cost related. In those cases such agreements are valued as strategic, cost economizing or mixed according to a 'common sense' interpretation of the occurrence and distribution of several motives per agreement. If the majority of motives indicated the strategic content of such an agreement it has been labeled as strategic, on the other hand with a majority of cost economizing motives the agreement was considered likewise. A mixed strategic content is found for an equal or close to equal distribution of motives. This procedure enabled us to 'measure' the strategic implications of every agreement in our database.

In this article we also distinguish two broad groups of motives according to the so-called T/M ratio, indicating whether interfirm partnering is related to:

- motives associated with basic and applied research, or
- motives associated with market access and influencing the market structure.

This distinction enables us to determine the content of each strategic alliance, whether it is predominantly research oriented, or primarily market oriented; in other words, whether its motivation is found in the first or in the third group of motives mentioned in Table 1. We define the technology–market ratio as the \( \log_{10} \) of the ratio between a firm's total number of prevailing research inclined strategic linkages and its total number of predominantly market-related strategic linkages. By taking the \( \log_{10} \) form, we accomplish that zero is a neutral score indicating equal weight for the technology and the market aspects of strategic cooperation. A positive value marks an inclination towards 'pure' technology cooperation; negative scores indicate a dominance of motives primarily related to market access and influencing the market structure.

**DISCUSSION OF MAJOR FINDINGS**

In Table 3 we present an overview of major motives for strategic alliances as found in our data bank. From our material it becomes obvious that, if one looks at the general outcomes, only three motives play a role of true significance. Technology complementarity, reduction of the innovation time-span, and market access and influencing the market structure are the most mentioned motives. The first two motives are probably the most important motives for companies to engage in technology cooperation. Secondary analysis of the material, not reported in this paper, suggests that their relevance has increased during the past decades. In terms of the general rationale for partnering, discussed above, these outcomes could be interpreted as supporting the notion that cooperation has to be understood in the light of attempts made by companies to cope with the complexity and interrelatedness of different fields of technology and their efforts to gain time and reduce uncertainty in joint undertakings during a period of growing technological intricacy. Other motives appear to play only a very limited role.

If we take a closer look at the divergence in motives for different fields of technology and sectors of industry we notice considerable variation. One of the most significant findings from Table 3 is that two major motives for cooperation, i.e., technological complementarity and reduction of the innovation period, appear to be clearly less relevant in sectors such as chemicals, consumer electronics, food and beverages and, to a certain extent, also the automotive industry. These sectors are generally accepted as somewhat mature industries for which we also find that, even within this domain of strategic technology cooperation, motives related to influencing market structures such as market access and restructuring appear most appropriate.

Technological complementarity receives an above average score in a number of sectors. In biotechnology the explanation can be found in the complementarity of specialized biotechnology firms and their partners that have a wide array of activities and technological competencies.
<table>
<thead>
<tr>
<th>Industry</th>
<th>Number of alliances</th>
<th>Technol. Complementarity</th>
<th>Basic R&amp;D</th>
<th>High cost/risks</th>
<th>Lack of financial resources</th>
<th>Reduction innovation time span</th>
<th>Monitoring technology/ market entry</th>
<th>Market access/structure</th>
<th>Technology/ market ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotechnology*</td>
<td>847</td>
<td>35%</td>
<td>10%</td>
<td>1%</td>
<td>13%</td>
<td>31%</td>
<td>15%</td>
<td>13%</td>
<td>0.55</td>
</tr>
<tr>
<td>New Materials Technology*</td>
<td>430</td>
<td>38%</td>
<td></td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>Computers*</td>
<td>198</td>
<td>28%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>22%</td>
<td>10%</td>
<td>51%</td>
<td>-0.18</td>
</tr>
<tr>
<td>Industrial Automation*</td>
<td>278</td>
<td>41%</td>
<td>4%</td>
<td>0%</td>
<td>3%</td>
<td>32%</td>
<td>7%</td>
<td>31%</td>
<td>0.18</td>
</tr>
<tr>
<td>Microelectronics*</td>
<td>383</td>
<td>33%</td>
<td>5%</td>
<td>3%</td>
<td>3%</td>
<td>33%</td>
<td>6%</td>
<td>52%</td>
<td>-0.15</td>
</tr>
<tr>
<td>Software*</td>
<td>344</td>
<td>38%</td>
<td>2%</td>
<td>1%</td>
<td>4%</td>
<td>36%</td>
<td>11%</td>
<td>24%</td>
<td>0.26</td>
</tr>
<tr>
<td>Telecommunications*</td>
<td>366</td>
<td>28%</td>
<td>1%</td>
<td>11%</td>
<td>2%</td>
<td>28%</td>
<td>16%</td>
<td>35%</td>
<td>-0.04</td>
</tr>
<tr>
<td>Other I.T.</td>
<td>91</td>
<td>29%</td>
<td>2%</td>
<td>1%</td>
<td>0%</td>
<td>28%</td>
<td>24%</td>
<td>35%</td>
<td>-0.04</td>
</tr>
<tr>
<td>Automotive</td>
<td>205</td>
<td>27%</td>
<td>2%</td>
<td>4%</td>
<td>2%</td>
<td>22%</td>
<td>4%</td>
<td>52%</td>
<td>-0.25</td>
</tr>
<tr>
<td>Aviation/Defense*</td>
<td>228</td>
<td>34%</td>
<td>0%</td>
<td>36%</td>
<td>1%</td>
<td>26%</td>
<td>8%</td>
<td>13%</td>
<td>0.43</td>
</tr>
<tr>
<td>Chemicals</td>
<td>410</td>
<td>16%</td>
<td>1%</td>
<td>7%</td>
<td>1%</td>
<td>13%</td>
<td>8%</td>
<td>51%</td>
<td>-0.45</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>58</td>
<td>19%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>19%</td>
<td>9%</td>
<td>53%</td>
<td>-0.38</td>
</tr>
<tr>
<td>Food and Beverage</td>
<td>42</td>
<td>17%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>10%</td>
<td>7%</td>
<td>43%</td>
<td>-0.35</td>
</tr>
<tr>
<td>Heavy Electric/Power*</td>
<td>141</td>
<td>31%</td>
<td>4%</td>
<td>36%</td>
<td>1%</td>
<td>10%</td>
<td>11%</td>
<td>23%</td>
<td>0.17</td>
</tr>
<tr>
<td>Instruments/Medical Technology*</td>
<td>95</td>
<td>35%</td>
<td>2%</td>
<td>0%</td>
<td>4%</td>
<td>40%</td>
<td>10%</td>
<td>28%</td>
<td>0.15</td>
</tr>
<tr>
<td>Other</td>
<td>76</td>
<td>9%</td>
<td>0%</td>
<td>35%</td>
<td>0%</td>
<td>6%</td>
<td>8%</td>
<td>23%</td>
<td>-0.41</td>
</tr>
<tr>
<td>Total</td>
<td>4192</td>
<td>31%</td>
<td>5%</td>
<td>6%</td>
<td>4%</td>
<td>28%</td>
<td>11%</td>
<td>32%</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*high-tech industries, see Appendix 2; †the total of motives mentioned do not add to 100 percent because for several alliances one can find a number of motives. Source: MERIT - CATI bank.
such as the large chemical and pharmaceutical companies. The generic character of new materials, which often entails a combination of different technological disciplines, generates clear possibilities for a number of uses of these new materials for which technological competence, that goes beyond plain development work, appears necessary. In that context users and combined producers of new materials have a clear need for technological complementarity. In a sense the same holds for industrial automation, software and aviation where technological complementarity appears to be the major motive as well. In industrial automation manufacturers of such systems are in a clear need of cooperation with users from different sectors of industry, as well as with companies that are competent in information technology. In the software sector technological complementarity is in particular necessary for the development of complex and dedicated software for a large number of applications in all spheres of automation.

The reduction of the innovation period is also a major motive for interfirm cooperation. It has a high score in most sectors with the exception of the previously mentioned mature industries and industries such as automotive, computers and heavy electrical equipment. Although we cannot provide a definite explanation it could be that the largely oligopolistic character of these industries and their mature market structures with few entrants and at present some international restructuring provide little incentives for an extra effort in speeding the process of innovation for individual products through a joint activity.

Market access and restructuring, the most prevalent motive, is of considerable relevance in the four mature sectors already mentioned and in telecommunications, computers and microelectronics. For telecommunications the importance of this motive is quite understandable if we recognize that the international telecom market has until recently been characterized by many national monopolies and domestic oligopolistic markets. Even for the largest companies market access to particular foreign markets was only possible through alliances with national producers. In recent years this sector is also witnessing a process of restructuring due to excess capacity, far-reaching technological development and fierce competition in which strategic alliances play their role. These latter arguments also explain the importance of this motive for fields such as computers and microelectronics. On the other side this motive has only little significance in sectors such as aviation and biotechnology. For biotechnology this is understandable because technological development so far has generated few products that could cause a major shift towards market access or a restructuring of existing markets. For aviation the present oligopolistic structures and established global markets probably provide little incentives for market access and restructuring through alliances.

Monitoring of technological development and monitoring of market entry score relatively high in three sectors, i.e., biotechnology, new materials and telecommunications. For the first two relatively new fields of technology it makes sense that firms apply alliances to monitor the possibilities of these fields of technology for their future product-market combinations. As far as telecommunications is concerned the explanation has to be found in the direction of monitoring possible convergence with other fields of information technologies and the possibilities of a wider range of applications and services in the near future.

The motive of high costs and financial risks, although frequently mentioned in the literature, plays only a limited role with the exception of three fields, i.e., aviation and heavy electrical equipment and telecommunication systems which are all sectors manufacturing expensive capital goods that are often manufactured in coproduction and where the creation of new generations is very costly. For instance, in aviation, main producers and coproducers often share financial risks. In biotechnology the lack of financial resources plays a role as the research of many small firms has gradually entered the phase of developing new products. The necessary capital is frequently obtained through alliances with larger companies.

For a more systematic verification of the hypothesis we apply a positive T/M ratio as an indicator of the research oriented character of strategic technology partnering. The final column of Table 3 gives the T/M ratio for industrial sectors or fields of technology. We expect a positive sign for so-called high-tech industries and a negative sign for the other sectors. Out of a total of 14 sectors, only three do not confirm the hypothesis. Apparently strategic alliances in
these sectors, i.e., computers, microelectronics and telecommunications, are, despite their high-tech character, somewhat more market oriented for which an indicative explanation has already been offered in the above. However, for sectors representing over 80 percent of the strategic technology alliances in our data base we can verify the first hypothesis indicating a positive relationship between the research orientation of alliances and the research intensity of the sectors affected and the strongly market-oriented motivation of partnering in non-high-tech industries.

With regard to the second hypothesis, we find that the motive of performing basic research is only of some relevance in two fields and even there its relevance should not be overstated. In order to control for the R&D intensity of sectors, we have to consider in particular high-tech industries as ‘normal’ sectors are characterized by low R&D inputs and consequently basic R&D is not at all expected to affect interfirm partnering. In our sectoral setting 11 (sub-)fields qualify as high-tech sectors, but we found that only in two of them performing corporate basic R&D provides a motive for strategic technology partnering. For these two sectors, i.e., biotechnology and new materials, certain market structural characteristics could explain the relevance of basic research as a motive for partnering. In biotechnology we see a relatively new field of technology in which a substantial number of small R&D intensive firms have found an important share of their business in performing R&D, both basic and applied, through alliances and contract research with large firms (Hagedoorn and Schakenraad, 1990b; Pisano, 1991). In new materials, a field which is more of a generic character, the situation is somewhat different with cooperation on research between companies from different technological disciplines. Here, companies that originate from a wide variety of industries such as aviation, chemicals, electronics, machine building, automotive, etc. cooperate on the future use of new and advanced materials and consequently performing basic research is expected to be a somewhat more relevant motive than in many other sectors (Hagedoorn and Schakenraad, 1991). However, also for these two fields of technology basic research as a motive for strategic partnering should not be exaggerated as its share remains relatively small.

Following our third hypothesis we expect complex interorganizational modes of strategic partnering such as joint ventures to have a balanced T/M ratio close to nought. Contractual arrangements such as R&D pacts are assumed to be aimed at short-term technological development with a fairly positive T/M ratio. The results for the measurement of the T/M ratio for both categories of strategic technology partnering are presented in Table 4. For complex interorganizational modes of partnering we see that the motivation for partnering comes close to a balance between market and technology mediated motives with a T/M ratio of -0.16. Strategic technology partnering through contractual modes is more one-dimensionally aimed at joint R&D as strongly suggested by a T/M ratio of 0.58. In the above we have already shown that basic research is in general not a motive for strategic technology partnering between firms. Hence, a positive and high T/M ratio indicates a tendency for contractual arrangements to be directed towards joint applied research and shared development activities which are, by definition, of a more short-term character than basic research.

**CONCLUSIONS**

Concrete understanding of the motives of firms to engage in partnerships provides additional insights to purely theoretical understanding of collaboration as an alternative to both markets and hierarchies. At first the differentiated picture of motives and modes of organization generates a wide variety of concrete forms of interfirm cooperative agreements and motives across a broad spectrum of alternative incentives to collaborate. Although there are a large number of motives we have shown that two basic categories, i.e., market and technology-related motives, dominate the scene.

Sectoral differences, in terms of the role technological development plays in several fields, have to be taken into account as technology-related motives are dominant in so-called high-tech sectors. In other sectors, characterized as mature industries or sectors that undergo a process of consolidation, a
Table 4. T/M ratio's of complex and contractual modes of strategic technology partnering

<table>
<thead>
<tr>
<th></th>
<th>Frequency of research related motives (1)</th>
<th>Frequency of market related motives (2)</th>
<th>T/M ratio (log10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex modes</td>
<td>601</td>
<td>863</td>
<td>0.696</td>
</tr>
<tr>
<td>Contractual arrangements</td>
<td>1841</td>
<td>488</td>
<td>3.773</td>
</tr>
</tbody>
</table>

broad spectrum of market-related objectives can be linked to strategic technology partnering.

Also the wide variety of strategic technology alliances with many forms of partnering and combinations of different modes of collaboration can be aggregated to a dichotomy of contractual and complex arrangements as basic modes. Apparently complex interorganizational modes of strategic technology partnering such as joint ventures are applied by companies if they aim at a wider set of objectives than they intend to improve innovative efforts. Such a wider set of objectives with both market access and technology-related motivation demands a larger span of control by the company than a one-dimensionally motivated agreement. Through complex agreements with equity investments and share-holder control partners increase their governance over their strategic alliances. In contrast to this, contractual arrangements demand less control through administration and supervision and are more suited for agreements which are less complex regarding their span of objectives. Therefore, companies appear to prefer this mode of strategic technology partnering for agreements with a one-dimensional goal, strongly biased in favor of applied research cooperation.

ACKNOWLEDGEMENTS

This paper is one of a series of papers in a joint research project with Jos Schakenraad on 'Intercompany 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 interfirm 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-data base which contains information on several thousands of world-wide cooperative agreements and the companies involved. Helpful comments by two referees are gratefully acknowledged.

REFERENCES


Understanding Strategic Technology Partnering


OECD Observer (June-July 1990).


APPENDIX 1: Classification of motives underlying technology cooperation agreements and their strategic impacts

In the following we will present a list of catch words applied to analyze the major motives for cooperation in our present research. This inventory is based on the motives we found in the literature and in our previous research. These motives will be related to joint research and development pacts, joint ventures and technology exchange agreements first, followed by a special list of additional motives for joint ventures and an inventory of motives for direct investments such as minority holdings. The list of motives is complemented by a number of forms of cooperation which by their nature have only one obvious purpose.

Throughout our research we will make a distinction between cooperative agreements which are aimed at the strategic, long-term perspective of the companies involved which we will indicate below with an 's', and those agreements which we think are more associated with the control of either transaction costs or operating costs of companies, which we will mark with a 'c'. In case both general motives appear possible, either because it is not feasible to differentiate between the cost or the strategic argument or because partners can be expected to have alternating motives as a consequence of the character of the agreement, we have marked such agreements with a 'b'. Agreements characterized by us as strategic or of a more mixed quality are considered to be strategic alliances. An overview of modes of cooperation, motives, and strategic content:

A. Motives, underlying joint research and development agreements, joint research pacts, joint ventures and research corporations:

1. Costs and risks—high costs and risks of R&D in high-tech industries, c, because both costs and strategic implications (risks) are relevant;
2. The lack of sufficient financial resources, b, although one might expect that costs are the main aspect of this motive, at least one of the partners will have a long-term strategic motivation in particular because most of these agreements are between a small company and a large financially supportive company;
3. Technological complementarity—increased complexity and intersectoral nature of new technologies, the technological competence of the partner, the necessity for some firms to monitor a spectrum of technologies (both offensive and defensive), s;
4. Reduction of innovation time-span—shortening the period between discovery (invention) and market introduction (innovation), getting patents as fast as possible, enlarge product supply, reduce period of development, b, because both cost and strategic positioning are at stake;
5. Perform basic research, s;
6. Influencing market structure—setting up a combination against a third party (both offensive and defensive); reduce the number of competitors, competitive positioning, s;
7. Monitoring technological opportunities—monitoring the evolution of technologies and opportunities, switching to new—at least to the firm—promising technologies, s;
8. Hidden agenda—capturing and absorbing tacit knowledge, extracting skills, among other things by engaging into a network of changing partnerships, s.

B. For joint ventures we will examine some further potential motives in addition to the ones mentioned above:

1. Economies of scale, rationalization of production, c;
2. Expansion, new markets—offensive marketing agreements, international expansion, internationalization of market, exploitation of new market opportunities, s;
3. Defensive restructuring—outsourcing of peripheral activities, subsidiaries merger, c;
4. National circumstances—benefiting from partner's particular national interests, s;
5. Bidding consortia, s.

C. Motives for direct investments, minority holdings and cross holdings:

1. Tighten customer—supplier partnerships—to assure supply of high quality components, sometimes in combination with contract research, control of upstream activities and relations, in which costs control is decisive, therefore c;
2. Profitability—(potential) profitability of company to be invested in, s;
3. Matching of core activities—sharing particular core businesses in lateral relationship, s;
4. Monitoring possible entry—investigate possible entry into new fields of technology or new products, s;
5. Marketing entry—entry into marketing channel of the target company, as both strategic and cost options can play a role; b;
6. Control over partner—to prevent a hostile take-over by a third party, to block would-be participants, create interlocking shareholder structure, s;
7. Technological competence of partner, s.

D Forms of cooperation which can be directly related to one dominant motive:

- Comakership contract—CMC, c;
- Coproduction contract—CPC, c;
- Customer—supplier partnership—CSP, c;
- Licensing, c because it generates income for the licensor and reduces costs for the licensee;
- Combination of CSP and licensing, b because in such a combination the technology transfer involved is usually of a more strategic importance to at least one partner and also closer to best practice technology;
- Cross-licensing, b, see above;
- Research contract—RDC, b because it reduces the cost of research for one contractor but it also provides strategic information on technologies and capabilities of the other contractor;
- Second-sourcing agreement—SSA, b, both strategic options and costs of development lead companies to engage in such agreements;
- Mutual second-sourcing agreement—MSSA, b, see above;
- Technology sharing agreement—TS, as this agreement covers the sharing of existing technology cost economizing is central, hence c;
- Combinations of TS with licensing, c see above.

APPENDIX 2: LIST OF HIGH TECH SECTORS

<table>
<thead>
<tr>
<th>Sector</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotechnology</td>
<td>high</td>
</tr>
<tr>
<td>New materials</td>
<td>high</td>
</tr>
<tr>
<td>Computers</td>
<td>high</td>
</tr>
<tr>
<td>Industrial automation</td>
<td>high</td>
</tr>
<tr>
<td>Microelectronics</td>
<td>high</td>
</tr>
<tr>
<td>Software</td>
<td>high</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>high</td>
</tr>
<tr>
<td>Automotive</td>
<td>medium</td>
</tr>
<tr>
<td>Aviation/defense</td>
<td>high</td>
</tr>
<tr>
<td>Chemicals</td>
<td>medium</td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>medium</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>low</td>
</tr>
<tr>
<td>Heavy electr. eq./power</td>
<td>high</td>
</tr>
<tr>
<td>Instruments/med. techn.</td>
<td>high</td>
</tr>
<tr>
<td>Others</td>
<td>low</td>
</tr>
</tbody>
</table>

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1 Indication of high tech (R&D intensity) based on OECD Observer, June–July 1990; biotechnology, see Pisano, Shan, and Teece, 1988; new materials, see Cohendet, Ledoux, and Zuscovich, 1988; software and telecommunications, see Osborn and Baughn, 1990.