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Financiadora de Estudos e Projetos - FINEP  
Programa de Apoio ao Desenvolvimento Científico e Tecnológico - PADCT

## **ESTUDO DA COMPETITIVIDADE DA INDÚSTRIA BRASILEIRA**

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**NEW TRENDS OF COOPERATIVE R&D AGREEMENTS:  
CHALLENGES AND OPPORTUNITIES FOR THIRD  
WORLD COUNTRIES**

Nota Técnica Temática do Bloco  
"Condicionantes Internacionais da Competitividade"

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## EXECUTIVE SUMMARY

### 1. THE INTERNATIONAL CONTEXT

#### 1.1. Recent Trends in Networks of Innovators

**Network of Innovators** is a basic institutional arrangement to cope with systemic innovation and consists on an inter-penetrated form of market organization. Empirically, networks are loosely coupled organizations having a core with both weak and strong ties among constituent members.

Strategic alliances with outside firms and other institutions are not totally new, nor limited to the recent decades. However, the observation that the last two decades have witnessed a significant quantitative and qualitative increase in innovation networking has attracted much interest to the analysis of collaborative ventures world-wide. In addition, it has been shown that there are important qualitative differences between new and previous forms of R&D collaboration.

Accompanying the interest in monitoring and interpreting the new phenomenon, the importance of establishing and operating data bases about these collaborative arrangements has also greatly increased in the last few years. Among the main findings arising from the analysis of the data available about networking are:

- an extremely rapid recent growth of inter-firm R&D-motivated collaborative arrangements. Compared to the period 1970/79, the number of alliances almost doubled in the following five years (1980/84), and again it more than doubled in the period 1985/89.

- a concentration of the new agreements on the research base that directly underlies firms' competitive interests, with R&D agreements representing the largest category of partnering with a share of more than 40%.

- a concentration of the new collaborative arrangements on fields that are characterized as high tech sectors. Information and communication technology - ICT (with 41.2%), biotechnology (with 20.2%) and advanced materials (with 10.3%) accounted for about 72% of all the agreements recorded from 1980 to 1989.

- a concentration of the agreements on the Triad countries (US, Western Europe and Japan), which accounted for over 90% of all the agreements recorded in the 1980s. Only the Asian newly industrialized countries (NICs) entered the picture in significant numbers from outside.

- a predominance of very large, multinational and diversified companies participating in the new R&D-motivated collaborative ventures.

In contrast to much of the previous literature, considerations of cost-sharing and cost-minimization appeared to play a relatively small role in comparison with strategic objectives relating to new technologies and markets. According to empirical evidence, strategic behaviour of firms (rather than costs) would explain better the recent explosion in innovation networking and the following motives were found to predominate: (a) reduction, minimization and sharing of uncertainty and lead times in new area of R&D; (b) shortening of product life cycle, reduction of the period between invention and market introduction; (c) cross fertilization of scientific disciplines and fields of technology, technological synergies, access to scientific knowledge or complementary technology, acquisition of core competencies; (d) monitoring of environmental changes and opportunities; (e) strategies relating to technological competence and market access and positioning; and internationalization, globalization and entry to foreign markets

In trying to interpret the recent trend of networks of innovators, it has been stressed that the combination of scientific, technical and market information from external and internal sources will vary, not only according to companies' size and structure, type of industries and countries, and to each different techno-economic paradigms but also with the nature of the innovation. The main points of this argument are that:

- at times when there is a radical discontinuity in technology systems, scientific knowledge becomes extremely important in opening up new possibilities of major technological advances. Therefore, the role of S&T networks stands out;

- conversely, when the main direction of technical change is the improvement and diffusion of a technology, incremental innovations prevail. Then, the experience of production, plant design and construction, marketing and the interaction with users, suppliers and contractors become more important.

Since the new technologies have confronted most firms with a radical break in their previous trajectories, the need for information from both external and internal sources of knowledge has become even more crucial. Three major factors help explaining why the access to a wide scientific and technological base that was an advantage in earlier phases is now a necessity:

a) major innovations are based even more strongly on scientific knowledge;

b) the increased speed with which the new developments have taken place; and

c) the key role played by technological interrelatedness in the growth of new industries and in the rejuvenation of others.

All this reinforce the point that the main source of change underlying the new developments in networking for innovation lies in the new forms of the rapid development and diffusion of

generic technologies associated with the new techno-economic paradigm and especially information technology (which provides both the need for collaboration and the technical means for improving networks). As the potential for linking the information systems of separate organizations has gradually been realized (with the development and diffusion of computer networks), parallel changes in the relationship between them have occurred.

There is still an open debate about the transient and permanent aspects of the present networking phenomenon. On the one hand, there are arguments indicating that the upsurge of networking arrangements is a transitory adaptation to the diffusion of new generic technologies. On the other hand, there is the supposition that networking will grow still more important and will become the normal way of conducting product and process development in the following decades. However, its present importance is undeniable.

## **1.2. Government Policies in Developed Countries**

Collaborative arrangements are frequently promoted by governments, acting as brokers in setting up various types of R&D consortia and the promotion of R&D networking has played an important role in government R&D policy in the recent years. In Japan much of the support for industrial R&D are geared towards collaborative networking. By the late 1980s, four-fifths of all government R&D loans were allocated to joint projects, involving a number of research associations and also many other types of consortia, forums and joint research centres. On the other hand, according to Japanese firms, government intervention has had an important role in promoting inter-firm research collaboration.

The apparent success of the Japanese collaborative programmes led to the emphasis on this type of organization and funding in other countries. As one consequence, this form of

organization and funding became important in terms of US and European R&D programmes, particularly in the 1980s. By the end of the decade about two-thirds of the European Community Research Budget was disbursed in this form for the support of the new generic technologies.

### **1.3. Limited Opportunities for Less Developed Countries**

As may be inferred from the above discussion, it should be expected that less developed countries (LDCs), in principle, would not be involved in the new R&D-motivated collaborative arrangements pursuing the rapid development and diffusion of novel generic technologies. The relatively higher importance of frontier scientific knowledge and the fact that firms and countries participating in such arrangements have a long history of real commitment to R&D and science and technology-related externalities, all contribute to making it unlikely that firms in LDCs would be appealing partners. In fact, there is some evidence indicating that the difficulties of finding partners from the most advanced countries who would be interested in jointly develop research with partners in LDCs have increased during the last decade.

With the exception of the Asian NICs, the participation of companies from the less developed countries in the recent wave of new R&D-motivated collaborative arrangements is only marginal.

Among other main conclusions regarding the involvement of LDCs in such alliances are that:

a) only 4.3% of the strategic technology partnerships recorded in the period 1980/89 involve firms from those countries;

b) most arrangements concentrate on projects using relatively mature and stable technologies;

- c) very few agreements involving LDCs are R&D-oriented;
- d) considering those agreements for which technology-transfer is a major objective, the share of LDCs has fallen from 5.3% in the first half of 80s to 4.8% in the second half of the decade.

## 2. POLICY IMPLICATIONS FOR BRAZIL

Data available about networks of innovators show that the Asian NICs (countries with the highest R&D intensity in the Third World) are those which participate more frequently in international technology collaborative agreements. Successful cases (relating not only LDCs but also the most advanced countries) seem to be related to the adoption of policies which are consistently pursued aiming to build up scientific and technical infrastructure, to form and train skilled personnel and to expand the absorptive capacity of the economy.

This reinforces the urgent need to strengthen LDCs' indigenous science and technology system as well as to improve their capability to absorb external contributions. The strengthening of the scientific and technical competence of these countries cannot be expected to result from market forces alone (such as, for instance, the activities and interests of multinational companies). Therefore, the primary role of public policies of shaping the overall structure of production and the institutional set-up to promote organized learning.

Similar conclusions underlie recent contributions to economic theory and policy making. The main argument here is that the recent changes in technological competitiveness associated with the new paradigm have demanded a correspondent change in policy making. The observation that the old policy frameworks appear inadequate to deal with this new reality has provided justifications for a government strategy of networking. Above all, it has been stressed that S&T policy should not be limited to R&D support of individual firms or projects. Instead, the main objective of government policy for S&T should concentrate on:

- the early identification of important future technological opportunities;

- enhancing the rate at which information flows through the system;
- rapidly diffusing new technologies; and
- increasing the connectivity of the different constituent parts of the S&T system to accelerate the learning process.

In addition, it is argued that, compared to the support to individual projects in companies, the adoption of a **systems approach** to policy making imply a more efficient and flexible perspective to face the new challenges imposed by the new patterns of technical change.

Although it should be expected that this type of policy change would implicitly rely on a long run commitment to consistent scientific and technological development, there are important measures to be taken in the short run. Among others, the following points are suggested:

- government agencies should reconsider their mode of intervention and pursue policies aiming at exploiting more effectively the positive inter-institutional and inter-sectoral linkages of innovation. In particular, government financing institutions should shift their focus from centrally financing individual projects and firms, as they have done in the past, to financing inter-firm technical collaboration and joint R&D projects involving firms and research institutions;

- there are few, but nonetheless important, cases of domestic and international collaboration involving Brazilian firms. These cases could be reinforced and their experience used as examples of how could national advantages of technological cooperation be maximized (and its disadvantages minimized);

- local cooperation could also be promoted by government enterprises using their purchasing power, by stimulating scientific and technical collaboration among their suppliers and other contractors;

- technical cooperation with suppliers and customers should become priority policy areas not only to improve quality, but also production, process engineering and R&D. In particular, cooperation between potential users in traditional sectors (such as steel, the agro-industrial complex, paper and pulp) and developers/producers of new generic technologies should be pursued.

**INTRODUCTION**

The observation that the last two decades have witnessed a significant quantitative and qualitative increase in innovation networking has attracted much interest to the analysis of collaborative ventures world-wide. A number of studies have tried to investigate the intensity, forms and consequences of the new collaborative arrangements and to answer questions such as the following:

What is really new in networking?

What are the motives inducing firms (and other institutions) to collaborate with each other?

Is government intervention playing any significant role in the promotion of such arrangements?

Is it a temporary phenomenon to cope with the need for technological complementarities associated with the diffusion of the new techno-economic paradigm? Or is it a result of the evolution of both market and hierarchical relationships which are being replaced by new forms of organizations?

Will networking become the basis of the new style of industrial competition?

Is there an actual tendency for today's networks to become tomorrow's monopolies?

Are the new collaborative ventures circumscribed to advanced countries?

What are the opportunities and challenges faced by Third World countries?

Most of these issues will be approached in this paper. In the first chapter, section 1.1 will start (a) by defining innovation network; and (b) by classifying the most important categories of network relevant for innovation. It will then illustrate and discuss the new trends in networking: the growth of inter-firm strategic alliances in the 1980s, its geographical concentration, the main participants, sectors and forms of collaboration. Section 1.2 will examine the motives for firms to enter into cooperative R&D agreements, while, in section 1.3, the macro-causes that brought about the recent changes in networking will be investigated and section 1.4 will focus upon the role of the government in promoting R&D-motivated networks.

Chapter 2 will discuss the characteristics and level of participation of developing countries in the new collaborative arrangements, as well as it will examine the opportunities and challenges for Third World countries.

Chapter 3 will bring together the main conclusions of the discussion and, finally, chapter 4 will summarize the main policy implications deriving from the discussion developed throughout the paper.

## 1. THE INTERNATIONAL CONTEXT

### 1.1. The Growth of Strategic Alliances in the 1980s

Strategic alliances with outside firms and other institutions are not totally new, nor limited to the recent decades. However, as several studies have shown, all sort of collaborative ventures, and particularly R&D-motivated alliances, were growing rapidly in the 1970s and 1980s (Fusfeld & Haklisch, 1985; OCDE, 1986; Teece, 1986; Chesnais, 1988; Mowery, 1988 and 1989; Hladik, 1988; Hagedoorn & Schakenraad, 1990; Markusen, 1990; Freeman, 1991).

Given the outstanding importance of these new innovation alliances, much emphasis has been given to their definition, classification and interpretation. At the 'International Interdisciplinary Workshop on Network of Innovators' (Montreal, 1990), the following definition was considered as the one which best apprehends the essence of those alliances.<sup>1</sup>

**Network of Innovators** is a basic institutional arrangement to cope with systemic innovation and consists on an interpenetrated form of market organization. Empirically, networks are loosely coupled organizations having a core with both weak and strong ties among constituent members (Imai & Baba, 1989).

Table 1 lists the most important categories of network which are relevant for innovation, naming some of the authors who have worked with each category.

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<sup>1</sup> See, for instance, DeBresson & Amesse (1991) and Freeman (1991).

TABLE 1  
CATEGORIES OF NETWORKS WHICH ARE RELEVANT FOR INNOVATION

- 
- 1 - joint ventures and research corporations (Fusfeld & Haklisch, 1985; OCDE, 1986; Mowery, 1988 and 1989; Hladik, 1988; Hagedoorn & Shakenraad, 1990; Lastres, 1992)
- 2 - joint R&D agreements (OCDE, 1986; Mowery, 1988 and 1989; Hagedoorn & Schakenraad, 1990)
- 3 - technology exchange agreements (OCDE, 1986; Mowery, 1988 and 1989; Hagedoorn & Schakenraad, 1990)
- 4 - direct investment (minority holdings, motivated by technology factors) (OCDE, 1986; Mowery, 1988; Hagedoorn & Schakenraad, 1990)
- 5 - licensing and second-sourcing agreements (Hagedoorn & Schakenraad, 1990)
- 6 - sub-contracting, production-sharing and user-producer networks (von Hippel, 1988; Lundvall, 1988; Hagedoorn & Schakenraad, 1990; Freeman, 1991)
- 7 - research associations (Levy & Samuel, 1989; Ito, 1991; Freeman, 1991)
- 8 - government-sponsored joint research programmes (Fransman, 1990; Freeman, 1991)
- 9 - computerized data banks and networks for technical and scientific interchange (Bar & Borrus, 1989; van Kooiji, 1990)
- 11 - informal networks (von Hippel, 1988; Jagger & Miles, 1991; Lundvall, 1990; Erikson & Hakansson, 1990)
- 12 - other networks
- 

Note: These categories are not mutually exclusive and a number of firms are involved in several of these modes of networking and many are involved in all.

Source: Adapted from Freeman (1991) and Hagedoorn & Shakenraad (1991).

Both sectoral and global recent investigations have shown that the relevance of networking arrangements has significantly increased in the last two decades. In addition, these studies have also shown that there are qualitative differences between new and previous forms of R&D collaboration. Accompanying the interest in monitoring and interpreting the new phenomenon, the importance of establishing and operating data bases about these collaborative arrangements has also greatly increased in the last few years. The analysis below will concentrate mainly on the information provided by the MERIT Data Bank, which is probably the largest data bank in the area with information on nearly 10,000 international alliances and several thousands of companies.<sup>2</sup>

<sup>2</sup> Additional information, relying on other data banks, will be given, in the form of notes, whenever required.

The data provided by MERIT through its Cooperative Agreements and Technology Indicators (CATI) information system is based on public announcements of new agreements. Major sources for the data bank are: books, newspaper articles, and in particular, specialized technical journals which report on business events. It has some bias towards Western European and US sources, and towards firms with well-established names.

Cooperative agreements are defined as common interests between independent partners which are not connected through majority ownership. In the CATI information system only those inter-firm agreements that contain some arrangement for transferring technology or research are collected. Mere production or marketing joint ventures are excluded. The data bank does not cover informal innovation networks and its systematic coverage is confined to: **joint ventures; joint R&D agreements; technology exchange agreements; direct investment; licensing and second-sourcing agreements; and sub-contracting, production-sharing and supplier networks** (in which new technology is received at least from one partner or which involve some R&D programme).<sup>3</sup>

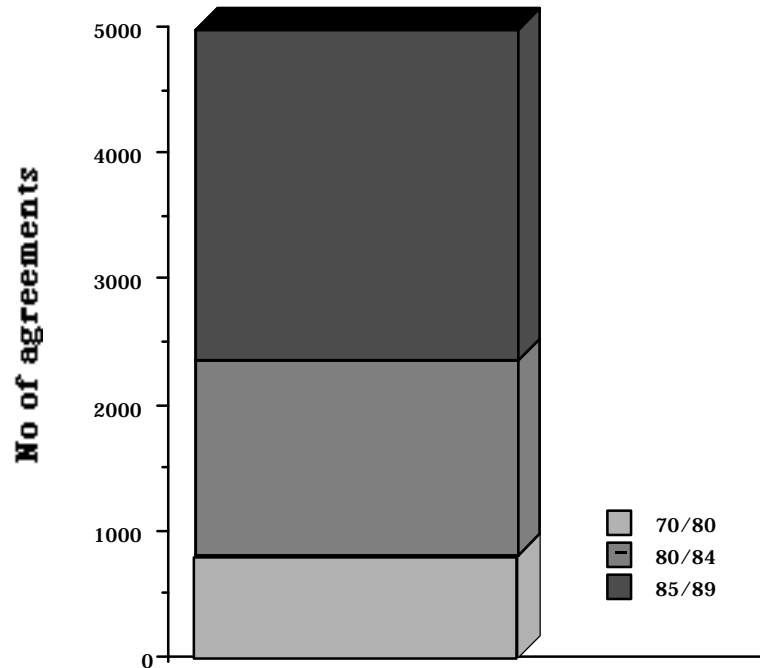
Among the main findings arising from the analysis of the data available are:

a) An extremely rapid growth of inter-firm collaborative arrangements in the 1980s. Figure 1 illustrates this growth in the number of the agreements recorded from 1970 to 1989. It shows that, compared to the period 1970/79, the number of alliances almost doubled in the following five years (1980/84), and again it more than doubled in the period 1985/89.

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<sup>3</sup> Hagedoorn and Schakenraad (1990) make a distinction between cooperative agreements which are aimed at the strategic, long term perspective of the companies involved and those cost-economizing agreements, which are considered to be more associated with the control of either transaction costs or operating costs of companies. They also remark that when strategic and cost-economizing aims cannot be dissociated, they classify the agreement as of a mixed character. Unless otherwise stated, in this paper, data about collaboration will refer to their classification of strategic technology alliances. As will be discussed below they divide these in two groups: R&D/technology/innovation driven alliances and production/market structure driven alliances. See also Hagedoorn & Schakenraad (1991).

FIGURE 1  
 GROWTH OF STRATEGIC TECHNOLOGY COOPERATION AGREEMENTS  
 1970-1989  
 (Total number of cases = 4986)



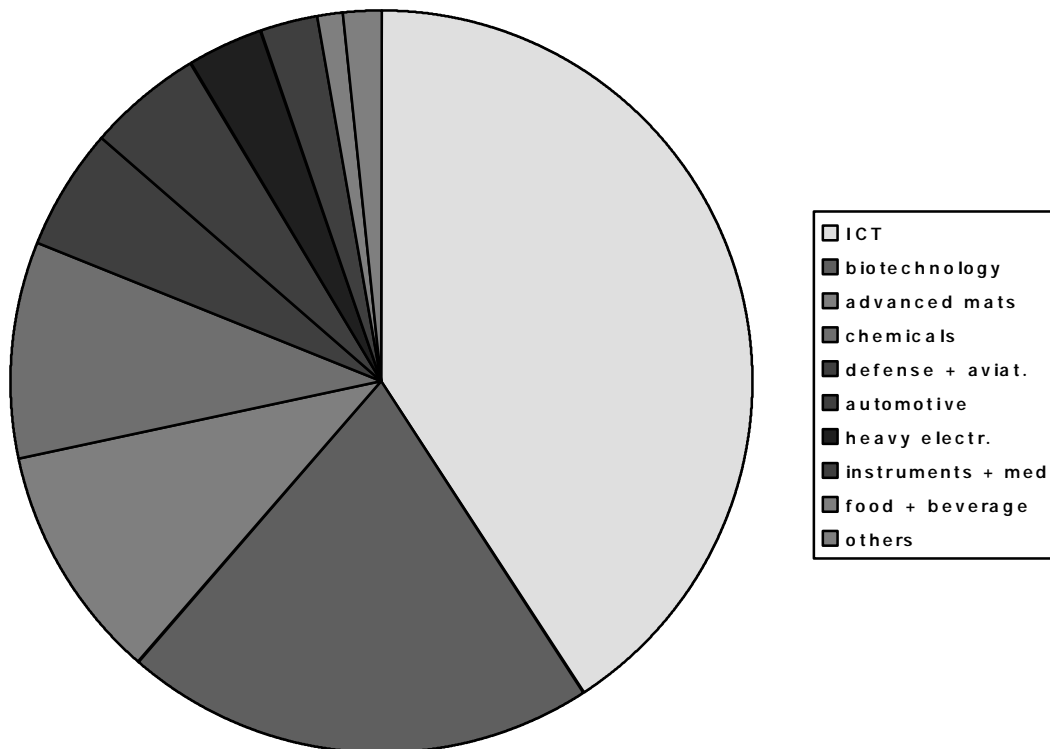
Source: MERIT - CATI data bank.

b) A concentration of the new collaborative arrangements on those fields that are characterized as high tech sectors. As Figure 2 shows, information and communication technology - ICT<sup>4</sup> (with 41.2%), biotechnology (with 20.2%) and advanced materials (with 10.3%) accounted for about 72% of all the agreements recorded from 1980 to 1989.<sup>5</sup>

<sup>4</sup> Includes a wide spectrum of technologies ranging from microelectronics, informatics and telecommunications.

<sup>5</sup> Fusfeld and Haklisch (1985) argue that the main targets of collaboration have varied throughout the years. The associations established from 1900 through the 1960s primarily served the automotive, food, paper and textile industries. In the 1970s the associations to serve the chemical and energy industries predominated. Since the 1980s, the main concern has concentrated on the support, development and diffusion of information technology, biotechnology, and advanced materials.

FIGURE 2  
 TECHNOLOGY COOPERATION AGREEMENTS ACCORDING TO ECONOMIC  
 SECTORS  
 1980-1989  
 (Total number of cases = 4192)



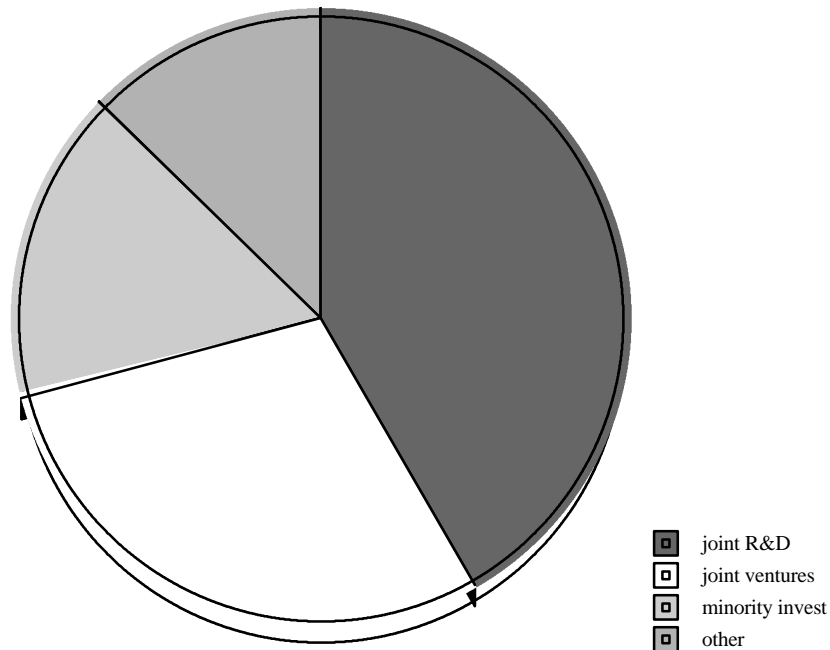
Source: MERIT - CATI data bank.

c) A concentration of the new agreements on the research base that directly underlies firms' competitive interests.<sup>6</sup> As Figure 3 indicates, the group of R&D pacts is the largest category of partnering with a share of more than 40%. It is followed by joint ventures with about 30%; minority investments with over 16%; and other modes of cooperation (mainly R&D

<sup>6</sup> Some authors, have argued that the new agreements are mostly centred around the pre-competitive (or pro-competitive) technical base of firms, such as, basic research (or, at least, less applied in character and less closely linked to a specific commercial product), education and dissemination of technical information (Fusfeld & Haklisch, 1985; Mowery, 1989).

contracts and second-sourcing agreements, which amount to nearly 13%).

FIGURE 3  
 MODES OF TECHNOLOGY COOPERATION AGREEMENTS  
 1980-1989  
 (Total number of cases = 4192)



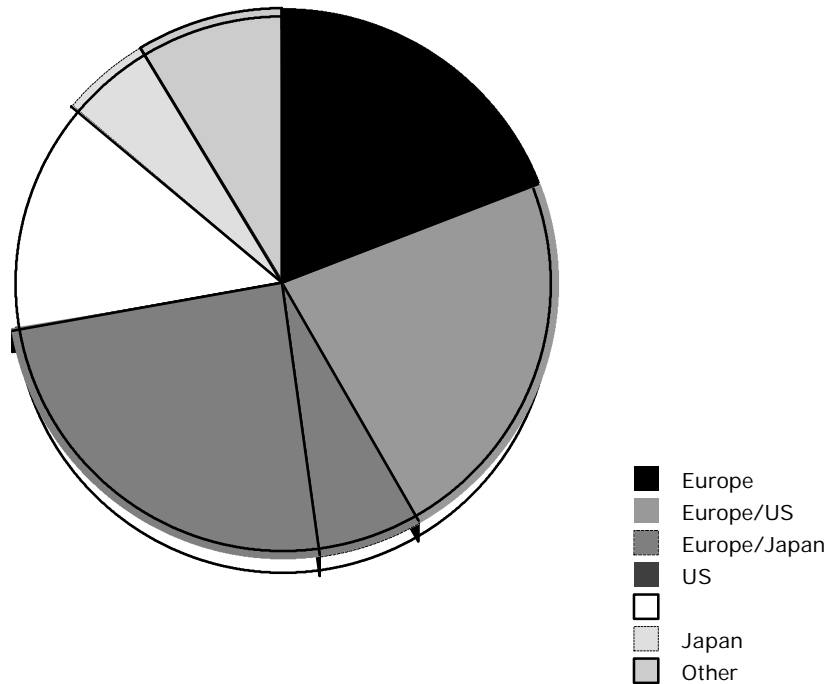
Source: MERIT - CATI data bank.

d) A geographical concentration of collaborative agreements on the advanced countries. The so-called Triad (the US, Japan, the EC and EFTA countries) accounted for over 90% of all the agreements recorded<sup>7</sup> in the 80s and only the Asian NICs entered the picture in significant numbers from outside.

<sup>7</sup>

As already noted, the information regarding Japanese agreements in the MERIT/CATI data bank is considered to be underestimated. However, it is worth stressing that 7 out of the top fifteen companies with most strategic alliances in the 1980s are Japanese. In addition, 3 out of the top 4 are large Japanese conglomerates. See Table A.2 in the Appendix.

FIGURE 4  
 DISTRIBUTION OF TECHNOLOGY ALLIANCES WITHIN ECONOMIC BLOCKS  
 1980-1989  
 (All sectors - total number of cases = 4192)



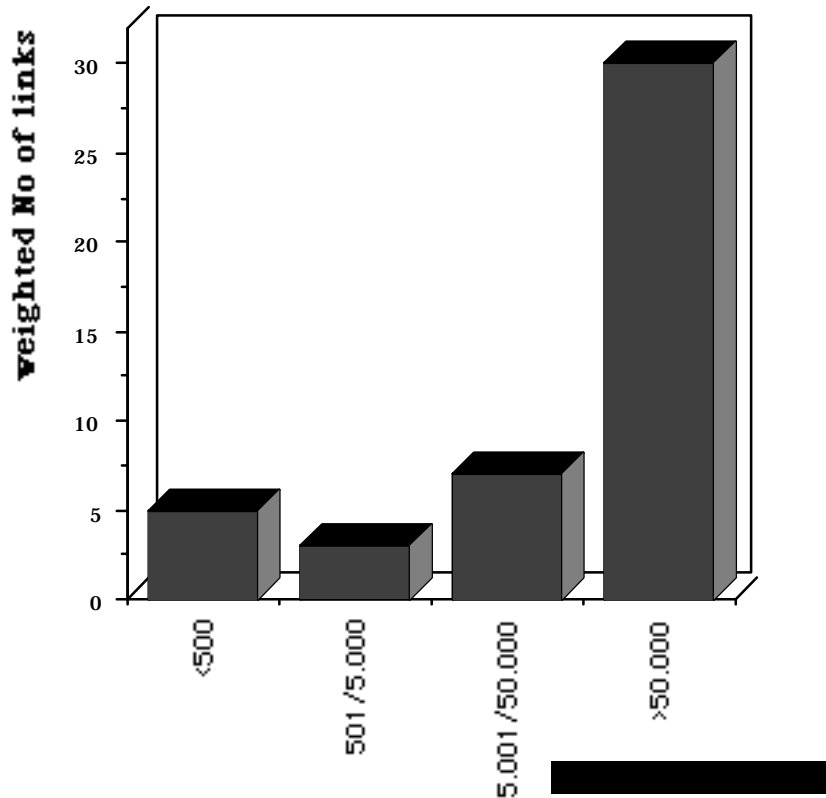
Source: MERIT - CATI data bank.

apart from the group of small firms. On average, large and very large firms appear to be more cooperation intensive. Figure 5

dominance of large, multinational and diversified companies is also confirmed by Table A.2 in the Appendix, which lists the top

The available data also shows that many firms make use of several different arrangements simultaneously.

FIGURE 5  
COOPERATION INTENSITY AND SIZE OF FIRMS  
1980-1989



Source: MERIT - CATI data bank.

### 1.2. Motives for the Changes in Innovation Networking

In trying to understand the growth of innovation networks and the qualitative changes in their mode of operation in the 1980s (and also their implications for policy making and research in the 1990s), the motives for firms to enter into cooperative R&D agreements have been investigated.

It was found out that, in contrast to much of the previous literature, considerations of cost-sharing and cost-minimization appeared to play a relatively small role in comparison with strategic objectives relating to new technologies and markets. Therefore, according to empirical evidence, strategic behaviour

of firms (**rather than costs** explosion in innovation networking. Table 2 lists the predominant motives found out by a number of authors when

TABLE 2  
MOTIVES FOUND IN THE LITERATURE FOR THE NEW COOPERATIVE R&D

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1986;  
Mariotti & Ricotta, 1986, Mytelka & Delapierre, 1987; Obleros & MacDonald, 1988; Hladik, 1988; 1989; Freeman, 1991; Saxenian, 1991)

- shortening of product life cycle, reduction of the period between invention and market (OCDE, 1986; Mariotti & Ricotta, 1986)
- cross fertilization of scientific disciplines and fields of technology, technological synergies, to scientific knowledge or complementary technology, acquisition of core competencies (OCDE, 1986;

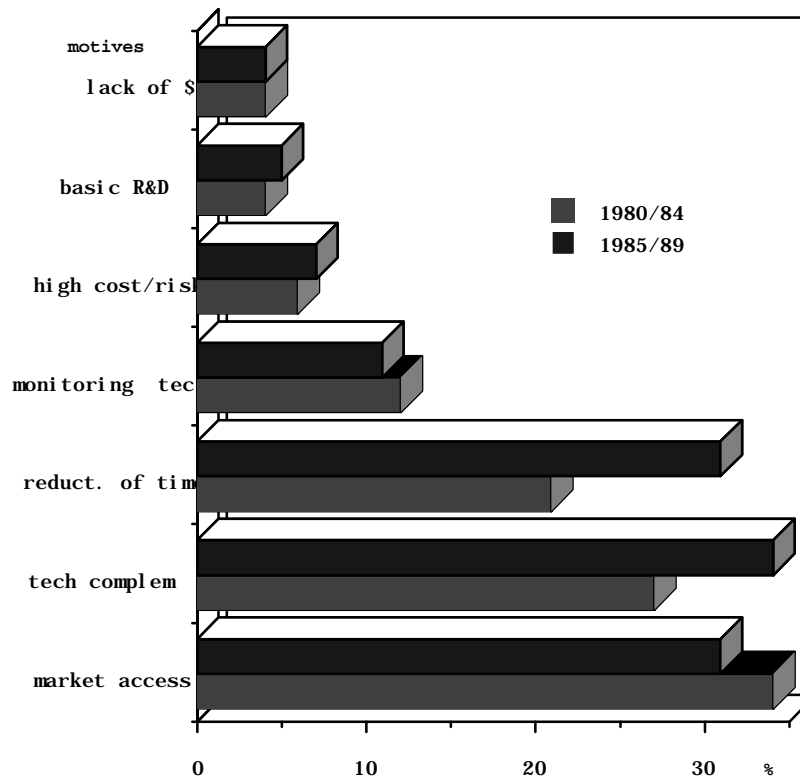
1987;  
Obleros & MacDonald, 1988; Mowery, 1988; Hladik, 1988; von Hippel, 1988; Lundvall, 1990; Hagedoorn Schakenraad, 1990; Saxenian, 1991; Freeman, 1991; Lastres, 1992)

- monitoring of environmental changes and opportunities (Mariotti & Ricotta, 1986; Freeman, 1987; & MacDonald, 1988; Mowery & Rosenberg, 1989; Ito, 1991; Freeman, 1991; Lastres, 1992)
- strategies relating to technological competence and market access and positioning (Hladik, 1988; 1986; Mariotti & Ricotta; Porter & Fuller, 1986; Mowery, 1988; Hagedoorn & Schakenraad, 1990; Freeman,
- internationalization, globalization and entry to foreign markets (OCDE, 1986; Porter & Fuller, 1986;

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Figure 6 presents the relative weight for the main motives for strategic alliances according to the information available **market access and influencing the market structure technology complementarity reduction of the innovation time-span** have technology cooperation.

FIGURE 6  
 MOTIVES FOR STRATEGIC ALLIANCES  
 1980-1989  
 (All sectors - total number of cases = 4192)



Source: MERIT - CATI data bank.

However, the figure also shows that, while the relevance of **technological complementarity** and of **reduction of time span** has increased during the second half of the past decade, the importance of **market access** has slightly decreased in the same period. Therefore, the former two main motives are now considered as the most important for companies to engage in technology cooperation.

A complementary discussion here refers to the main advantages and disadvantages for collaboration. Although the establishment of the new collaborative ventures are a reasonably recent phenomenon, some studies have already approached the



TABLE 3  
SOURCES OF IDEAS AND INFORMATION FOR NEW TECHNOLOGY

- 
- 
- (1) in-house research, design and development;
  - (2) experience in production, quality control and testing;
  - (3) experience in marketing and feedback from users;
  - (4) experience in plant design and construction and feedback from contractors and suppliers;
  - (5) scanning the world scientific and technical literature, patents and other information sources;
  - (6) analysis of competitors' strategies and developments (including, for instance, the practice of reverse engineering);
  - (7) recruitment of engineers and scientists;
  - (8) contact with university science and engineering faculties;
  - (9) contact with government research organizations;
  - (10) consultancy arrangements with (8) and (9);
  - (11) acquisition of other firm or merger;
  - (12) joint venture;
  - (13) cooperative research arrangements;
  - (14) licensing and cross-licensing of new products, processes and know-how;
  - (15) contract research;
  - (16) other.
- 

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Source: Based on Freeman (1989 and 1990).

The idea that the generation and maintenance of firm competitive advantages will depend greatly on a creative combination of scientific and technical inputs from external and internal sources has become now common sense in the literature. However, a first point to stress is that the very ability to pose a feasible research problem, to select, evaluate and negotiate and finally adopt a new technology may require substantial technical expertise within the firm. Therefore, it has been greatly emphasized that firms invest in in-house R&D not only to pursue directly new process and product innovation, but also to develop and maintain their broader capabilities to

recognize, assimilate and exploit externally available information.

This emphasizes the point that licensing and other forms of inter-firm transfer of technology cannot be seen as possible substitutes for indigenous innovative activities. As Mowery and Rosenberg (1989) stress, where such expertise is lacking, cooperative research organizations often have been unsuccessful in industry. **"The difficulties inherent in the provision of research on a contractual or arm's-length basis can undercut the effectiveness of these organizations in industries with little or no in-house R&D activity"** (p. 290).<sup>8</sup> Also as Freeman, 1991, stresses, **"it is not just a question of getting a lot of 'information'; often there is a overload of information. The problem of innovation is to process and convert information from diverse sources into useful knowledge about designing, making and selling new products and processes"** (p. 501).

In trying to interpret the recent wave of networks of innovators, it has been stressed that the combination of scientific, technical and market information from external and internal sources will vary according to a number of aspects: with companies' size and structure, type of industries, national environment, each different techno-economic paradigms, type of technology and innovation (process, product, service, organization), and also with the nature of the innovation (Freeman, 1991). The main points of the latter argument can be summarized in the following way:

- at times when there is a radical discontinuity in technology systems, scientific knowledge becomes extremely important in opening up new possibilities of major technological advances. Therefore, the role of S&T networks stands out - points (1) and (5) to (15) in Table 3 above.

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<sup>8</sup>

This argument has been particularly reiterated in the analysis of the Japanese import and exploitation of foreign technologies during the post-war period, when firms invested heavily in research as a means of absorbing and modifying technologies from external sources (Goto & Wakasugi, 1987).

- conversely, when the main direction of technical change is the improvement and diffusion of a technology, incremental innovations prevail. Then, the experience of production, plant design and construction, marketing and the interaction with users, suppliers and contractors become more important - points (2) to (4).<sup>9</sup>

Despite the emphasis on the cumulateness of the process of innovation and the acknowledgement that past success constrains the future, it is recognized that there are times when the very strength of a particular technological tradition may inhibit further innovation. Technological discontinuities inevitably result in obsolescence (not only of plant and equipment, but also of individual and organizational skills, experience and culture). This is most obvious in the cases where the new technology seems to be heading in a direction totally unrelated to the firm's main technologies and markets. Or worse yet, when the new technology seems destined to become a substitute for some of the firm's established core technologies. Even in the case that an established firm has developed a radically new technology which complements its established technologies and markets, it is probable that the firm's existing productive units, and perhaps also its management, may be poor receptors for the new technology. In particular, it is worth stressing that, at the level of both the industry and the nation, the management systems - which have been developed to promote one type of technology - are generally inappropriate for entirely new technologies (Perez, 1983; Freeman & Perez, 1988; Dosi, Pavitt & Soete, 1990; Obleros & MacDonald, 1988; Achilladelis, 1991<sup>10</sup>; Lundvall et al., 1992).

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<sup>9</sup> A number of empirical studies have emphasized the determinant role of the interaction with contemporary and future users of an innovation, not only in the case of incremental innovation, but also radical innovations (Lundvall, 1988 and 1992; von Hippel, 1988; Schmitz & Cassiolato, 1992).

<sup>10</sup> "Firms which fail to recognize the importance of a new paradigm and do not shake-off their inertia will tend to have their technology and market positions eroded. If, on the contrary, they move quickly to assimilate the new technology, they may, by introducing a market successful radical innovation, create a new Corporate Technology Tradition and prolong their dominance over technology and markets for much longer periods of time" (p. 55).

Since the new technologies have confronted most firms with a radical break in their previous trajectories, the need for information from external sources of knowledge has become even more crucial. Therefore, three main factors help explaining why the access to a wide scientific and technological base that was an advantage in earlier phases is now a necessity (Chesnais, 1988; Freeman, 1991): (a) major innovations are based even more strongly on scientific knowledge; (b) the increased speed with which the new developments have taken place; and (c) the key role played by technological interrelatedness in the growth of new industries and in the rejuvenation of others have been emphasized.

This would help explaining why a marked characteristic of the 80s has been a rapid proliferation of new agreements, consortia and collaborative R&D programmes. Networking has become of critical importance for effective innovation and particularly to provide more rapid access to technological capabilities that are not well developed within a firm. As seen in section 1.1, all sort of firms have entered into a series of R&D collaborative arrangements, particularly those large multinationals - which often have huge in-house R&D facilities and have resources greater than many small countries.<sup>11</sup>

In addition, it has been emphasized that at the same time that the new paradigm requires more collaboration within and between the scientific and technological institutions and firms, ICT facilitates it, by making feasible to rapidly communicate, transmit data and design drawings, use common data banks, pool patent data, etc. and by favouring rapid changes in design, customization and flexibility. As a corollary, it is argued that **"ICT is a networking technology par excellence"** (Freeman, 1991: 509). Therefore, as the potential for linking the information systems of separate organizations has gradually been realized

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<sup>11</sup> Freeman (1991) points out "characteristic of periods of change in techno-economic paradigm is the rise of new firms associated with competence in the new technologies and the strategic re-positioning of many established firms as they try to cope with the rapid structural and technical change affecting their markets and their very existence" (p. 509). See also Fusfeld & Haklisch (1985); Chesnais (1988); Mowery (1988); Dalum, Johnson & Lundvall (1992); Freeman (1993).

(with the development and diffusion of computer networks), parallel changes in the relationship between them have occurred. This also reinforces the idea of interrelatedness between technical and organizational innovations, which are mutually determining and mutually dependent.<sup>12</sup>

Finally, it is worth mentioning in this section that there is still an open debate about the transient and permanent aspects of the present networking phenomenon. On the one hand, there are arguments indicating that the upsurge of networking arrangements is a transitory adaptation to the diffusion of new generic technologies.

These arguments find support in the evidence provided by the MERIT data bank, which shows that, in the second part of the 80s, there has been a decline in the creation of new alliances (Hagedoorn & Schakenraad, 1990). The hypothesis here is that as firms become more familiar with the new technologies, they would tend to internalize some of the networks which are now subject of cooperative arrangements. According to this view, a wave of industrial re-concentration - which, some claim, have already started with the take-over of important small firms by larger ones - would predominate during this and the next decades. In addition, it is argued that some of the service networks are already controlled by "electronic cartels".<sup>13</sup>

On the other hand, there are those who argue that networking will grow still more important and will become the normal way of conducting product and process development. This group includes mainly: (a) those analysts who see the recent growth of collaborative arrangements as the result of the evolutionary and changing aspects of firm organization and behaviour, and who claim that now market and hierarchical relationships are being superseded by these new forms of organization (Chandler, 1990; Fransman, 1990; Okimoto, 1988; Imai & Baba, 1989; Imai, 1989<sup>14</sup>, Best, 1990<sup>15</sup>) associated with

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<sup>12</sup> See also Webster (1993).

<sup>13</sup> See, for instance, Bressand & Calypso (1989).

<sup>14</sup> Imai (1989), for instance, argues that the evolution of Japanese industrial networks (since the pre-war zaibatsu networks) has produced a new type of production system.

(of various kinds) has been a normal feature of the industrial and regional landscape for many years, its association to industrial structure and behaviour. This view emphasizes the interrelatedness of IT and networking (as indicated above) as and complexity of its application (Freeman, 1991).

#### 1.4. Role of the Government in Promoting R&D Networks

governments, acting as brokers in setting up various types of R&D consortia and the promotion of R&D networking has played an (Arnold & Guy, 1987; Fransman, 1990; Best, 1990; Freeman, 1991; Lundval, 1992; Lastres, 1992; Dodgson, 1993; Larédo & Mustar,

In Japan much of the support for industrial R&D are geared towards collaborative networking. By the late 1980s, four-fifths involving a number of research associations and also many other types of consortia, forums and joint research centres (Fransman,

16

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15 new from the argues that "the new competition (which involve not only transformed principles and practices within enterprises, but extends to buyer- . ... Without the extra-firm infrastructure, enterprises seeking to become entrepreneurial firms will likely pursue a 'go it (p. 21).

16 promoting inter-firm research collaboration. The small number of cases involving spontaneous inter-firm research cooperation was stressed by Fransman (1990) when analysing collaboration in in the Japanese computer and electronic devices industry the author was able to discover only two examples in the post-war period, involving cooperation; that is cooperation arranged privately between the cooperating firms without the intervention of government agencies or a large procurer." arrangements were found to be made between companies themselves, similar conclusions were reached in the investigation about collaboration in Japan in the areas of advanced materials

The apparent success of the Japanese collaborative programmes led to the emphasis on this type of organization and funding in other countries. As one consequence, this form of organization and funding became important in terms of US and European R&D programmes, particularly in the 1980s. By the end of the decade about two-thirds of the European Community Research Budget was disbursed in this form for the support of the new generic technologies (Fusfeld & Haklisch, 1985; Mytelka & Delapierre, 1987; Sharp, 1991; Larédo & Mustar, 1993).

Some other important measures have been adopted aiming to facilitate networking and promote a closer relationship between firms and between them and other institutions. Perhaps the most significant example of this new approach is the pressure towards the removal of regulatory obstacles to the formation of joint ventures (such as the modification of the US antitrust legislation, as in the case of the adoption of the US National Research Act of 1984, which minimizes penalties resulting from collective R&D) (Jorde & Teece, 1989; Mowery & Rosenberg, 1989; Nelson, 1992).

Of course, as noted in section 1.3, cooperative programmes alone are insufficient to transform the innovative performance of firms. The development of sufficient expertise within these firms is required for their utilization of the results of externally performed research. Therefore, concomitantly with the increase in networking, there has been a tendency in the largest and most powerful firms to build up/reinforce their own in-house basic research laboratories. As stressed above, these tendencies are not mutually exclusive; on the contrary, they represent two aspects of the same process.

However, as also stressed above, many of the economic and technical advantages that the new techno-economic paradigm make possible depend on extensive structural change and institutional and social innovations (including the education and training system, the industrial relations system, managerial and corporate structures, the capital markets and financial systems,

the pattern of investment, the legal and political framework, and the international framework within which trade and recognized that (a) there is usually more resistance to institutional change than to technical change; and that (b) the process if left to itself in a period of radical change (Freeman & Perez, 1988; Achilladelis, 1991; Lundvall et al., 1992).

**institutional sclerosis** built into the as the main reason for their inadequate response to the challenges of the 1970s and 1980s. A number of studies have and social changes and pointed to crucial interconnections between industrial policies, policies for science and & Soete, 1987; OECD, 1988; Johnson, 1992).

In a more detailed analysis, the six of the US economy - identified by the MIT in its report "Made in reasons for the failure of the US system to adapt to the potential of the new techno-economic paradigm. The report obstacles hampering US firms to capture the full economic benefits from exploiting recent scientific advances. It also to the mass production paradigm, with its rigid departmental structures, craft skills, sequential and inflexible procedures time horizons which limit US firms' strategies (including particularly those related to R&D) and particularly stresses management and unions, and among various types of firms. It is then emphasized that, even though the need for change is at the root of the productivity problem are notoriously hard to

change and involve deep transformations. **"Change if it is to occur will have to take place on a broad front involving firms, government, educational institutions and organized labor"** (Dertouzos et al., 1989:45).

Therefore, the role of government in stimulating the renewal or breaking-up of those mature development blocks locked into old technological trajectories, and in supporting the formation of new ones has been recognized as particularly important. Of course this role is not circumscribed to the promotion of particular R&D projects. It has also to deal with all sort of policies concerning education and training, diffusion, adaptation and effective exploitation of new technologies, incentives for investments in new equipment and various other aspects related to the general economic and social environment. Finally it has been stressed that (a) this match-maker role can be assumed either by direct government intervention or by non-governmental institutions; and that (b) there already exist institutions more or less efficiently playing such a role. Examples include: the German banks, the military complex in the US, MITI in Japan (particularly in bringing together parties that would not spontaneously collaborate) and the welfare-state in Scandinavia (Freeman, 1989; Best, 1990; Dalum, Johnson & Lundvall, 1992).

A number of studies have provided empirical and theoretical justifications for a government strategy of networking (DeBresson, 1989; Carlsson & Jacobsson, 1992; Dalum, Johnson & Lundvall, 1992<sup>17</sup>). They suggest that if policy makers adopt a system perspective and an evolutionary, instead of a static, approach, they would recognize that S&T policy should not be limited to R&D support of individual firms or projects. The emphasis would then shift from the pursuit of individual technologies to the early identification of important future

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<sup>17</sup> Dalum, Johnson and Lundvall (1992) argue that the need for and role of state intervention will differ drastically between national systems. Above all, the primary role of shaping the overall structure of production and the institutional set-up to promote self-organized learning and thereby reduce the need for fine-tuning and detailed intervention into the economy is emphasized.

capacity of the economy. In addition, it is argued that, compared to the support to individual projects in companies compete in individual product areas), the **evolutionary and** to policy making imply a more flexible and efficient perspective.

policy for S&T should concentrate on: (a) rapidly diffusing new technologies, so that the entire local industries procure and

competitors;<sup>18</sup>

through the system, so that the general awareness of the technological opportunity set is raised and the visions are

constituent parts of the scientific and technological system to accelerate the learning process.

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18

new technologies are the existence of (a) market and non-market connections between firms and other economic actors (b) an efficient educational system; (c) an adequate information and and of linking the different actors of the system; (d) centres of excellence capable of integrating various technologies (Carlsson & Jacobsson, 1992; Stankiewicz, 1991).

## 2. ASSESSMENT OF THE OPPORTUNITIES AND CHALLENGES FOR THIRD WORLD COUNTRIES

Most data bases and investigations about networking and R&D-motivated collaborative arrangements focus on activities involving advanced countries' firms. The main argument to justify this is that firms in LDCs have not participated with the same intensity as their advanced countries' counterparts in the new forms of collaboration. However, it is also true that information about networking in LDCs is not frequently available.

It is well known that there are enormous difficulties in obtaining comparable data and information about different countries, whichever their level of development. But it is undeniable that the most mature economies are generally in better conditions to provide better information, and that most international data bases rely on information (often in English) offered by those countries. That is one reason for the above mentioned bias towards the US and Western European countries in the international comparison about collaborative arrangements.

However, it is often argued that if LDCs were in fact active partners in those collaborative arrangements, they would have been participating intensely, not only in regional, but also in international collaborative activities. Therefore, it is claimed that even if information about regional collaboration were not available, LDCs participation in international collaborative arrangements would be accessible.

Both arguments would then be coherent with the fact that even if information about collaborative arrangements in East Asian countries (and even in Japan) is underestimated, the data available indicates that there has been much more collaboration there than in other industrializing area.

in section 1.3), it should be expected that LDCs, in principle, would not be involved in the new R&D-motivated collaborative novel generic technologies. The relatively higher importance of frontier scientific knowledge, the fact that firms and countries commitment to R&D and to science and technology-related externalities, and the high costs and risks involved, all appealing partners in these new innovation networks.

These general conclusions are confirmed by the evidence findings of the analyses concerning the involvement of LDCs using this system are that: (a) only 4.3% of the strategic technology alliances and 5% of the technology transfer Figure 7); (b) the countries which participate more frequently in international technology collaborative agreements in the <sup>20</sup> (c) with

East Asian Dragons in **microelectronics** **miscellaneous IT**, the most significant sectors where arrangements involving LDCs occur are those characterized as of low or medium **automotive; chemicals; and beverages**); (d) partnership with companies from developing countries are to a large extent organized through joint oriented (less than 13% of the total); (f) considering those agreements for which technology-transfer is a major objective,

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20 This evidence reinforces the argument made in section 1.3 concerning indigenous innovative activities and the use of external sources of knowledge.

21

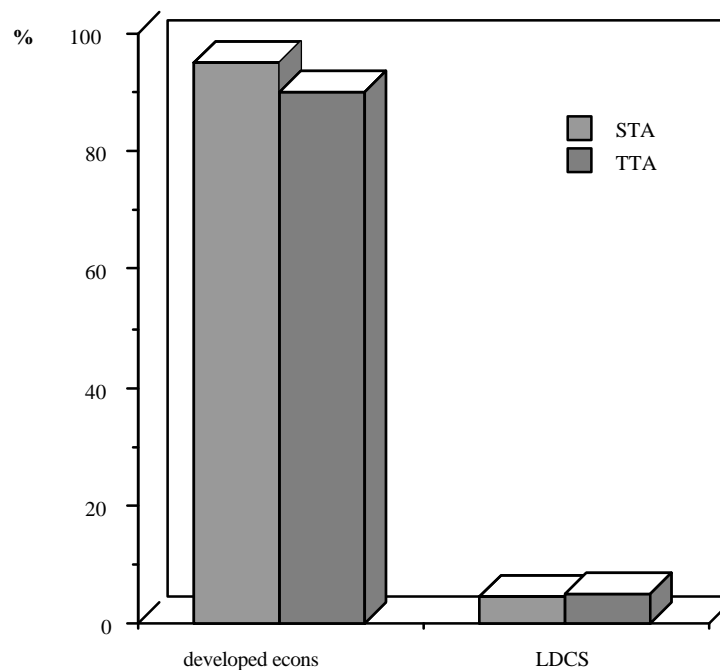
22 Discussing cooperative strategies in developing countries, Oman (1988) also found out that, in using relatively stable or mature technologies. He makes a distinction between non-traditional and traditional foreign direct investment - TFDI includes joint ventures in which foreign equity does not exceed 50%, licensing agreements, management contracts, franchising, turnkey and "product-in-hand" contracts, production-sharing at least 50% locally owned).

the share of LDCs has fallen from 5.3% in the first half of 80s to 4.8% in the second half.<sup>23</sup>

FIGURE 7  
COMPARISON OF THE INTERNATIONAL DISTRIBUTION OF STRATEGIC  
TECHNOLOGY ALLIANCES WITH INTER-FIRM TECHNOLOGY TRANSFER  
AGREEMENTS

1980-1989

(All sectors - total number of cases = 4192)



STA = strategic technology alliances

TTA = technology transfer agreements

Source: MERIT - CATI data bank

These figures contrast greatly with those discussed in chapter 1 about the participation of firms from the Triad in the new cooperative strategies.

As noted before, most studies available do not refer exclusively to LDCs and these new forms of collaboration and, as with the case of the data provided by MERIT, they tend to focus

<sup>23</sup> This confirms the pessimistic conclusions concerning LDCs drawn by the OECD TEP report.



hand, the availability of samples for research and development greatly depended on the Brazilian supply. On the other hand, local scientists and researchers had, throughout the years, developed significant research capability on those metals, which conferred them participation in world level research.<sup>24</sup>

Nevertheless, with the advent of the ceramic superconductors, this picture has been much altered. Obviously, it is still important to develop research into metallic low temperature superconductors. However, it is undeniable that the new high temperature ceramics are now at the central stage of the research into superconductivity world-wide and that the Brazilian appeal and comparative advantages have greatly declined in this area (Lastres 1992).

Of course this is just one illustration, from which one cannot draw conclusions upon. However, it is worth stressing that in the area of materials technology as a whole, a similar trend has been confirmed. With the recent so-called advanced materials revolution, a pronounced shift in the intensity of different materials usage has taken place during the last two decades. The previous growth of consumption of major bulk materials has been broken and nowadays there is a more rapid increase in advanced materials consumption.<sup>25</sup> On the other hand, it is worth stressing the increased sophistication of the new processes and methods required by the R&D, production and commercialization of the new synthetic materials (Lastres, 1992). The changes experienced in this sector have been so complex that it is not by chance that, as the analysis above indicates, advanced materials represent one of the main areas of

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<sup>24</sup> The characterization of the constituting elements of the metallic alloy (which is essential for any research work dealing with such material), for instance, could even be seen as an naturally exclusive area of specialization for Brazilian researchers.

<sup>25</sup> From some materials producers' point of view, particularly developing countries, the advanced materials revolution poses important challenges. Strategies based on producing for export ores and basic metals are becoming more and more vulnerable. A significant number of developing countries have had exports of minerals and basic metals as the core of their growth strategies. In 1989, various countries among the LDCs had more than 50% of their exports originating in the mineral sector: Zambia (92%), Zaire (85%), Guinea (83%), Bolivia (80%), Congo (76%), Chile (57%), Peru (55%), Papua New Guinea (54%) and Togo (53%). Even bigger countries which have implemented more sophisticated economic structures like Brazil and Australia have a significant share of their export revenues (15% and 32% respectively) derived from mineral production (Lastres, 1992).

interest in the new wave of R&D-motivated collaborative ventures practised centrally in advanced economies.

of diffusion of the new generic technologies on LDCs. Specifically in terms of the central issue of this paper, a

forms of new collaborative arrangements involving less developed countries, both in those mature and new areas of technologies,

constraints for those countries to participate in the so-called innovation networks, is highly recommended.

and international collaboration involving Brazilian firms. These cases could be reinforced and their experience used as examples

maximized (and its disadvantages minimized).

### 3. CONCLUSIONS

This paper has argued that networking has always been important, but it has also shown that (a) the importance of networking arrangements has hugely increased in the last two decades; (b) there are qualitative differences between the new and previous forms of R&D collaboration.

The facts that (a) major innovations are based even more strongly on scientific knowledge; (b) the increased speed with which the new developments have taken place and (c) the key role played by technological interrelatedness in the growth of new industries and in the rejuvenation of others, all help explaining why the access to a wide scientific and technological base that was an advantage in earlier phases is now a necessity.

The main source of change underlying the new developments in networking for innovation lies in the new forms of the rapid development and diffusion of generic technologies associated with the new techno-economic paradigm and especially information technology (which provides both the need for collaboration and the technical means for improving networks).

The paper has also noted that (a) many of the economic and technical advantages that the new paradigm make possible depend on extensive structural change and institutional and social innovations; and that (b) the structural adaptation of the economy will be a slow and painful process if left to itself in a period of radical change. In addition, it has stressed that the promotion of R&D networking has played an important role in government R&D policy in the recent years.

There are few institutions from less developing countries participating in the new forms of collaborative ventures, as well as presenting reasonable conditions to do so. In contrast with what is happening among firms belonging to the most advanced countries, the articulation between North and South

does not seem to have experienced a major change. The motives and forms of articulation remain practically unaltered. The few exceptions in this picture seems to be confined to the East Asian NICs.

Among other main conclusions stressed in this paper regarding the sharp contrast between advanced countries and LDCs involvement in cooperative arrangements are:

- more than 95% of the strategic technology partnerships recorded in the period 1980/89 involve advanced economies, while only 4.3% involve firms from LDCs countries;

- while 72% of the strategic collaborative arrangements involving advanced countries concentrate on those new generic technologies, the most significant sectors where arrangements involving LDCs occur are those characterized as of low or medium technology content;

- while for the group of advanced countries joint R&D agreements consist in the largest category of partnering, with a share of more than 40%, partnerships with companies from developing countries are to a large extent organized through joint ventures;

- over 50% of the alliances between companies from the developed economies are strongly oriented towards R&D, however only less than 13% of the agreements involving LDCs are R&D-oriented;

- considering those agreements for which technology-transfer is a major objective, nearly 90% of the total registered in the 1980s are made between the companies from the advanced economies. While this share increased throughout the decade, the share of LDCs fell from 5.3% in the first half of 80s to 4.8% in the second half.

This situation offers important reasons for reflection. Developing countries are participating only marginally in the

transfer.

As this paper has attempted to show, networking has become more rapid access to the new technologies associated with the information and communication paradigm. Firms pursuing a "go it a competitive disadvantage in the international arena.

The paper has pointed out that it is not yet really networking will remain and which are transitory; and how it will affect industrial concentration, reinforcing monopolies and networks throughout the 1990s.

However, as argued in chapter 1, (a) the new R&D-motivated possibilities of major technological advances; and (b) there are reasons to believe that networking will grow still more product and process development. Therefore, returning to the title of this paper, there is reasonable evidence that the to most Third World countries seem very high, while the opportunities seem very distant.

a deeper investigation about the real level of involvement of LDCs in collaborative ventures, the constraints, as well as the

#### 4. POLICY IMPLICATIONS

The present threats faced by Third World countries point to the urgent need to strengthen their indigenous science and technology system as well as to improve their capability to absorb external contributions. Of course, the reinforcement of the scientific and technical competence of LDCs cannot be expected to result from market forces alone (such as, for instance, the activities and interests of multinational companies).

The need for agencies playing the role of match-maker, renovating or breaking up old relationships and establishing new ones and the importance of the adoption of consistent policies - aiming to build up scientific and technical infrastructure, to form and train skilled personnel, to shape the overall structure of production and to enlarge the absorptive capacity of the economy - were particularly stressed in the paper.

Obviously, it would be a mistake to believe that technology and industrial policies alone, however well-conceived and executed, could free market economies from their present difficulties. In the same way, the paper has stressed that, however good other parts of the system are, the basis for the development and accumulation of technologies, of course, lies in the firm. Therefore, the emphasis to the importance of these R&D-motivated collaborative arrangements, which lies in enlarging the path for such accumulation, by enabling firms to make their own technology accumulation and by facilitating access to the sources of new technology.

Recent contributions to economic theory and policy making have also suggested the adoption of an **evolutionary and systems approach to policy making** and have provided empirical and theoretical justifications for a government strategy of networking. The main argument here is that the recent changes in

technological competitiveness associated with the new TEP have demanded a correspondent change in policy making.

According to this view, old policy frameworks appear inadequate to deal with the new reality. Above all, it has been stressed that S&T policy should not be limited to R&D support of individual firms or projects. Instead, the main objective of government policy for S&T should concentrate on: the early identification of important future technological opportunities; rapidly diffusing new technologies; enhancing the rate at which information flows through the system; and on increasing the connectivity of the different constituent parts of the S&T system to accelerate the learning process.

Although it should be expected that the required policy changes would implicitly rely on a long run commitment to consistent scientific and technological development, there are important measures to be taken in the short run. Among others, the following points are suggested:

- government agencies should reconsider their mode of intervention and pursue policies aiming at exploiting more effectively the positive inter-institutional and inter-sectoral linkages of innovation. In particular, government financing institutions should shift their focus from predominantly financing individual projects and firms, as they have done in the past, to financing inter-firm technical collaboration and joint R&D projects involving firms and research institutions;<sup>26</sup>

- local cooperation could also be promoted by government enterprises using their purchasing power, by stimulating

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<sup>26</sup> Of course international experiences vary greatly regarding each national environment and also regarding: (a) type of institutions in charge with promoting innovation networks; (b) instruments and mechanisms used to stimulate collaboration; (c) areas subject of collaborative programmes. In addition, the level of difficulty in promoting innovation networks, as well as the level of success of each particular initiative also vary greatly. As stressed in section 1.4, only in Japan, a number of consortia, forums and joint research centres have been established. Each of those have distinct characteristics and *modus operandi*. For a in depth analysis of a recent collaborative research programme involving the establishment of a joint research facility in Japan see, for instance, Lastres (1992).

scientific and technical collaboration among their suppliers and other contractors;<sup>27</sup>

- technical cooperation with suppliers and customers should become priority policy areas not only to improve quality, but also production, process engineering and R&D. In particular, cooperation between potential users in traditional sectors (such as steel, the agro-industrial complex, paper and pulp) and developers/producers of new generic technologies should be pursued.

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<sup>27</sup> Examples of initiatives of that kind promoted by companies such as Petrobrás, Telebrás and Eletrobrás were given during the Workshop "Condiçantes Internacionais da Competitividade" (29.04.93), when the first version of this paper was discussed.

## APPENDIX

TABLE A.1  
ADVANTAGES AND DISADVANTAGES OF STRATEGIC ALLIANCES

CATEGORY	ADVANTAGES	DISADVANTAGES
Research grant	Creative Avant gard Public image	Unfocused Low proprietorship Transfer of technology Removed from manufacture expertise Requires large sums of money
R&D contract	Focused Less costly Access to key development expertise	Transfer of technology Dissociates development expertise from manufacture expertise
Licensing	Speedy entry & technology access Reduced financial exposure	Royalties against development cost Vulnerability to disloyalty
Equity investment	Greater control while retaining the active involvement of the founders Proximity to key expertise	Formal linkage, not strategy, stipulates property Termination of involvement depends on performance of stocks
Venture nurturing	Management of risk as to market and technological alternatives Possibility of synergies between different ventures	Danger of dissipation of management effort Costly
Joint venture	Cross fertilization of complementary expertise	Management and legal overhead Agreement on extensive commitment Coordination of time horizons
Joint R&D project	Cross fertilization of complementary expertise Minimization of risks and costs	Member companies try to maximize the inflow and minimize their information outflow
Joint R&D centre	Great mobilization of financial, human and technical resources Cross fertilization of complementary expertise Access to specialized equipment Minimization of risks and costs Gathering, centralizing and distributing specialized information	Organization and management Intellectual property rights Transfer of technology Member companies try to maximize the inflow and minimize their information outflow

Source: Adapted from Olleros & Macdonald (1988).

TABLE A.2

FIFTEEN TOP COMPANIES WITH MOST STRATEGIC ALLIANCES IN THE 1980s

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COMPANIES	COUNTRY	SECTOR	NO OF LINKS
Mitsubishi Group	Japan	conglomerates	335
Siemens A. G.	Germany	electronics	316
Dai-Ichi Kangyo (DKB) Group	Japan	conglomerates	291
Sumitomo Group	Japan	conglomerates	268
Philips	Netherlands	electronics	229
Mitsui Group	Japan	conglomerates	215
Daimler-Benz A. G.	Germany	automotive	182
IBM	USA	electronics	179
Thompson	France	electronics	165
Hitachi Ltd	Japan	conglomerates	160
Toshiba Corp.	Japan	electronics	157
Olivetti Spa	Italy	electronics	154
Fuyo Group	Japan	conglomerates	151
General Electric Co.	USA	electronics	151
AT&T	USA	electronics	139

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**ABBREVIATIONS**

- CATI - Cooperative Agreements and Technology Indicators of MERIT
- EC - European Community
- EFTA - European Free Trade Association
- IBM - International Business Machinery (USA)
- ICT - Information and Communication Technology
- IT - Information Technology
- LDCs - Less Developed Countries
- MERIT - Maastricht Economic Research Institute on Innovation and Technology, University of Limburg, The Netherlands
- MITI - Ministry of International Trade and Industry (Japan)
- NASA - National Aeronautics and Space Administration (USA)
- NICs - Newly Industrialized Countries
- NSI - National Systems of Innovation
- OECD - Organization for Economic Cooperation and Development
- R&D - Research and Development
- S&T - Science and Technology
- TEP - Techno-Economic Paradigm

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