

Interfirm Co-operation and Networking: Concepts, Evidence and Policy

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1. Introduction

It has become widely recognised in recent years that innovation processes are characterised by a considerable degree of interaction and division of labour. One concept for analysing this interaction in the innovation process is the so-called 'network approach'. However, at one or more levels the "network" metaphor has seen a wonderful career within the last century and appears well on its way to becoming the transcendent symbol and dominant metaphor of the 'information century' (David, 1999). The network concept has by and large been developed in social sciences other than economics and has figured with increasing prominence in efforts to describe and understand the evolving cognitive structures of scientific knowledge. Moreover, the network metaphor has been widely used and was affected by physical networks that have been on scene for a very long time – such as electrical and power networks, telephone networks, national highway systems etc. There are still other, less tangible network structures like news agency networks or broadcast networks and others which are perceived as relational patterns of interaction – like distribution networks or inter-company procurement networks. Networking has thus become an important subject in several disciplines as well as in policy actions. With the globalisation as the driving force of development and change networking seems as the adequate and appropriate measure.

Economists have not been backward in invoking the image of the network as a new mode of interaction – a form of organisational arrangement that eludes placement within the conventional dichotomy between resource allocation mechanism that work via the price system and those that depend on command. Networks are seen in the recent literature as standing somewhere *between markets and hierarchies* but represent no simple mechanistic connection between the elements, but coherence without contract or command and as such a new stage in organisational forms. *Network capability* (Kogut, 1998) is thus a source of imputed value to firms and represent a contributive factor for learning and knowledge generation. Although social and economic networks are affected by physical networks (internet, telecommunication or traffic networks) they have acquired new significance as a distinctive organisational form in business.

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As the following sections will show there is a broad literature of available theory and empirical investigations focusing on different reasons of why firms participate in networks and about the effects of co-operative relationships. Due to this fact the definition of a network should be a broad one based on the attribute knowledge transmission. Metcalfe (1995) mentioned in his definition this characteristic in stating that “networks can be seen as economic clubs acting to internalise the problems of effective knowledge transmission”.

The possible wide-ranging impact of networks on both network members and the economy as a whole has not only made network theory prominent as subject of broad analytical treatment and research, but also an interesting option in technology and innovation policy. This applies to many European countries and the European Commission as well. By stimulating contacts and co-operation between different actors in innovation systems, policy makers expect that synergies can be achieved and innovation potentials be exploited in existing and in new firms, in research and in society as a whole. But facing the high diversity of conceptions and theories which policy should in fact be adopted? Should the policy maker stimulate networks by simply relaxing anti-trust laws? Should the state stimulate or prevent inter-firm agreements because of social (in)efficiencies? These and many other questions are a matter of perspective adopted by policy-maker. This paper contributes to some clarifications.

In section 2 the theoretical literature and different approaches to networks and co-operation is overviewed. Section 3 focus lies on innovation economics, transaction costs, strategic management and industrial organisation. Section 4 gives a short overview of the different forms networks can take. Section 5 summarises the different benefits of networks and inter-firm co-operation. Section 6 discusses some of the main empirical results of the Focus-Group of Innovative Firms and Networks of the MERIT/CATI database as well as the results of the research on the MERIT/CATI database. The final section discusses some practical problems of networking and the role of government in solving them at different stages of the networking process.

2. Different approaches

One looks in a vast literature of different theoretical approaches to provide the basis for understanding why firms enter into co-operations, networks or form alliances and what are the results of such co-operative behaviour for the partners, industry, and society at large. Useful, but partial, insights can be drawn from different approaches (economics, game theory, strategic-management theory, or technology driven arguments among others). The results from a long-lasting division of labour between the different approaches which hence does not lead to a unified theory. The different approaches are focused on different levels of co-operative relations between organisations (see Hagedoorn et al., 2000). Management theory has traditionally focused on the firm and its internal organisation of its activities. Industrial organisation theorists have, until recently, typically taken the

development of market structures and/or demand, within all there is immanent *uncertainty* about future development. In case of technological change, for instance with a switch of technological trajectories with new basic designs (Dosi et al., 1988), it is hard for firms to assess which company or group of companies will be the first to master and develop new technologies or who will be the main carriers of new innovation. A number of analyses of collaboration link it with uncertainties in the generation and early diffusion of new technologies (Freeman, 1991). Co-operation may enable the development of de facto technological standards. Particularly in services, many co-operative arrangements are aimed at the establishment of such standards, as they may enable compatibility between different technologies and *reduce technological uncertainty*. Thus in early technological developments there are periods of high interaction between organisations until a dominant design emerges in a technology. As the technology matures, uncertainty declines and collaborative activity recedes.

Another benefit of collaboration concerns the way it is believed to assist with *environmental uncertainty*. Kranton and Minehart (1999) show in their model how demand uncertainty for specific inputs and investment cost affect the structure of industries. Transaction cost economics imply vertical integration is likely when technology involves costly specific investments that improve the value of inputs: vertical integration eliminates ex post non-cooperative bargaining between a buyer and a seller and thus improves investment incentives. Kranton and Minehart (1999) posit the countervailing incentive for vertical disintegration rooted in uncertainty in demand for specialised inputs. They show that with multiple sourcing arrangements networks are efficient outcomes and yield greater welfare than vertical integration and markets. They further distinguish between firms-specific and aggregate demand uncertainty and show that uncertainty per se does not lead to networks. Idiosyncratic shocks, not aggregate shocks, are the source of network benefits.

In advanced sectors where new designs are frequently developed by new players it is essential not to concentrate only on the relation to the main, well-known players of a network, but for *being open for new knowledge from new players*. In a similar way the argument is applicable to market structural change, where entry, from either new companies, international competitors or diversifying companies, can change the competitive space for a particular company (or group of companies). In some recent contributions to network theory, the implications of *open systems* for the perception of efficiency in networks with entry of new players are recognised. Thus networking, learning and knowledge accumulation represent a cumulative process, by which firms might enter into path dependency. It thus seems also important that companies have the ability to enter into new relations with other firms and organisations and to build relations with various players with whom they can jointly develop new technological knowledge.

Mowery and Rosenberg (1989) and Chesnais (1988) have argued that the increasing partnering and changing organisation of technological activities during the 1980s was mainly related to recent developments in technology, such as: (i) the continued growth in development costs; (ii) technological convergence of cross-fertilisation of technologies; (iii) shorter product cycles; and (iv) faster rates of technical change. The growth in the R&D costs implies that the minimum efficient scale of R&D projects has increased. This is particularly important if the time to profit from the innovation has been reduced, because the fixed costs of innovation will have to be covered in a

shorter period. Technological convergence has demanded firm's competencies to be spread over a greater number of technological fields, that is, the number of technologies that a firm has to deal with has increased. This implies a higher degree of uncertainty and complexity of technological environments associated with its outcomes and costs.

Furthermore, as technical knowledge involves tacit characteristics and is cumulative, firms should need to absorb knowledge in order to take decisions about recent developments and to determine what types of knowledge they should contract. Patel and Pavitt (1997) and Granstrand et al. (1997) add some empirical evidence to these observations. They show that big firms' competencies are spread across technical fields outside those where they hold specific competencies. Moreover, firms have become increasingly more technologically diversified in recent years (*multi-technology corporations*). They argue that this should be a consequence of the need to develop knowledge on those technical fields where firms do not act directly, but need to interact with other firms. For the specific case of collaborative agreements, this can be confirmed by case studies that show that in order to absorb knowledge produced outside their boundaries, firms have to develop competencies in the technical field where co-operation is being used (Granstrand et al. 1992).

Transaction costs economics

Most theoretical findings of collaboration and partnerships are building on the work of Coase and Williamson in which the co-ordination of economic activities is analysed in a market-hierarchy opposition. According to Williamson, limited rationality, opportunism, uncertainty, and asset specificity explain the existence of particular contracts compared to those of the standard theory. Firms try different ways to organise a transaction, including arm's length markets and market displacements through internal administrative organisations or hierarchies (Williamson, 1985). Two kinds of costs are relevant in order to explain distinct governance structures: production costs and transaction costs. Production costs may vary from firm to firm according to proprietary knowledge, abilities to learn, and economies of scale and scope. Transaction costs are basically information costs, which increase steeply when contracts are incomplete. Originally the transaction cost approach was a rather static theory in taking the circumstances of production as given and investigate comparatively the properties of market-contract arrangements and different modes of organisations. Hence, because of contractual incompleteness and unpredictable changes the effect of vertical integration would be greatest when there is a high degree of interdependence among the relevant stages of production. However, this approach operates with a "thin" conception of technology. From the perspective of real-world firm behaviour and the boundaries of the firm, the view of the firm only in the context of transactions ignores some of the most important factors that determine firm organisations, i.e. deciding what to produce and how to produce it. Firms as organisations need to tackle a variety of goals which are interdependent.

Transaction cost theorist thus have more recently begun not to focus only of the transaction costs but to put more emphasis on the production side. Even Ronald Coase has argued in this direction with now being more sceptical towards the only focus on transaction costs: "[...] while transaction cost considerations undoubtedly

explain why firms come into existence, once most production is carried out within firms and most transactions are firm-firm transactions and not factor-factor transactions, the level of transaction costs will be greatly reduced and the dominant factor determining the institutional structure of production will in general no longer be transaction cost but the relative costs of different firms in organising particular activities" (Coase, 1990). This includes alternative forms of adaptations, such as co-operations and alliances among organisations which are modes of production specificities. Co-operation and research partnerships are thus explained in transaction cost economics as a hybrid form of organisation between the market and the hierarchy to facilitate carrying out an activity specifically related to the production and dissemination of technical knowledge.

With some shortcomings of the transaction cost approach in mind, a number of neo-Schumpeterian studies have thus suggested that the growth of networking arrangements means that both market and hierarchical relationships are being superseded by new forms of organisations. Others have suggested that this may be associated with the diffusion of information and communication technology, providing both the necessity for collaboration and better means for achieving it. However, a good deal of the empirical evidence points to the view that for explaining the development of networks both, strategic behaviour of firms as well as terms of costs are necessary. Hämmäläinen and Schienstock (2000) developed four organisational determinants of networks and show that different levels of these factors tend to favour different organisational arrangements. Thus, the comparative efficiency of markets, corporate hierarchies and networks is determined by the level of (a) resource (dis)similarity, (b) transaction and (c) coordination costs, and (d) the organisational implications of modern innovation processes in a particular value-adding chain.

Strategic management

The perspective on co-operative strategy offered by this approach draws attention to the need for prospective partners to achieve a fit between their respective strategies, so that an alliance between them makes a positive contribution to the attainment of each party's objectives. An effective *competitive strategy* involves coalitions by co-ordinating or sharing value chains with partners that broaden the effective scope of the firm's own activities. This permits firms to react swiftly to market needs and allows them to bring technology to the market place faster.

As was mentioned above (section 2) learning through various contacts pays off in a dynamic environment as this behaviour can outperform short-term maximising behaviour. This *strategic network* approach sees multiple co-operative relationships of a firm as the source of its competitive strength. Hagedoorn et al. (2000) mention three categories of theoretical rationales which can explain the formation of strategic networks: efficiency, synergy, and power. Networks can achieve efficiencies via scale and scope economies and via the reduction of transactional inefficiency in the open market. Firms can concentrate on those parts of the value chain which better reflect their competitive advantage. The resulting synergies can be achieved through linking and exploiting the different competencies of a group within a quasi-organisational framework. By mentioning power as the central concept, network strategy can be understood as strategy to influence the decision of others.

The *resource-based view of the firm*, traceable to Penrose (1959), has become popular within the strategic management analysis (see Foss, 1997). This approach goes back to case studies, revealing that firms within the same industry differed in terms of policies regarding product quality, distribution channels, competitive strategies, etc. resulting in different profit rates within industries. These differences came to be identified as differences in strategies with the obvious implication that performance is something extremely specific to individual firms. The sources of sustained competitive advantages are firm resources that are valuable, rare, and not easily substitutable with the well known result that two different firms simply will not have the same costs of carrying out the “same” productive operation. This is what specialisation and the division of labour is all about. The root of the benefits of specialisation is accumulation of more or less tacit knowledge – in the form of individual skills as well as in the form of firm-specific knowledge capital represented by capabilities. Richardson (1972) introduced the term “capabilities” to talk about the necessarily limited range of productive knowledge firms and individuals possess. However, it was well before Williamson’s first book when Richardson stressed the fact that “[...] firms are not islands of planned co-ordinations in a sea of market relations but are linked together in patterns of co-operation and affiliation”. Production can be broken down into various stages or activities. Some activities are similar, in that they draw on the same general capabilities. Activities can also be complementary (in both technical and economic sense) in that they are connected in the chain of production and therefore need to be co-ordinated with one another. Access to external *complementary resources* may be necessary in order to fully exploit the existing resources and develop sustained competitive advantages. A series of studies show that most of the alliances are motivated by the need to access complementary assets (Hagedoorn, 1996). Firms increasingly seek partnerships and alliances as a means of strengthening their core competencies and expanding into technology fields considered critical for maintaining market share. Cross-border alliances are thus crucial in specific sectors because it allows firms to compete in several markets simultaneously and to exploit and utilise assets and technology that may be specific to particular locations.

This opens the spectrum of co-operations in which firms see their activities in a dense network by which they are inter-related. The analysis denotes not only manufacturing processes but relates equally to research, development and marketing. Stressing *dynamic capabilities* (Teece et al., 1994) leads to the analysis of the mechanism by which firms accumulate and deploy new skills and capabilities. A primary factor influencing a firm’s ability to develop technology-based competencies via a co-operative venture is to learn from the relationship (see above). Inter-firm co-operation can be viewed as a vehicle for organisational learning, that can be used to analyse the motive, process and outcome of strategic technical alliances.

Industrial organisation

Noteworthy in this context has been the interest in *industrial organisation theory* in understanding firms that have, through co-operative agreements of diverse forms, created networks for purposes of innovation which refers both to the structure of agents’ interaction and to the economic property of positive externalities. In *game theory* many contributions have tried to find conditions favouring co-operation and networking between self-interested agents –

for instance game repetition during an infinite number of periods. Under such conditions, particular strategies will induce co-operation during a long period. Friedman (1971) demonstrates that the “trigger strategies” allows co-operation to emerge under specific conditions. Axelrod (1984) considers self-interested heterogeneous agents with imperfect rationality and shows that “tit-for-tat” strategy constitutes a solid way to solve the dilemma when the horizon is infinite and the probability of meeting again is high. The infinite horizon approach has taken by many studies dealing with collusive behaviour in the product market, although most of them are based on an economic theory of the firm relying on incomplete contracts. Kreps (1990) suggested an alternative version in arguing that the fundamental role of the firm is to be long-lasting party in a sequence of short run (finite) transactions. It should then hold a reputation that ensures the correct fulfilling of incomplete contracts (i.e. the ability to write contracts on future and uncertain contingencies). He therefore states that the role of corporate culture is to act as a commitment for the maintenance of contractual clauses – that is for not acting opportunistically. The corporate culture or reputation in sustaining certain kinds of behaviour is their ex ante commitment for the agreement to take place. These approaches had contributed a lot for the growth of co-operative strategies and to acknowledge the importance of human agents being “embedded” in inter-personal and inter-organisational networks.

Influenced by game theoretical tools and models IO scholars have been interested in the resource allocation and economic welfare effects of inter-firm co-operation in R&D as part of a broader concern over the potentiality of failure in the market of scientific and technological knowledge. This failure is due to the perceived public good nature of knowledge that makes in the pioneering models by D’Aspremont and Jacequemin (1988) its production relatively more expensive than its transmission. The price system fails to co-ordinate the decentralised agents’ innovative activities and market failure appears. Intellectual property rights, public subsidies, and co-operation in R&D are considered as the main tools for reducing market imperfections. The D’Aspremont and Jacequemin (1988) model is based on R&D spillover hypothesis. Many subsequent models have been built on their structure, but differ in some detail. Roughly speaking, all these contributions suppose that in a first stage firms choose R&D investments either co-operatively or non-co-operatively and than in a second step they compete to produce the improved output. The model clearly shows, that with a high spillover parameter firms always have incentives to co-operate in R&D as their individual collusive profits are higher than in the non-cooperative case. Moreover, economic welfare under R&D co-operation is higher than under competition. Other models like Kamien et al. (1992) examine the effect of product differentiation within competitive R&D joint ventures with unclear profit and welfare results. A model most recently developed by Kamien (2000) considers not only exogenous spillovers but also the absorptive capacity of R&D in strengthening a firm’s ability to identify, assimilate, and exploit knowledge from the environment.

These types of models have important implications in terms of public policy. The welfare analysis highlights the fact that the economy is better off under co-operation than under competition when spillovers are relatively high. Moreover, in case of high spillovers, firms have incentives to internalise their R&D decision in an agreement, and to invest more. Hence, the recognised advantages of R&D co-operation over competition in terms of welfare are

higher R&D investment, better diffusion of results, elimination of wasteful duplication of efforts, and access to new markets.

3. Different ways to characterise networks

Considering the influencing factors and approaches developed above it should become clear that there is not just one network approach but a whole group of rather heterogeneous concepts, approaches and definitions of networks. This reflects the numerous forms that networks can take. The following section gives an short overview of the different forms networks can take (see for the overview Hämäläinen and Schienstock, 2000).

Vertical and horizontal: In a wide view networks can be divided into vertical and horizontal networks according to the value-adding chain. Vertical networks connect firms or production activities along a particular value-adding chain or production process; whereas horizontal networks connect individuals and organisations in particular functional areas (such as research, production, logistics, marketing, etc.). In recent years, network type of arrangements have also been created between private and public sector organisations.

Geographic scope: Networks can also be differentiated by their geographical scope. Thus, it can be distinguished between local, regional, national, international and global networks.⁴

Organisational structure: The formality of network relationships may also vary considerably from highly informal, flexible and trust-based relations toward more formal and rigid connections (Lundvall and Borrás, 1997).

Duration: The duration of networks can also differ: for example, project teams and virtual corporations can be formed to achieve a particular short term goal, whereas strategic alliances, joint ventures and business associations typically have longer run objectives.

Boundary: The boundary of a network can be more or less clear-cut. In most cases no clear boundaries between a network and its environment exist. It is not always easy to say whether a specific individual or organisation belongs to a particular network or not. The membership of a network can also change over time. Old members can leave, while new members can join it. This means that networks are open constructs and one can speak of blurred boundaries. However, the access to networks is not always easy and the costs of leaving a network can be quite high. Hence, networks differ according to their degree of openness and closeness.

⁴ The new information and communication technologies have increasingly liberated networks from the need for physical proximity. As a result, traditional social networks with face-to-face communication have been supplemented by virtual networks and electronic interaction.

Architecture and balance of power: Networks can also differ according to the dimension of centrality. In principle, networks are defined as an association of autonomous social actors having equal rights. However, the dependency among the members of a network can be more or less symmetric. In some cases, a number of small companies can form a network of partners with equal rights and mutual assistance while, in other cases, the network may be led by one or more “flagship” firms which more or less control the other network partners.

Stability and Trust: Finally, the stability of networks may also vary considerably. In general, networks are seen as a structure of loosely coupled actors, which makes it easy for new members to join them and for established partners to leave if they want. This could mean that the membership of networks would change quite rapidly and the relationships within them would be relatively unstable. Hämmäläinen and Schienstock (2000) thus use a broad definition by characterising networks by close interdependency and high-trust relationships among their members, both factors which contribute to the stability of networks.

4. Different approaches stress different benefits

Although co-operation and networks occur in different forms, and may reflect different motives, a number of generalizable assumptions underpin them. Collaborations and networks lead to positive sum gains (Dodgson, 1994) in internal activities and have positive welfare effects under specific conditions. That is, partners can together obtain mutual benefits which they could not achieve independently. But as was shown above benefits and effects of co-operations depend on the perspective and approach the analysis uses. Overall, the theoretical literature on networks and co-operations has varies in terms of both research focus and results. This variability reflects the fact the industrial set-ups differ in terms of market organisations, the environment for innovation, strategic interaction between firms, and the objectives and organisations of inter-firm collaborative agreements. And in addition, as the resource based theory has shown, no two firms are alike, and their strategies and competencies differ even within the same industry. The following benefits can be summarised:

- Increased scale and scope of activities: the outcomes of collaboration may be applicable to all partners' market, and thus may expand individual firm's customer base. If a firm is part of a customary network, its performance capacity can be considerably extended through synergies between firm's different technological competencies.
- Shared costs and risks: costs for major innovations, such as a new generation of semiconductors or aircraft, have risen rapidly and are now beyond the means of any single firm. Collaboration can share the high costs and therefore risks of innovation.
- Improved ability to deal with complexity: many key technological developments are complex and draw on a wide range of scientific and commercial knowledge. This reinforces the need for co-operation from participants in different fields of expertise and a closer strategic and technological integration between firms is a means for dealing with the complexity of multiple sources and forms of technology.

- Enhanced learning effects: with continuous and rapid market and technology change there are pressures on firms to improve their learning capacities. Collaboration and networks can provide possibilities not only of learning about new technologies, but learning about methods of creating future technologies and of the ways those technologies might affect the existing business. It can teach companies new ways of doing things not only technologically, but also organisationally.
- Positive welfare effect: internalising positive externalities through R&D collaboration results in increased R&D efficiency and an increase of overall R&D expenditure.
- A set of benefits underlying the collaboration is one that considers *flexibility* and *efficiencies*. Networks offer flexibility not in contrast to markets but to hierarchies. Vertically integrated firms establish overheads and production capacities, and in doing so forsake the flexibility of immediate resource reallocation that networks provide. Hence, large firm/small firm interaction might be facilitated such that the resource advantages of the former are linked with the behavioural or creative advantage of the latter. The efficiency enhancing effect of networks is related to the specific nature of technological knowledge. Much of the knowledge is tacit – that is difficult to codify in the form of blueprints – and firm specific. It is therefore difficult to transfer easily and quickly through market mechanism. Collaboration provides an mechanism to transfer whereby this kind of transfer is based on trust between the partners.
- The last (but not least) argument for the enhancement of network structures is the provision of *speed*. Speed may be needed to take advantage of opportunities that might not exist for long, and might require a fast response. An existing network can put together a package of resources and capacities to meet such challenges in a customised response which, in its flexibility and scope, lies beyond the capacity of an unnetworked integrated firm. Moreover, rapid product development depends on the reliance on outside suppliers. Both Clarke et al. (1987) and Mansfield (1988) found that time to market was speeded through a policy of outsourcing to suppliers. The capability to commercialise products can in this case be seen to rest on the successful exploitation of the knowledge of other firms. In this sense, the competitive capabilities of a firm rest not only on its own knowledge or on its knowledge of the network but it highly depends upon the quality of the knowledge embedded in the principles by which co-operation among firms is co-ordinated and supported in the network. Networks thus determines not only access to information, but also constitutes itself capabilities that support co-ordination and learning among member firms (Kogut, 1998).

5. Empirical evidence

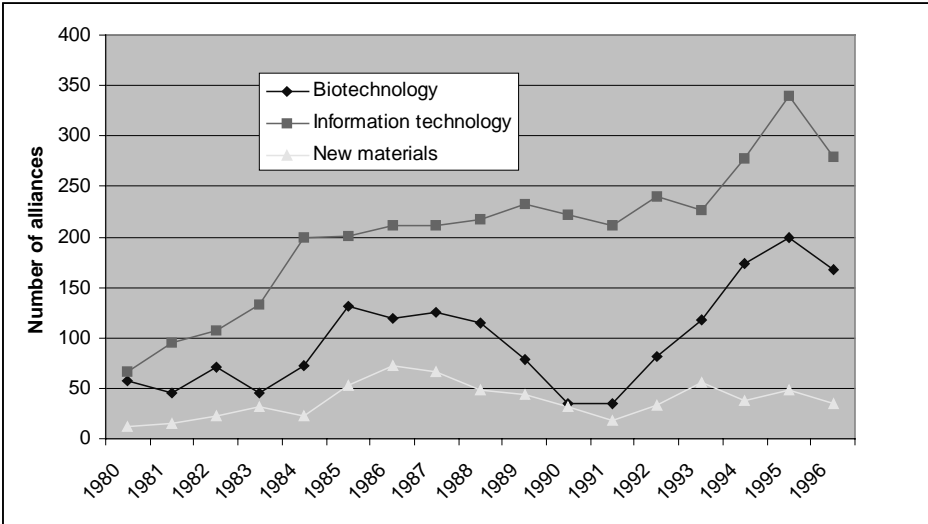
The empirical literature on networks and partnerships has over the years taken one of two approaches. One approach investigates co-operative activity through analysis of existing data sets or through specialised surveys, and the other approach investigates using the case studies. Both research methods have reached important conclusion and have provided useful insights into science and technology policy (Hagedoorn et al., 2000). In the following section the main results of the analysis of the well known MERIT/CATI database are summarised.

Additionally some results of the work of the Focus-group on innovative firms and networks within the OECD project National Innovation System are presented.

Development of technology alliances

International alliances increased sharply throughout the industrialised world in the early 1980s and accelerated as the decade continued (NSF, 1998). Formation of alliances has been particularly extensive among high-tech firms in such core areas as information technologies, biotechnology, and new materials (see Figure 1). Agreements in these technology fields account for more than 70% of all agreements monitored.

Figure 1: New international strategic technology alliances, by technology



Source: NSF, MERIT/CATI database

Although the CATI database focuses exclusively on alliances that involve innovative activity and thus does not allow to distinguish the relative significance of strategic technology alliances to other collaborative activity, it does confirm the rapid growth since the early 1980s. Figure 1 charts the growth in the number of newly established alliances in any given year with a clear evidence that during the first half of the 1970s, strategic alliances were almost non-existent in core technologies, as well as in other sectors, but expanded rapidly in the last decades. There are two major reasons why agreements are so popular in fast-growing technologies: (i) these new technological paradigms are more knowledge-intensive than in the past, and successful innovative performance relies on the capability to acquire information on what is going on in the field and (ii) that for the industries in their infant stage it is particularly necessary to acquire information, and therefore also to share it.

Country specific characteristics affecting alliances

The following table shows the total number of alliances undertaken by firms of some important home countries and provide clear evidence that this propensity varies considerably by country. As one might expect, firms from

the three largest industrial powers dominate the strategic technology alliances, with the US, Japan and Germany are engaged in 64.1%, 25.6% and 11.3% of all alliances included in the sample respectively. Although on the surface the ranking in table 1 might suggest that this propensity simply represent differences in economic size, this is not entirely true. For instance, companies from the Netherlands engage in more alliances than Italian, although Italy is 4 times larger than the Netherlands in terms of market size. Narula and Hagedoorn (1998) included other variables that shed light on this, which suggest that two major factors determine the differences between countries.

- (i) The level of technological sophistication of the country is a key factor in the propensity of its firms to undertake strategic technology partnering, both in terms of undertaking high levels of R&D activity, as well as being involved in high-tech sectors. Two proxies are included for this: the share of the OECD high technology export markets of these countries and the level of business expenditure on R&D in these countries. Both are highly correlated to strategic technology partnering.
- (ii) The structure of domestic sector plays an important role in determining the ability to undertake alliances. On the one hand, countries such as Italy tend to be dominated by small and medium size enterprises, whereas countries such as the UK and US tend to have larger firms dominating the industrial landscape. This is important, since large firms tend to undertake more R&D activity, and are thus more likely to undertake strategic technology alliances. Narula and Hagedoorn (1998) proxy this by the total number of firms from each of these countries that are included in the Fortune 500 list. These variables are also highly significant related to the number of alliances by each of these countries.

Table 1: Strategic technology partnering by major country and indicators of country specific characteristics

country	Number of all alliances, 1980-94	Population (000)	Business exp. On R&D (US\$)	Share of OECD high-tech exports (%)	Number of Fortune 500 companies
USA	4848	257908	121314	23.5	167
Japan	1931	124670	50235	8.0	111
Germany	857	81190	24887	14.3	32
France	722	57667	16084	8.4	29
UK	927	57830	13445	8.9	44
Netherlands	703	15300	2492	4.1	7
Switzerland	276	6940	2830	3.5	10
Sweden	231	8718	2830	1.9	15
Canada	163	28753	4390	2.3	13
Italy	421	57070	7783	4.1	7
Belgium	134	10010	1900	1.9	3
Norway	46	4310	715	0.3	2
Denmark	42	5190	898	1.1	0
Spain	59	39080	2330	1.4	5

Source: Narula and Hagedoorn (1998) with data from MERIT/CATI, Fortune, World Investment Report 1996.

Different co-operative patterns has become one of the key topics in the research on national innovation systems (see the work of the Focus Group on Innovative Firms Networks). It was shown that different kinds of interactions between firms are country specific, reflecting differences in institutional frameworks or policy orientation. Although

national factors do play an important role in determining issues such as the type of industries its firms operates in (infrastructure, market structure or competition laws) the propensity of a firm to be part of an alliance is still very much a firm level decision.

The changing organisational status of R&D Co-operation

As the numbers have increased, the forms of co-operative activity have changed as well. The most prevalent mode of global industrial R&D co-operation in the 1970s were joint ventures and research co-operations. In these arrangements, at least two companies share equity investments to form a separate and distinct company; profits and losses are shared according to the equity investment. In the second half of the 1980s and continuing into the 1990s, joint nonequity R&D agreements became the most important form of partnership. Under such agreements, two or more companies organise joint R&D activities to reduce costs and minimise risk, while pursuing similar innovations. Participants share technologies but have no joint equity linkages (Hagedoorn 1990 and 1996).

To summarise, the use of collaboration to undertake production relations with other firms may be almost an old phenomenon, but novelty comes at least four levels (Narula, Hagedoorn, 1998). First, collaboration is now often considered as first-best option, instead of last resort. Second, firms increasingly use such agreements to undertake R&D, an activity that traditionally has always been jealously guarded. Third, not only are firms doing more R&D through collaboration, they are doing so with overseas partners, and often in foreign locations. The fourth novelty in terms of R&D alliances is the growing use of several different non-traditional organisational modes, in particular the growing use of non-equity agreements, which in some ways are superior mechanism to undertake technology development in high-tech sectors.

Firms rarely innovate alone

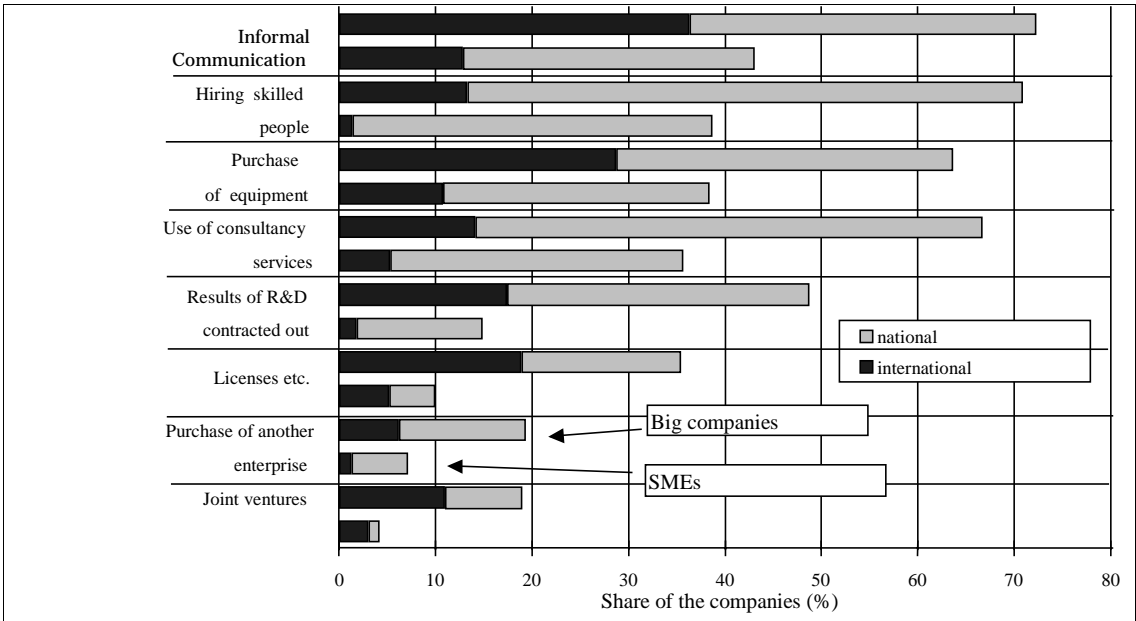
The illustration of some determining factors of networking and collaboration has shown that the competitiveness of innovative organisations is becoming more dependent upon the ability to apply new knowledge and technology in products and processes. It was shown that the rapid advancement of knowledge, new technologies and innovative concepts have a wider variety of sources, most of them outside the direct control of firms. The CIS-surveys as well as the CATI-surveys carried out with the Focus-group bear evidence to the fact that firms rarely innovate alone. In Austria 61% of the product innovating firms in the CATI-survey had collaboration with one or more partners. In Spain 83% collaborated with one or more partners while in Denmark, the proportion was as high as 97%. In fact, there is a clearly discernible tendency pointing to the fact that (product) innovating firms are interacting with other organisations and with a multitude rather than with a single external partner. The most central finding of De Bresson (1999) giving an overview of most of the innovation surveys is that the co-ordination of an innovative endeavour almost always requires a network of independent organisations with different competencies. To a large extent, innovation is thus a result of inputs from co-operative systems, networks of firms and knowledge-based organisations. The first representative surveys of innovative activity in the industrialised world have shown, that one out of two firms introduce new or improved products or processes every three years

(De Bresson et al., 1997). Contrary to the vision that Schumpeter left us, innovation is neither an exceptional nor a heroic venture; it is the pervasive with a great variety and number of economic actors, constantly occurring in everyday economic activity and central to its processes. Networks are present when innovative activity occurs and it is thus reasonable to assume that such networks are required for innovation to emerge, i.e. a necessary condition – although of course, not sufficient.

Technology transfer mechanism

It is important to stress that technology transfer subsumes more than contract research, and the conditions under which contract research is effective cannot always be separated from the effects of other technology transfer modes. In many cases, it is not technologies or products which are transferred, but knowledge, enabling companies to develop market-driven innovations and thus expanding their own innovative potential. As can be seen from Figure ... transfer of knowledge can be implemented through various channels.

Figure 1: Technology transfer mechanism in the manufacturing sector



Source: ZEW Mannheim Innovation Panel (1996)

For more than 40% of SMEs in the manufacturing sector informal communication is an important know-how transfer mechanism, and indeed the most important when compared to other channels. More than 70% of large companies are transferring know-how by using informal communication as transfer mechanism. Besides informal communication, the hiring of qualified staff was the second most common followed by the purchase of equipment and the use of consultancy services. However, in general large firms are more actively using transfer mechanism than SMEs. Large companies also display a tendency to be more involved in international business. In conclusion joint ventures, purchase of licenses or patents seem to be relative important international transfer mechanism,

whereas the purchase of another enterprise, hiring skilled people and the use of consultancy services seem to be more suitable in a national context.

The Swiss innovation survey (Lenz, 1997) exhibits similar results. Although the Swiss survey explicitly refers to R&D collaborating manufacturing firms, more than 50% indicate that they use informal information exchange concerning technology as a form of collaboration. Keeping the difficulties of comparability in mind, most of the surveys point to the fact that much of the knowledge, which is communicated between firms, is tacit in the sense that it might be difficult to codify in formal specifications. However, both surveys indicate, that it does not seem as if informal information exchange substitute more "classical" and formal contractual forms of collaboration. Therefore, the high significance attached to informal information exchange might reflect the fact that it is a form of collaboration which is often additional (or complementary) to more binding forms of collaboration. This indicates that information based networks become an effective innovation technique in its own right.

Informal networks are based on trust

Due to the finding that informal information exchange is important for the innovation process most surveys also show that knowledge is often embodied as much in people as in organisations. Networking and collaboration require a *social basis* (Dodgson, 1996) in affinity, and loyalty, since the quality of relationships among partners inevitably affects the outcome of the co-operation. A wide range of studies has shown how intensive inter-firm links and learning between partners depend on high levels of trust. Lundvall (1988) for example argues that in order to overcome the inevitable uncertainties in jointly developed product innovations, "[...] mutual trust and mutually codes of behaviour will normally be necessary". In the Austrian survey (Schibany, 1998) more than 70% of the co-operating firms fully agree that trust and confidentiality is a very important requirement for co-operation. Yet, this kind of basis has to be built *ex ante* before substantial resources are allocated to the common development project. As a rather logical consequence, 55% of the Austrian firms indicate that the reputation of the partner is very important. Results of the Danish DISKO-survey indicate that, when summarising the percentages for Danish firms indicating that trust is important or very important the proportion amounts to 60% (Christensen, J. et al., 1999).

Networks formations are highly dominated by cultural affinities and social settings. The importance of the background is strongly emphasised by the literature. Freeman (1991) argues: "Personal relationships of trust and confidence (and sometimes of fear and obligation) are important both at the formal and informal level [...] For this reason cultural factors such as language, educational background, regional loyalties, shared ideologies and experiences and even common leisure interests continue to play an important role in networking. "

A number of reasons can be suggested to explain why high trust facilitates effective inter-firm co-operation (Dodgson, 1996). The first relates to the sort of knowledge being transferred, which is often tacit, uncodified, firm-specific and more or less commercially sensitive. It is therefore not immediately transferable and requires some dense and reliable communication paths. Partners are expected to share trust in each other's ability to provide valid and helpful responses to uncertainty. Furthermore they are trusted not to use this information in ways which

may prove disadvantageous to partners. A second reason relates to time scale of successful inter-firm links. Trust facilitates continuing relationships between firms. Continuity is highly valuable because the objective of inter-firm co-operation may change over time, for example, when entering new markets or new technological opportunities. Furthermore, it is only within a long-term horizon that reciprocity in collaboration can occur - trust militates against opportunistic behaviour. In underlining these theoretical findings the Austrian survey exhibit that within every group of co-operation partners the co-operations in repetition outweigh those which are for the first time.

The third reason for high trust in co-operation reflects the high management costs of such linkages. Selecting a suitable partner and building the dense communication paths through which information can be transferred requires considerable management costs, both real and opportunity costs. Trust between firms has to exist on a general as well as on a personal level. It has to be engrained in organisational routines, norms and values. Such features are not costless, and having made the effort to build a strong relation to a partner, jeopardising them through a lack of trust is not a sensible option.

A growing importance of knowledge-intensive sectors

The service sector plays an increasingly important role in the innovation process. The data of the CIS as well as the surveys carried out by the Focus-Group indicate that manufacturing firms today are increasingly interacting with knowledge-intensive service firms. Both types of innovation surveys show that roughly between 30-50% of the surveyed firms had established a co-operative link with consultancies, technological firms etc.

Internationalisation goes hand in hand with strengthening domestic networks

The available evidence suggests that inter-firm collaboration is still predominantly among domestic firms. However, foreign firms, especially suppliers of materials and components and private customers, play a significant and growing role within national innovation networks. Empirical data on such developments indicate a growing frequency of international relationships. Especially firms in small countries tend to have more technology alliances with foreign firms which seems to go hand in hand with a strengthening of domestic networks.

The CIS survey shows that in the case of Austrian manufacturing firms, on average, a strong domestic network with 77% of co-operating firms indicating a domestic partner goes hand in hand with 63% of the co-operating firms indicating a foreign partner from the EU.

Table 2: Distribution of Collaborating partners and size (in %)

		Size (number of employees)					
	total	10-19	20-49	50-99	100-249	250-499	>500
Austria	77.1	81.7	96.0	74.2	55.1	68.2	78.1
EU	62.8	47.0	51.1	65.4	75.8	79.2	85.0
USA	13.2	3.3	14.4	17.9	10.3	16.0	30.3
Japan	2.2	-	-	3.7	4.7	2.2	5.1
Others	21.0	11.5	50.6	19.8	11.9	14.0	13.1

Source: CIS II (Austria), in: Leo, H. (1999)

The data show a clear tendency: for firms with more than 100 employees foreign co-operation partners from the EU are more important than domestic partners. Even co-operations with partners from the USA or Japan are more probable for bigger firms than for smaller ones. Smaller firms have a higher propensity to co-operate with domestic firms although with a high tendency towards co-operation with foreign firms - 47% of the smallest firms indicate a co-operation with a partner from the EU. Increased international competition appears to have strengthened domestic networks while at the same time they open up to international suppliers and customers. This points to the importance of networking for small and medium-sized enterprises, as it may enable them to combine advantages of small size at the firm level, such as flexibility, with economies of scale at the level of networks.

6. Network facilitating policy⁵

The growing importance of cooperative networks has also been recognised by governments in recent years. They have developed many different types of policy measures to facilitate the creation and efficient functioning of inter-firm networks. However, these government interventions have not been based on a sound theoretical framework of government role in network facilitation. Indeed, there is not, yet, a well-developed theory of network policies available.

Market failures, governance failures and network policies

The traditional theories of government intervention were not developed with network facilitation in mind⁶ and the research on networks has paid very little attention to policy questions. The scholars of innovation systems and processes have recently moved toward a new policy paradigm that is more relevant to network facilitation but they are not very clear about the key problems that governments should address and, more importantly, about the division of labour among government, third sector organisations and firms in addressing such problems (see Lunvall and Borrás 1997; OECD 1998, 1999).

It is not enough to emphasise new types of "failures" in learning economies and argue that governments should do something about them. As institutional economists have shown, the existence of a governance problem does not automatically call for government intervention (Coase 1960). Other organisational solutions - such as markets, corporate hierarchies and third sector organisations - should also be examined. In particular, problems in networking can sometimes be solved more efficiently by large firms (hierarchies) and business associations

⁵ This section was taken from Hämäläinen, Schienstock (2000).

⁶ These theories come from multiple subdisciplines of economics such as neoclassical, development, welfare, and new institutional economics. For a comprehensive review, see Hämäläinen (1999).

(third sector) than by government intervention. Since all organisational arrangements involve their own strengths and weaknesses economic efficiency requires that different types of governance problems should be addressed by those organisational arrangements which have a comparative advantage in solving them in a particular social context (Hämäläinen 1999).

Due to the scarcity of research on network facilitating policies, policy makers know very little about the (a) conditions in which network arrangements are more efficient than alternative organisational solutions, (b) types of problems or "failures" that are typical in setting up and operating networks, and (c) which of these problems could most efficiently be overcome by governments.

In fact, similar governance problems can also be found with other organisational arrangements, such as corporate hierarchies, third sector organisations and the government itself. Since the government is the only organisation that has an economy- and society-wide responsibility for social welfare it should be concerned about the efficiency all types of organisational arrangements, not just markets. For example, the tax and regulatory systems, which are shaped by public policy makers, have a great influence on firms' incentives to maximise their organisational efficiency and, hence, the comparative efficiency of hierarchical arrangements. In a similar vein, government policies can also shape the efficiency of third sector organisations and inter-firm networks. Dunning and Hämäläinen have called this wider efficiency-enhancing approach as the *macro-organisational role of government* (Dunning 1992; Hämäläinen 1999).

The wide responsibilities of government in the macro-organisational approach do not mean that it should intervene more actively in the economy. The government role is limited by the comparative advantages of private and third sector organisational alternatives. In the present context, governments should worry about the problems in networking but only to the extent that they can provide superior solutions to those of the private and third sectors. In other words, the practical network policies of governments should depend on their organisational capabilities vis-a-vis the private and third sector alternatives in solving specific networking problems in particular contexts. Unfortunately, there are no rules of thumb for deciding the efficient division of organisational labour among different organisational alternatives (Coase 1990).

Matching policies to stages of networking

The following section will now turn to the analysis of practical problems in networking and the role of government in solving them at different stages of the networking process. These stages are the following: (a) awareness of networking possibility, (b) search for partners, (c) building trust and shared knowledge base, (d) organising the network, (e) adding complementary resources, and (f) active co-operation. We will pay particular attention to problems which create a wedge between the private and social benefits of networking.

Creating awareness. Despite wide media coverage and active promotion by different policy makers, the nature and potential benefits of network cooperation are not always very well known and internalised among small firms. They are often too busy to consider and test new business models and may even be afraid of losing their

competitive advantages to prospective partners. This information problem may slow down organisational adjustments among firms that could benefit from active network cooperation. Governments and third sector organisations can promote firms' awareness about networking e.g. by arranging seminars and distributing information about it and by trying to get the media to cover successful examples of networking. The fact that network cooperation is not a panacea to all organisational problems should be borne in mind in all network promotion.

Besides the awareness, there are many other problems that need to be solved before a network can successfully be established. The costs of setting up a network tend to fall primarily on the organisation that actively promotes it. These costs stem from the process of finding the right partners, negotiating with them, creating behavioural rules for cooperation, and building the necessary shared resources. However, the benefits of a well functioning network tend to diffuse to all members of the network. Thus, the formation of networks tends to suffer from a *public good or externality problem*: the private benefits from network formation may not cover the private costs, though social benefits might well do so.

Only when the private benefits of setting up a network exceed the private costs will a firm engage in network formation. If this is not the case, and a market solution fails, there may be room for efficiency enhancing government intervention. However, even then business associations or other third sector organisations (chambers of commerce, centers of excellence, etc.) may provide more efficient solutions to the externality problem.

Searching for partners. Governments can support firms' own search for network partners with information, brokerage and matching services (Lundvall and Borrás 1997; Narula and Dunning 1999). Such services can be arranged with trade fairs and business seminars or they can be provided with modern information technologies. For example, the European Union has web-based matching services that cover the whole EU-area. Besides firms, successful networks often involve other types of organisations such as universities, research institutes, government agencies, etc. These organisations can be direct participants or provide important complementary resources for the network.

The above policy measures assume that firms actively participate in government programs. This might not always be so. Especially small firms are often too busy with their daily business or simply lack the financial or human resources to find out and participate in different networking initiatives. As a result, many potentially beneficial networks are not created without more active policies and encouragement.

Finding out potential networks and partners is not easy, however. It requires deep knowledge about firms' specific strengths and weaknesses and how they could complement each other (Lundvall and Borrás 1997: 112). This suggests that the search for potential network partners should take place very close to firms at local and sectoral levels. Besides the firms themselves, local authorities and business associations could play a key role in this process. Moreover, practical experience suggests that network policies should not aim to create new networks

from scratch: network promotion could be focused on emerging and fragile networks which require further encouragement and support. This would minimise the potential for government failure.

Building trust and shared knowledge base. Once the appropriate partners have been found there may still be many mental barriers to effective cooperation. In fact, the mental rigidities and old behavioural routines of entrepreneurs are often the biggest hurdle to effective networking. Potential partners need to learn more about each others' world view (cognitive frame), beliefs and attitudes, values, business strategies and operating methods. This can only be done through a intensive and open discussions where the participants gradually build trust and a shared knowledge base. Being a neutral and trusted "third party", governments can often reduce the suspicions and reservations that firms have toward closer inter-firm cooperation.

Building shared understandings and trust takes time. As a result, governments should favour policies which provide firms adequate incentives to continue participating in the networking process long enough to build the necessary shared knowledge base and social capital. Setting up long-term network facilitation programs and building inter-firm meeting arenas may be more productive than trying to more directly match potential partners who have not had enough time to learn to know each other well nor build the shared understandings and trust. One example of such a long-term process is the British technology forecast program which has resulted in active network formation among the participating firms and other organisations (see www.foresight.uk.gov).

Taking into account the time and resource constraints of small firms government programs should preferably offer them some additional benefits beyond the uncertain advantages of networking. For example, the Finnish authorities are currently considering the use of a "strategy foresight process" to encourage potential network partners to come together, analyse and discuss common development challenges, and create new networks. Besides the potential benefits of networking, the firms will get an easy access to well-analysed information about major changes in their business environment.

The intensive inter-firm communication required for trust-building can also be facilitated with shared information infrastructures, such as network-specific extranets or internet pages. The provision of such public goods could initially be supported by governments if the benefits of networking can only be expected in the longer term.

Organising the network. Once firms understand and trust each other enough, they can start to build a shared vision, strategy, structure and behavioural rules for the network. A shared vision of the future and a common strategy are important co-ordinating mechanisms in highly specialised and interdependent networks where the market mechanism or hierarchical co-ordination cannot be relied on. However, these co-ordination mechanisms do not emerge automatically; someone has to provide the leadership in their development. This role is often played by a strong "flagship firm" which has a keen interest in the success of the network (Rugman and D'Cruz 1996). Indeed, in the search stage of network formation, government activities could focus primarily on finding such flagship firms. The other partners could then be sought in cooperation with these firms.

Even in the absence of a flagship firm, governments can support inter-firm coordination by providing institutional arenas, such as the Japanese "deliberation councils" (World Bank 1993) or the Finnish cluster programs, for

intensive inter-firm communication. The task of building a shared strategy for the network could also be explicitly included into public networking programs. Lacking detailed business knowledge, governments should try to avoid undertaking the coordination task themselves.

Governments can also support the actual organisation of the network and its business processes by providing information about potential problems and best practices in network cooperation. It can also develop contract models and arrange consulting services to help structuring the network. However, governments should be very careful in expanding their subsidised consulting services because there are well-functioning markets in organisational consulting.

Adding complementary resources. Emerging new networks do not often have all the key resources and capabilities required for competitive success. For example, a key technology or other input may not be available from the existing network partners, or the network could lack access to important foreign markets. More generally, such "systemic failures" could relate to any part of the network's value-adding system and its socio-institutional environment (OECD 1999), such as resources (e.g. human, financial, infrastructure), technologies (ICTs, specific technologies), organisation (intra-firm organisation, incentive systems, etc.), product markets (sophisticated demand, product market regulation, competition, etc.), international business activities (access to foreign markets, technologies, business systems, etc.), institutions (laws, regulations, norms, customs) and policy framework (public sector organisations and their activities).

The problem of missing complementary resources is familiar from development economics. Many development economists have emphasised the problem of building a mutually-reinforcing business system in developing countries (Rosenstein-Rodan 1943; Hirschman 1958). Missing key resources can create negative external effects through "forward and backward linkages" in the interdependent business system. This calls for explicit coordination of development investments, or a "big push", throughout the system (Rosenstein-Rodan 1943; Richardson 1960). On the other hand, fixing the systemic failures may release the positive externalities of a network and lead to increasing returns and sustained competitiveness (Arthur 1994; Hämmäläinen 1999).

Depending on the nature of the systemic failure, policy measures could be needed in any part of the network's value-adding system and its immediate socio-economic environment. However, since systemic failures could theoretically be found anywhere in the system policy makers have to be very careful of not becoming too active in their interventions. The systemic interdependencies within and around the network should be carefully evaluated before any intervention. Moreover, governments should not intervene if private or third sector organisational alternatives could provide the complementary resources more efficiently.

Availability of financial capital. Although networks of firms can spread risks among their members, some activities are so uncertain that not even networks can undertake them without government help. Basic research, development of major new technologies or entry into foreign markets are typical examples. In such cases, the uncertainty and costs of particular key activities may exceed the combined resources of the network though the

potential benefits for the society at large could warrant undertaking these activities. This may call for government intervention and partial socialisation of the activity's risk (Thurow 1983; Narula and Dunning 1999).

The cooperation of public research institutes, universities and firms in basic research is a good example of such risk sharing. Governments may also develop new financial instruments to support networks which undertake activities that are too risky to be financed from the private markets. Public orders for specific new technologies may also be used to reduce firms' risks.

ICT infrastructure. The rapid diffusion of cooperative networks has been facilitated by a complementary paradigm shift in the nature and use of information and communication technologies. Traditionally, ICTs were used to automate human operations; they made it possible and economically attractive to process large amounts of information and perform simple value-adding activities more precisely and rapidly than before. As a labour-saving device, modern ICTs do not differ in any way from traditional machines.

Zuboff (1988) notes that modern ICTs not only automate activities and work processes but also translate them into information. Once modern ICTs are used in production they generate information about the underlying production and administration processes. This information can be used to improve the monitoring and control of work processes.

While Zuboff stresses the control aspect of modern ICTs, Castells associates the reflexive character of modern ICTs with processes of innovation and learning. He points out that these new technologies produce new work-related information which workers can use in their daily learning and innovation activities. Information technology creates a feedback loop between the generation and the application of new knowledge (Castells 1997: 32).

The real revolutionary feature of modern ICTs, however, is their development into a global communication system. They are now conceived of as media which connects people with each other as well as with machines. Hence, modern ICTs have become important infrastructure for intra- and inter-firm information flows as more and more communication has become technically mediated. While the use of new ICTs led to restructuring of corporate hierarchies in the 1980s and early 1990s, the present ICT applications tend to produce structural changes in inter-company relationships and create a new networked business architecture (Tapscott 1995: 97).

The paradigm shift in information and communication technologies and organisational forms are complementary and mutually reinforcing phenomena. The full benefits of the one cannot be reached without the other (OECD 1996). Geographically dispersed parts of a network can be linked with powerful information and communication networks. Massive flows of codified coordination information can be easily communicated, processed and stored with modern ICTs.

The communication through the ICTs requires a shared language as well as overlapping knowledge base and cognitive frames at both ends of the communication flows. Thus, more demanding use of ICTs tends to require previous face-to-face interaction. Such informal and rich communication is more effective in the transfer of tacit knowledge. However, the modern ICTs can support the creation and mobilisation of tacit knowledge by

reinforcing human interaction and interactive learning (Ernst and Lundvall 1997: 28). E-mails, file transfers and network technologies are effective communication mechanisms for researchers with shared understandings and knowledge bases.

The new ICT paradigm has recently shifted from mere linkages between computers to "co-operative computing" where the interacting partners could be located anywhere in the world (Castells 1998: 170). In decentralised work group computing, several geographically dispersed partners can jointly work on a complex task, such as the development of a new product or strategy, and simultaneously co-ordinate reciprocal sub-processes. "Qualitative advances in ICTs...nowadays allow the emergence of fully interactive, computer-based, flexible processes of management, production, and distribution, involving simultaneously co-operation between different firms and units of such firms (Castells 1998: 170).

The latest trend is the integration of firm's internal information systems into a public information infrastructure. Two technological developments are important here: interactive multimedia telecommunication applications and the use of the Internet for commercial purposes. We can expect that, in the future, interactive multimedia applications will be developed which will support tele-co-operation within and among firms, and between them and other organisations.

Finally, there is the risk that, under the pressure from large internationally-oriented companies, telecommunication operators are not sufficiently interested in extending the local network infrastructures which benefit small firms and households as they focus on increasing the bandwidth of information highways. However, an important part of information exchange takes place among local partners even if firms are also connected with foreign partners in transnational business networks. Moreover, the social benefits of information networks depend on the number of active participants. For example, the selection of goods and services available through electronic commerce depends on the number of consumers that can be reached with the new ICTs. These network economies provide a clear rationale for government policies aimed at increasing the coverage of new information infrastructures and the use of modern ICTs among firms.

Intra-firm organisation. The full benefits of modern ICTs and inter-firm networks cannot be reached without restructuring the firms' internal organisations. Although such restructuring can take many forms, a new organisational paradigm seems to be emerging in industrialised countries (OECD 1996; Lundvall and Borrás 1997). This paradigm emphasises i.a. horizontal communication between firms' different functions (multifunctional teams, rotation of personnel among functions, etc.), flat hierarchies, individual responsibility, initiative and flexibility, and good social, communication and language skills.

Firms are not always aware of the benefits of the new organisational forms and mechanisms. Hence, there may sometimes be a need for government to promote the new organisational solutions, especially among the smaller firms. Governments also need to continuously develop the public education systems so that they can keep up with the rapidly changing needs of the working life. New types of skills and curricula are needed and the role of

on-the-job learning becoming increasingly important. The ability of firms to adopt new organisational forms depends to a large extent on the quality and skills of the labour force.

Product market. Innovative inter-firm networks may sometimes suffer from poorly developed product markets. There could be problems with demand patterns, institutional framework and competitive incentives. The local demand conditions can be too unsophisticated to spur innovative activities (Porter 1990). For example, the market could consist of numerous small firms which are unable to demand innovative new products or services. Alternatively, there could be a government monopsony with little incentives to push the supplying firms to improve their product offerings. In these and other types of situations, governments may be able to use public procurement and close cooperation with private producers (private-public partnerships) to encourage more innovative solutions. Moreover, by defining tasks that cannot be addressed by existing constellations of firms, governments can use their procurement programs more directly to encourage the formation of new inter-firm networks (Lundvall and Borras 1997: 130).

Besides the systemic failure argument, there are also more traditional market failure rationales for government intervention on the demand side. Government procurement can be used to reduce the risks of firms in long-term and high-risk R&D projects. Public procurement may also be warranted if there is under-investment in socially-desirable technologies (military, environmental, etc.) or if the early buyers and users of new technologies face considerable risks. Government procurement is a particularly interesting policy option in situations where the society needs to break out from the established paths of innovation (Lundvall and Borras 1997: 125, 130).

Governments also influence the product market structure through legislation, regulation, standardisation, and competition policies (Porter 1990; Hämmäläinen 1999). Tough environmental regulation, for example, may provide effective incentives for firms' technology development efforts (OECD 1996b). Open standards, deregulation (e.g. in telecommunication, transportation, airline industries) and competition policies, in turn, can be used to encourage competition among suppliers. Intensive rivalry in the product market not only provides good incentives for innovation (Porter 1990) but also encourage firms to try new organisational solutions, such as inter-firm cooperation and network arrangements, in other parts of the value-adding chain. Indeed, the cooperative forms of organisation pose a major challenge to traditional competition policy which views all inter-firm cooperation with suspicion. In the context of increasing innovation competition and inter-firm cooperation, the competition policy makers have to draw a very sophisticated line between efficiency-enhancing inter-firm cooperation and socially harmful collusive practices (Teece 1992). This is an area where more research is clearly needed. In general, national policy makers have become more permissive to inter-firm cooperation as its innovative benefits have become better understood (see Lundvall and Borras 1997)

Internationalisation. Networks of small firms often run into the problem of getting access to foreign markets. Even the pooled resources of the network may be inadequate for establishing a presence in the leading international markets. At the same time, the domestic markets may be too small to support the development of the network's highly specialised products.

Governments may be able to help the internationalisation of such networks by helping in the search of suitable local partners in target markets. Governments can also partially cover the expenses of joint market research and export initiatives. Government sponsored business trips to international fairs and conferences are also common.

We will conclude our analysis of the different stages of networking and network policy making by arguing that governments should not continue to support networks once they have become established and their benefits have become obvious to participants. At this stage, the members of the network should begin to contribute their own fair share of its operating costs. The government to step back and move on to support new networks.

Deciding on network policies

Our analysis of network facilitating policy suggest that the traditional market failure approach of welfare economics must be modified in the context of networks. The failure of markets and potential efficiency of networks is not a sufficient rationale for government intervention. There must be particular governance failures in setting up or operating networks which governments are best able to overcome. Moreover, the potential efficiency-enhancing role of government is much wider than that of overcoming the failures of the market mechanism. As we have suggested, governments can, and should, also try to improve the efficiency of other types of organisational arrangements such as networks. Indeed, there is no reason to limit such "macro-organisational" government role to markets and networks, governments are the only economic agents that can take responsibility of the efficiency of the whole socio-economic system, including private and public hierarchies (Dunning 1992; Hämmäläinen 1999).

All private, public and third sector organisational arrangements involve their own specific strengths and weaknesses and governments should aim to facilitate an efficient division of labour among them. This does not, of course, mean that the government should overemphasise its role in the economy. The large literature on government failures suggests that policy makers should be sensitive to their own limited capabilities (see Wolf 1988; Stiglitz 1989).

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