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1 INTRODUCTION

1.1 Background of the study

The internationalization of research and development in Finland was for the first time studied in a joint project by the Technical Research Centre of Finland (VTT) and Statistics Finland in 1993-1994. Specifically, the study carried out by VTT (Hölsä, 1993) concentrated on the internationalization of R&D organization in Finnish multinational companies (MNCs). Among the major findings of the earlier study were a strong growth trend in foreign R&D during 1985-1992, and the strengthening of domestic R&D through collaboration with foreign units. Statistics Finland, for its part, provided the first reliable figures on the intensity and distribution of foreign R&D by Finnish companies.

As no further comprehensive studies in this field have been done in Finland while the research has gone further in other countries, it seemed necessary to carry out a follow-up study using the same methods and the same population of companies as five years ago. The aims of this study are therefore to describe the changes, if any, since 1993 in international R&D of Finnish MNCs and to provide a closer scrutiny of network structures and R&D related management issues in the international context.

The research tradition in the field of R&D internationalization studies seems to favor the methods and theories used mainly in the science of economics. This is reasonable in a macro-level contemplation of national economies, but for proper understanding of the motives and methods of R&D internationalization an approach based on organization theory and strategic management issues would seem more fruitful. Particularly, organizational learning and networked collaboration theories should provide valuable insights. de Meyer supports this view by stating: ”though the classical theories on the internationalization of the firm explain some of the reasons why companies develop international R&D operations, the underlying concept can be summarized in the concept of learning.” (de Meyer, 1992).

1.2 Purpose and objectives

The objectives of this study were very clearly defined from the outset. The project plan approved by the project financier, the Technology Development Centre of Finland (TEKES), states as objectives the following:

The chosen 12 Finnish companies will be studied to provide information on their foreign R&D activities, their determinants and effects, particularly during the years 1994-1997. More specifically the goals include

- definition of foreign R&D units and activities, the reasons behind their establishment and the resultant problems and benefits
- defining other forms of internationalization of R&D in the study population
- finding out the effects of international R&D on domestic R&D and corporate strategy
- evaluating the development of R&D networking
- analysis of long-term development and trends, determinants and effects of R&D internationalization and the National Innovation System of Finland, based on longitudinal data from the previous and the current study.

According to representatives of Finnish MNCs, the internationalization of their R&D activities during the 1980's had primarily been an unintentional consequence of acquisitions made to gain foreign market access (Hölsä, 1993). Granstrand *et al.* state that "The most important reasons for multinationals locating the bulk of their R&D in their home countries are 'historical'" (1992). Paoli and Guercini (1997) argue strongly that R&D internationalization tends to be an emergent strategy of the firm, unintentionally brought out by management. Therefore, it seems necessary to get more and better information on the effects and determinants of global R&D to support the strategic decisions of management. A further point of interest is whether the executives

and companies have been able to exploit the results of their earlier acquisitions, or has the need for efficiency led to closures of R&D units and the consolidation of assets.

A focal point in this study is therefore the effects that increased internationalization has had on the processes of R&D in Finnish MNCs. The costs and benefits that corporate management perceives in increasing internationalization will be elaborated. Another important issue in need of clarification is the fact that in Finland the technological intensity of the firm (as measured by the ratio of R&D expenditure to total revenue) and the degree of internationalization of R&D activities actually seem to have a negative correlation (Åkerblom, 1994b). This is clearly a phenomenon that needs explanation, as these two dimensions usually have a positive correlation relationship. Certain industry specificities and company characteristics are offered as an explanation to this phenomenon in the analysis of the data from this survey.

R&D internationalization has been explained through various macro- and microeconomic theories, and there is still no generally accepted theory that would explain all of the various phenomena observed under this fairly vague term. As the motivation behind our study is mainly to shed new light on issues of strategic management of R&D, we try to elaborate the determinants of R&D internationalization as the managers actually making the decisions have perceived them. A quite natural result of this method is that our findings cannot be expressed as rigidly and precisely as the purely numerical data from various statistical analyses of e.g. patenting have customarily been analyzed. Possible connections between the various factors presented in the study are our interpretations of likely interrelations. We aim to support our claims by including various statements from the interviewees, as they tend to crystallize the thinking behind the actions. For a joint project we also felt it important not to be constrained in the first stage by too narrow definitions. The results from our study have been used to formulate the questionnaire for the second stage, to be carried out by Statistics Finland, which will provide quantitative information from a larger population of companies.

1.3 Methodology

This study was carried out by means of unstructured interviews of division and corporate level executives responsible for technology and R&D in 11 Finnish multinational companies. These companies were for the most part divisions of major corporations. As we wanted to focus particularly on business-specific internationalization in order to make the analysis of the data easier, our questions were explicitly limited to the division level. The interviewees were allowed to speak rather freely on the subject of R&D internationalization. On some issues of particular interest the interviewers probed a bit deeper and asked for elaboration. Some of the executives named other people from their organizations who would be able to provide additional information. Thus the total number of interviewees was 19.

The current study being a longitudinal continuation to a previous one, the population was determined from the outset. The same 12 divisions of Finnish MNCs as studied by Hölsä in 1993-1994 were approached for this study as well. One of them had been sold outside Finland, so a replacement was chosen, although from another industry. Furthermore, one corporation from the previous population declined to be interviewed this time. As this is a qualitative study, the minor change in the population should not bias the comparison between the studies, but is naturally to be taken into account by the reader.

1.4 Structure of the report

This introduction is followed by a review of previous research in chapter 2. A framework for this study is developed from the various research findings in internationalization of R&D. Chapter 3 introduces in detail the methodology used in the research process and discusses some limitations of the chosen methods. In chapter 4 the results of the study are presented, and in chapter 5 the causes and effects of the studied phenomenon are further elaborated. The concluding chapter 6 provides some key insights from the study,

as well as a recapitulation of the main findings and suggestions for future research. A short summary of the whole study can be found in chapter 7.

2 INTERNATIONALIZATION OF R&D

2.1 Defining R&D internationalization

The findings of various researchers of R&D internationalization up to 1993 have been well documented (e.g. Granstrand *et al*. 1993) and their implications for Finnish research have been examined by Hölsä (1993). These findings form a starting point for this study, but as previously stated, from a management point of view early research has been rather thin on the issues. Some of the interesting new research carried out since 1993 will be discussed in this chapter in order to bring current thinking on the crucial issues of strategy and management into the foreground.

To begin with the actual definition of internationalization of R&D, a recent contribution by Paoli and Guercini (1997) draws attention to the usually implicit and somewhat limited definition that has been used in virtually all research on the issue: "In the literature concerning international R&D management, internationalisation has been analysed almost exclusively with reference to multinational R&D units, that is to say, in relation to the merger, formation and evolution of research laboratories located abroad (multinationalisation)." (Paoli and Guercini 1997). With the premise of providing insight to management of international R&D operations, we would like to adopt the extended, and in our view more useful, definition presented by said authors (ibid. 3). In summary, their definition incorporates the elements of international exchange of intellectual property rights, contractual arrangements with foreign partners and global training and recruitment of research personnel.

An even broader definition of R&D internationalization is presented by Hölsä (1993, 19-21), where the phenomenon is taken to include not only R&D organization and collaboration, but also exploitation of the results of innovation through such means as licensing, spin-offs, joint ventures and others. This definition of the concept seems very valid, as it supports the emerging view that R&D cannot be a one-way flow of ideas and designs from the home country to abroad, nor does it take place in an hermetically sealed

organizational environment. Rather, R&D is and should be very interdisciplinary and interorganizational, in order to spark innovation and give opportunities for organizational learning. As the results of the current study began to emerge, it became apparent that given the way R&D processes have been developing in Finnish multinational companies, this broader definition of R&D internationalization is in fact becoming more and more accurate.

The importance of research into the internationalization of R&D is generally argued to stem from the growth trends in the phenomenon along with globalization. de Meyer and Mizushima assert as a basis for future research: "... international decentralisation of R&D activities has become an essential component of the global firm." (de Meyer and Mizushima 1989). A further argument is presented in Granstrand *et al.* (1992) by the editors as well as Pearce and Singh, namely the tendency of executives to rank R&D internationalization as one of their top priorities. Interestingly, Säynevirta and Ylä-Anttila (1994) present somewhat contrary data from years 1991 and 1993, which cover the population of this study. In their report they point (ibid. 44-46) to the fact that especially in 1993 less than 10% of the companies considered "moving the focus of R&D activities abroad" likely at all. The authors take this to mean that R&D internationalization is slowing down.

The interpretation offered above does not take into account the possibility of a rapid expansion in the global economy, which could result in more international R&D investments even if the center of gravity for R&D were to remain in the home country. Furthermore, Hölsä reports that all detected changes in the R&D organizations of the target companies had been in the direction of more local responsibility and dispersed R&D tasks (Hölsä 1994, 62). One of the questions posed in this study will therefore be the actual decisions made by the MNCs on R&D location compared with their previously stated intentions.

The issues of globalization on the one hand and local customization on the other go to the very heart of this survey. They help us bring out the dual nature of international

R&D. The globalized economy requires companies to be responsive to local needs and tastes, while at the same time reaping ever greater efficiencies of scale and scope. R&D management seems to have surpassed the old dichotomy of central vs. dispersed research and development. The executives are trying to form seamless R&D processes that are 'transparent' in order to accomplish efficient coordination, and simultaneously trying to integrate all the necessary elements from inside and outside their own organizations.

2.2 Measuring R&D internationalization

2.2.1 Taxonomies of R&D units

As the study of internationalization of R&D is a fairly recent phenomenon, there are yet few established conventions or common frameworks. A most important obstacle in the comparison of different studies has been the lack of a logical and fairly simple taxonomy of R&D units. Various authors have introduced their own terms for different kinds of R&D units, mainly based on the scope of their operations and the reasons for their existence. Among others, such authors are Chiesa (1997), Dunning (1992), Håkanson and Nobel (1993), Pearce and Singh (1992). Their typologies focus, however, on their respective findings and are not quite comprehensive enough for general use. Establishing a general taxonomy of R&D units is not getting easier either, as the nature of R&D work is changing rapidly. Tasks as diverse as customer support, trouble-shooting and basic research are carried out by the same people in the same units, as demands for efficiency and flexibility in R&D are on the increase.

Medcof (1997) addresses these issues in his paper and presents a taxonomy which seems rather elegant and useful in the context of this study, as well as fairly generalizable. His taxonomy uses three dimensions, which are: (1) The type of technical work being done; (2) Organizational locus of collaboration (marketing, manufacturing); and (3) Geographical locus of collaboration (local, regional, international). The first one of these dimensions is generally accepted and a set of commonly defined terms are in use. The types of technical work are usually referred to as research, development and

adaptation/support (e.g. Pearce and Singh 1992, pp. 140-142). For an elaboration of the other two dimensions and the rationale of the taxonomy, see Medcof (1997). With regard to our current work, it should be noted that these dimensions emerge as focal points in the previous Finnish research (Hölsä 1994, 51-57). This would seem to indicate that the taxonomy suggested by Medcof will indeed help present the findings of this study in a logical and intuitively consistent fashion.

However, after analyzing our findings about the current functions of foreign R&D units, it no longer appeared very relevant to measure their activities on the dimension of geographical collaboration. Almost without exception all the units surveyed in this study had various international contacts both inside and outside their own organizations. Another prominent phenomenon, perhaps most typical among the majority of companies that produce heavy machinery in our population, was the fact that it is extremely difficult to make a distinction between product and process improvement work in their development activities. Consequently, it is not very relevant to differentiate between marketing and production support either, as both of these activities would require active collaboration with major customers.

Bearing these peculiarities of the studied population in mind, it seemed appropriate for us to simplify Medcof's taxonomy considerably. As a result, we chose three main categories in which to present all the studied units. We characterize the units as follows:

- R&D center. These units are (one of) the most important technology unit(s) in the company. They generally do some basic research and product development, or at least maintain an active role in international technology scanning and networking in order to remain current on all relevant scientific developments. In a dispersed R&D organization they have the role of coordinating R&D activities across the organization and/or responsibility for technology transfer. In their keeping are all the core technologies of the company.

- Development unit. Although important, these units do not participate in such a wide scope of activities as the R&D centers. Their job is strictly applications oriented, and usually they have responsibility for just a few products/product groups. They have outside contacts only on issues concerning their own products or technologies, with the most important connections usually being to the corporate R&D center(s).

- Support unit. Having a very limited role, the support units only do certain modifications to the company's products/processes in order to better meet the customer's requirements. Usually having a head count of only a few people, these are not necessarily considered to be separate organizational units in their own right.

It should be noted that all combinations of the above kinds of units are theoretically possible. In one of the studied companies there was no central R&D unit; instead the work of dispersed divisional development units was coordinated through the company headquarters. This classification of the units has the added benefit of being fairly close to the one used by Hölsä (1993). In fact, other than excluding the word 'local' from Hölsä's definition of a development unit, these two classifications are similar.

2.2.2 Qualitative appraisal of the level of internationalization

As stated previously, the number of R&D units abroad is not by itself a sufficient proxy measure for the level of R&D internationalization. An example to clarify this point can be taken with regard to the parameter of size. In our study the smallest entity to be defined as an R&D unit was a support unit with 10 people, of whom only one performed work that could be considered to be actual product development. At the other end of the scale can be found R&D centers of more than 500 people serving two or three divisions. Yet both of these types of units qualify as one unit in the data. Therefore it is necessary to evaluate the internationalization more deeply and try to perceive the development paths of the companies from a more holistic perspective. Certain more elaborate means of

presenting our numerical data have been suggested to us, for example weighting the number of units by the number of employees in each unit. Due to the requirement of confidentiality we cannot present such figures here, though we gratefully acknowledge the advice and hope that later surveys with larger populations may present the numbers more thoroughly.

In the absence of satisfactory proxy measures for R&D internationalization (with regard to this study only, it has been pointed out to us that, for example, patenting activities are in fact representative of national R&D activities), we have resorted to less objective evaluation methods later in the text (Chapter 4, level of internationalization in the studied companies). This method is similar to the one used by Gerybadze and Reger (1997, Table 1), and is used to convey the impression we have received of the companies during our research project. It is worth noting that such qualitative descriptions, subjective as they may be, are useful in charting out the actual intentional component of R&D internationalization (or any management activities), as the researcher can account for various pieces of historical information. Such information has, in the case of this study, included the developments in the Finnish economy during the nineties, various ownership arrangements between the studied and other companies, as well as the fairly homogeneous background of the interviewees (male, technical education, 40-55 years old). For example, a different set of interviewees (say, younger business-side executives of both genders) would probably have offered a considerably different picture of the same developments.

2.3 Determinants of R&D internationalization

2.3.1 The viewpoint of economic theories

The determinants of international R&D have, in accordance with the common convention in economics, been divided into supply side and demand side factors. On the supply side the most important factors have been the availability and quality of research personnel. More recently this has been expanded to include the whole national innovation

system of the host country. This means its innovation infrastructure, which includes R&D capable suppliers and public research institutions as well as legislation and a level of education that are conducive to innovation. From the demand side the most important factors have been taken to be closeness to markets and helping production and marketing to customize the products or processes to local tastes and requirements. Various authors (e.g. Beise and Belitz, Dunning, Säynevirta and Ylä-Anttila) have dealt with the relative importance of these factors from the viewpoint of economic theory. It is, however, beyond the scope of this study to delve into the specificities of these theories, and they will only be brought up when directly relevant to our empirical findings.

As the basic differences between the various schools of thought seem to offer some very plausible explanations for R&D internationalization as well as for the more generally used internationalization theories, a very brief description of the Heckscher-Ohlin school and the Schumpeterian school is given here. This account is based on Säynevirta and Ylä-Anttila's description of the said theories (Säynevirta and Ylä-Anttila 1994). A firm is considered to be Schumpeterian if its competitive advantage stems from company-specific skills or knowledge. All of the companies in this study have a fairly high research intensity (and in certain cases, even though the research budget is rather modest, very strong marketing skills that could be considered self-developed company-specific competencies). Therefore they are at least partly Schumpeterian in their activities. This interpretation concurs with Säynevirta and Ylä-Anttila (ibid. 16), who state that concurrent companies can be characterized as both Schumpeterian and Heckscher-Ohlinian. The Heckscher-Ohlin theorem is based on the earlier situation in world trade, where the factors of production were mostly immobile. The theorem goes as follows: "Commodities requiring for their production much of [abundant factors of production] and little of [scarce factors] are exported in exchange for goods that call for factors in the opposite proportions. Thus indirectly, factors in abundant supply are exported and factors in scanty supply are imported." (Ohlin, 1933, p.92) This theorem, as interpreted from the viewpoint of internationalization, would label the Finnish paper companies as Heckscher-Ohlinian (Säynevirta and Ylä-Anttila 1994, 16). The differences explained

above are used in Chapter 5 for their part to explain the R&D internationalization pattern of the studied companies.

The new microeconomic theories of diffusion of technology and innovations have had a strong influence on the understanding of R&D internationalization and globalization in general (Granstrand *et al.* 1992, 2). The old theory of gradual diffusion of technology, first described by Vernon's product cycle hypothesis (Vernon 1966) has been rendered somewhat obsolete (see e.g. de Meyer and Mizushima 1989), replaced by hypothetical models of simultaneous global innovation (e.g. Pearce and Singh 1992, 138). Moreover, it should be noted that microeconomic theory in general is a good starting point for empirical research into strategic management, as Casson (1995) states with regard to the information cost theory. Casson has scrutinized the continuum from arm's length market transactions through trust-based network structures to the internalized transactions of the MNCs. This approach forms a firm basis for analyzing the real, often tacit determinants of R&D internationalization.

2.3.2 The viewpoint of practising management

The intentionality of the strategy process and decisions concerning R&D internationalization is questioned by Paoli and Guercini (1997). They use the intentional vs. emergent strategy concepts introduced by Mintzberg and state that "R&D activities can also be internationalised as an effect of an 'unintentional' process, in which case multinational R&D is the consequence of strategic actions that either do not correspond at all, or correspond only partially, to the contents of the pre-defined plan (emergent strategy)." (ibid. 19). This claim is highly consistent with the fact that in Finnish MNCs foreign R&D units had mostly been received as a by-product of a market-oriented acquisition (Hölsä, 1994). A similar trend has been observed in Germany by Beise and Belitz (1998, 8).

Carrying out research activities in globally dispersed facilities incurs decidedly higher costs of communication and coordination. Key personnel have to travel continuously,

which in addition to the monetary costs puts a serious strain on their most valuable asset, time. However, recent research suggests that dispersion of personnel and constant moves (changes in organizational structure or physical location) may in fact be a necessary requirement for rapid innovation (e.g. de Meyer and Mizushima 1989).

On the other hand, cost advantages based on lower wages or lower asset prices in foreign countries seem to be temporary in nature, and thus an insufficient basis for making strategic decisions in the long-term context of R&D. de Meyer suggests an initialization period of 5-10 years for a new R&D unit, and goes on to claim "this argument based on cost advantages does not seem to be the primary explanatory factor in the internationalization of R&D". (de Meyer, 1992) This point of view is supported by the findings in Hölsä (1994), where cost advantages are not explicitly mentioned by the interviewees.

It would seem that time, rather than money, is becoming the critical resource in R&D activities. This view was explicitly given by some interviewees in the empirical part of this study. To speed up their innovation processes and to avoid duplication of efforts, companies are starting to consolidate their R&D assets into what have been called "Global Centers of Excellence" (Gerybadze & Reger 1997, 18-19). These centers reside in geographical areas which have been recognized as being on the absolute leading edge in their respective technologies. Consequently, there can only be few such areas, and centers of excellence, worldwide.

As has been established in various management studies, the management of a large corporation is by no means a series of unanimous decisions and coherent strategic thinking. Rather, conflicts or at least different interpretations of the prevailing situation between organizational factions seem to be the norm. For example, in this study four executives from separate divisions of the same corporation offered four fairly different explanations for the reasons behind their internationalization, and even differing descriptions of the actual internationalization process. None of these accounts were less true than the others, they were merely 'different philosophical constructions' that the

interviewees offered as being valid from their particular point of view. In order to provide the necessary depth for understanding R&D internationalization, these and other similar individual accounts are briefly cited later in the text, where appropriate.

2.4 R&D internationalization studies in Finland

R&D internationalization was earlier followed by the Bank of Finland and as a part of the official investment statistics, but no focused surveys were done before 1993. The Confederation of Finnish Industry and Employers (TT), which has continued the monitoring of R&D investment after the Bank of Finland dispensed with these activities included foreign R&D investments in its Investment Survey for the first time in 1998. This survey is based on a sample of companies, and consistently gives lower figures than the official statistics, but is nevertheless very useful in estimating the direction and trends in foreign R&D expenditure.

In 1993 Statistics Finland and VTT Group for Technology Studies carried out a joint research project. Among the main findings were:

- 29% of R&D expenditures in major corporations and 24% in large to medium-sized companies were spent outside Finland. These proportions were markedly higher than expected.
- An increase in the number of foreign R&D units was mainly a result of acquisitions, with no explicit R&D related objectives.
- Strengthening foreign R&D had generally had only a positive effect on domestic R&D by improving the conditions for domestic R&D expansion and corporate technology transfer.

The current joint project forms a firm basis for regular R&D internationalization studies in Finland. A few recent case studies (Glader 1995, Honkala 1998) seem to indicate a growing interest in the internationalization of R&D among Finnish students of international business. Understanding the long-term development trends is the most

important objective. With closer connections between European research organizations and EU-wide research programs on Science & Technology Policy, the prospect of a pan-European R&D internationalization survey is hopefully raised.

3 THE RESEARCH FRAMEWORK AND METHODOLOGY

3.1 The framework of the study

An intuition based on following the developments in the Finnish and global economy during recent years, as well as some research commentary from various authors (a recent example can be found in Gerybadze & Reger 1997, 3-5) led us to believe that making evaluations of R&D work based on firms' physical structures would be an insufficient method for proper understanding. Therefore we tentatively chose as the unit of analysis the R&D processes of the studied companies, which in our definition would include all the different functions of R&D exploitation, organization and collaboration (cf. Hölsä 1993, 18-22). The empirical findings seemed to a certain extent to support this process view of R&D, as quite a few companies had recently adopted this kind of thinking as a basis for their R&D strategies. The formerly clear definition that an R&D unit located in a specific country operates mainly within the boundaries of the host country seems to have become somewhat inaccurate.

The above is not to say that identifying changes in the number and roles of foreign R&D units was not an important part of our study. On the contrary, analyzing the physical structures and their methods of establishment gave us an important measure for evaluating the validity of the answers received from the interviewees. For even if practising management, for obvious reasons, has the perception that they are very much the sole factor behind decisions affecting their companies, it was from the timing and manner of foreign expansion (or, in some cases, contraction) that we were able to make some seemingly sound generalizations. For example, all the major acquisitions that these companies have made during the last five years have happened since the strong upturn in the Finnish economy and Finland's EU-membership of 1995. Anecdotal as this may be considered, it nevertheless in our view highlights the fact that R&D internationalization generally follows the larger cycles in the economy, and that management actions are to a great extent merely adaptation to the environment.

In order to understand the studied phenomenon, the research findings are analyzed as follows. Chapter 4 is outlined to contrast the findings of this study against the results of the previous internationalization research project of 1993-1994. Answers are in particular sought to the following questions:

> How (quantitatively and qualitatively) has the organization of international R&D changed in Finnish MNCs during the last five years?
>
> How has the nature and volume of R&D work changed with regard to internationalization in dimensions other than internal organization?

After providing the data on the changes that have occurred recently, it is natural to try and explain why the said changes have happened. In Chapter 5 various answers to this question are offered, based on the opinions of the interviewees and on previous research in the field. The pivotal questions in that chapter are:

> Which macroeconomic factors have had an effect on the R&D and more generally on the businesses of major Finnish companies?
>
> Which aspects have had the most influence on Finnish managers' locational and organizational decisions regarding R&D?
>
> How is R&D work changing and what are the implications of these changes for the National Innovation System of Finland?

3.2 Methodology

The 11 companies that form the population of this study were chosen because they were studied in 1993. As a result of this current study we should be able to achieve longitudinal data for long-term analysis. We had to make some minor modifications to the study population, as one of the companies from the previous study had been sold to a

foreign owner, and could not reasonably be considered Finnish any more. The definition of a Finnish company was a remarkable problem, as most of the companies we chose were either directly or through parent companies at least partly in foreign ownership. One company, Tamrock, is even a wholly owned subsidiary of a Swedish firm. However, we considered each company separately and concluded that each of them can be said to reflect a specific Finnish character, or that the center of gravity in their operations is clearly in Finland.

The companies in our study population form three distinct sub-groups. A case of its own is naturally Nokia, which has shown phenomenal growth during the 1990's and is currently alone responsible for approximately a third of all industrial R&D in Finland. Nokia is by no means a uniform entity in its strategic behavior, as the two main divisions, Nokia Mobile Phones and Nokia Telecommunications operate in consumer and business-to-business environments, respectively. A thorough analysis on the internationalization of R&D in NTC from the point of view of an industrial systems supplier has been conducted by Lasse Glader (1995).

The second sub-group consists of two companies that can broadly be characterized as being in the digestibles business. Cultor and Leaf operate in fairly similar technological areas, even if Leaf's business is clearly more consumer oriented. Their businesses are connected through Xylitol, the artificial sweetener that Cultor manufactures and Leaf uses extensively in its products.

The third, and from a research point of view, most important sub-group is formed by the rest of the companies, which all operate in the heavy metal-working sector, most of them in forestry related businesses. These companies show many similarities in their strategic thinking, and form a fruitful platform for the analysis of R&D internationalization as their industry is historically very visible and important in Finland. It is notable that these industries (machinery, transport equipment, metal) were the most internationalized in their R&D expenditure in 1993 (Åkerblom 1994b).

The parent organizations of the companies in this study are among the 33 biggest in Finland and even the smallest of these companies would alone be among the 60 largest. The largest corporation, Nokia, had a turnover of FIM 52.6 billion in 1997 and a total R&D budget of FIM 4.6 billion. The smallest was Partek Cargotec with a turnover of approximately FIM 2.4 billion. The combined R&D investments of the studied companies are just over 50% of all industrial R&D expenditures in Finland. We therefore feel, considering the rather homogeneous background of Finnish companies and particularly their management, that we can make some fairly accurate generalizations and predictions on the basis of our study.

Loosely structured interviews of R&D executives were used as the main research method. The average duration of the interviews was approximately one hour, during which time the main categories of company background and interviewee's personal background, organization of R&D in the company, core processes of the company and R&D management were discussed (see Appendix for a more detailed structure of the interviews). All the interviews except two (due to technical problems) were taped and later transcribed. In addition the interviewer made notes, which were later checked against the tapes.

A total of 19 executives were interviewed, from corporate level senior vice presidents of technology to chief research engineers. The main objective was to get a comprehensive picture of the company's R&D activities. If we felt that additional information would be needed, another contact person was requested. In 8 companies two persons were interviewed, while in the remaining three we felt that the one interviewee had such an important position and/or long experience in the company that further interviews would not provide any remarkably different information. An interesting trend that emerged during the selection process and the interviews was that various firms had quite recently established the position of a corporate level technology manager. These persons were generally responsible for coordinating all the core technologies and R&D projects across the divisions or units.

Due to the extremely sensitive nature of R&D work, many of the interviewees expressed their concern for the confidentiality of the obtained information. We guaranteed to keep all the respondents anonymous, and if necessary, to refrain from reporting any company confidential data. With regard to this, some tables etc. are presented as aggregates only, and the interviews are identified by date and company name only. An additional problem is caused by the fact that Nokia would be easily identifiable by its size alone. The reader is asked to keep this fact in mind, as not all of our conclusions are directly drawn from the data presented in this report.

This research project was carried out in six months. During March the results of previous studies were analyzed to formulate the research problems and interview questions. At the same time the practical arrangements for the interviews were made. April and May were the months during which the empirical interview data was mainly collected, with a few interviews at the beginning of June. In June the collected data were analyzed, and the actual report was written during June and July. During August the report was refined to its final form and the research findings were distributed to the other organizations in the project for the eventual concluding report.

During the project we got valuable input and comments from various people at ETLA, the HSEBA, Statistics Finland and VTT. We also had an opportunity to meet German researchers of R&D internationalization from the Fraunhofer Institute in Karlsruhe, the Zentrum für Europäische Wirtschaftsforschung in Mannheim and the Deutsches Institut für Wirtschaftsforschung in Berlin. Their contributions are gratefully acknowledged.

3.3 Research critique

The traditional premise of step-by-step corporate internationalization through the establishment of new organizational units abroad has met with increased criticism during the last decade. The globalizing world economy no longer supports this gradual expansion of business activities. Rather, the more efficient distribution of factors of production, particularly the deregulated financial markets and tremendously improved

communication facilities, have made it possible for companies to rapidly expand their operations all over the world. Material limitations are not the constraining factor, but rather the very real friction and inertia caused by cultural differences and downright political and national legislative barriers. In consideration of this, we have tried to elaborate from our research findings particularly the kind of management thinking pertinent to the issues at hand. In doing this, we have had to assume that the chosen companies are in fact representative of Finnish industry at large, and also actual trend-setters in their business organization and operating procedures.

A caveat from de Meyer and Mizushima (1989) concisely sums up the limitations of the research approach used in this study: “While case studies provide ample and verifiable data on the past - and are as such an acceptable methodology to understand the frameworks as they were successfully or unsuccessfully applied in the past - they often only provide vague and by definition unverifiable opinions on what is to be expected.”

The most obvious limitation in our population is the heavy bias on the metal-working industry. This need not be a disadvantage though, as this sector can be considered relatively advanced in its strategic management. Whereas the forest industry in Finland has been pursuing economies of scale by making very large investments in paper-making machinery, metal-working has been a somewhat different story. When the prosperous bilateral trade with the Soviet Union abruptly ended in the early 1990’s, many of the companies had to rapidly adjust their business activities and to find new areas of competence. As a result of several mergers, business closures and reorganizations, the companies in this branch are intently focused on their core businesses. These trends of operational excellence and intense focus on a clear niche have obviously had a strong influence on R&D as well. It is therefore rewarding from a research perspective to scrutinize such companies that have undergone rapid change and therefore adopted new and improved concepts of strategic management, rather than, for example, the fairly stable forest companies that have in addition a remarkably low R&D intensity.

However interesting our study might be with regard to the one industry mentioned, it is far too limited in scope to make any real generalizations about the internationalization of R&D in Finland as a whole. The 'additional' cases of Nokia on the one hand and Cultor/Leaf on the other provide insights about different paths of internationalization and on the effects of industry or sector on the internationalization process of a firm, but they are not intended to be comprehensive in any way with regard to their respective industries. We are happy to note that as this was a joint project from the very outset, with three sub-projects of separate foci, there are already two other projects underway which will undoubtedly provide additional insights into the studied phenomenon.

We feel that our project and this report span the area of R&D internationalization sufficiently for the first phase of this joint project. The reader should notice that in comparison with the previous VTT study (Hölsä 1993), this one has some marked differences. The study population was defined from the outset, whereas in 1993 it was elaborated from corporate level interviews of 19 major corporations. As the scope of the research was somewhat expanded to include forms other than internal organization of R&D internationalization, we did not have the opportunity to probe quite as deeply into the daily activities of the studied units or their resource levels and shares of total work done. What we got back as a result of this tradeoff is still quite satisfactory. The explicit opinions and implied views of practising R&D management, although admittedly very subjective, are in fact the major factors behind the intentional strategic moves that companies make. Rather contrary to the findings of the previous study, it would now seem that the management of R&D has indeed become quite a bit more intentional, as companies strive to achieve operational excellence and to merge their processes seamlessly with their customers' processes.

4 INTERNATIONALIZATION OF R&D IN FINNISH MULTINATIONAL COMPANIES

4.1 Internationalization of the R&D organization of Finnish MNCs in 1993-1998

The organizations studied in this survey were chosen because earlier data about their R&D units and activities were available from the study of 1993-1994. The previous research project went through 14 divisions and companies, of which 10 were chosen for the final report. In this study we were able to gather information about 11 companies or divisions, three of which were not included in the previous report.

The studied organizations had as of spring 1998 a total of 77 R&D units, 50 of them outside Finland. Of the foreign units, 21 have been established or acquired since 1993. In 1993 the 10 companies studied had 35 foreign R&D units. 22 of these were identified in the present study as well, so 13 previously existing units had been sold, closed down or merged with other units. On the corporate level the largest firm currently has 36 foreign R&D units (not all of which are included in this study), whereas at the other end of the continuum can be found a very large corporation (turnover more than FIM 10 billion) with only Finnish R&D units.

All but two organizations in the study had around half or even more of their R&D personnel outside Finland. This is to a certain extent an unreliable indicator of domestic vs. foreign R&D intensity, as the nature of R&D work still varies according to location. The activities in the home country, in this case Finland, tend to be more comprehensive and research-based, while it is common that the units abroad do more customer-specific customization and trouble-shooting. Nevertheless the proportion of foreign R&D personnel shows that Finland is by no means the ‘natural’ home-base for corporate R&D even for Finnish companies.

The categorization we use for the different roles of the units is explained in chapter 2. By our definition, the total number of R&D centers had decreased from 16 to 13. Six centers had been turned into more focused development units. Three support units had grown into development units, and only 5 units in a clearly support role were left by the time of the present study. Only one development unit had atrophied into a support unit, and this we tentatively attribute to the decreased importance of defense-related businesses during the 1990's.

Product development was the most common role for a foreign R&D unit. This is to be expected, as support units are too limited in their operations, and R&D centers on the other hand too massive and costly to coordinate for developing new products. Out of the 21 new units, 11 were described as product development units, and in total there were 32 of them (64% of all foreign units), as compared with only 12 (34%) in 1993. Regardless of the scale of the development units, they were usually focused on a few technologies or product groups in which they historically had strong competencies or which had been dedicated especially to them. The core technologies of the companies were still maintained and further developed by the major R&D centers, even though some companies had deliberately duplicated the capability to reproduce these technologies in all their development units. As the major centers were, with only one exception, located in Finland, the technological heart and brains of these companies are still firmly in Finland.

The foreign R&D units have further been divided into three size categories, similar to those used in the previous study. Units of less than 15 employees have been labeled as small, 15 to 50 persons as medium and more than 50 as large. We were not able to get detailed numbers from all the companies and units, but within these categories our figures are very close to reality. It should be noted that in some companies the respondents were not able or willing to distinguish between workers of different divisions or functions, and some discrepancies might therefore have resulted. In our analysis we have tried to smooth out these inaccuracies by evaluating the unit's role as a

whole and choosing the most likely combination of key data. The specific numbers of different units are presented in Tables 4.1 and 4.2

The most common unit type was the medium-sized development unit (14), with small development units and large R&D centers sharing second place (11 of each). Interestingly, units of more than 50 people were the most numerous (18), which could be taken to indicate the importance of having a 'critical mass' for R&D in units that have actual product development responsibilities. None of the support units reached the level of more than 50 employees, with even the medium-sized one being very close to the lower end of the scale. It is interesting to note that whereas in 1993 the biggest foreign unit had about 200 employees, in 1998 units of more than 100 people were quite common, and the biggest ones had more than 500 employees. This is taken to be a result of ever more complex technologies and the systemic nature of modern R&D projects. Many of our interviewees mentioned growing project sizes as one of the most pressing management challenges.

	Support	Development unit	R&D center	**Total**
Small	2	2	1	5
Medium	0	7	1	8
Large	0	2	6	8
Total	3	11	8	21

Table 4.1. Foreign R&D units established after 1993 by size (n=21).

	Support	Development unit	R&D center	**Total**
Small	4	11	1	16
Medium	1	14	1	16
Large	0	7	11	18
Total	5	32	13	50

Table 4.2. All foreign R&D units by size (n=50).

Whereas in the previous study of Finnish R&D internationalization, acquisitions seemed to be the method of choice for Finnish companies going international, the figures from our present study tell a somewhat different story. Of all the units established after 1993

(21), more than half (11) were greenfield investments. The picture changes considerably, however, when we purge the effects of the single biggest company of the study from the tables. Of the remaining 10 units, only two were started as greenfield investments, although two other units which show up as acquisitions in our data were actually relocated after being acquired by a Finnish company. The assertion that greenfield investment is the only method of establishment that unarguably shows management intentionality was confirmed in our study once again. In the acquisitions there were usually various reasons present for the purchase of foreign units, and R&D was seldom, if ever (as managers' interpretations varied on this), the deciding factor. Detailed information about the methods of establishment for the various units can be found in tables 4.3. and 4.4.

Establishing (either as greenfield investment or by acquisition) a new R&D unit abroad is no simple venture. Whereas the respondents in de Meyer's study (de Meyer 1992) claimed initiation periods of as long as 5 to 10 years, in our study times this long were considered the ultimate end of the planning horizon, and even forecasting further ahead than perhaps two or three years was considered little better than clairvoyance. However, it was acknowledged that the rooting period for a new R&D unit is probably something like two years, during which time it is still economically and organizationally viable to cancel the project. After this, units very much acquire a life and purpose of their own, and unavoidably develop their own organizational inertia as well.

	Greenfield	Acquisition	Total
R&D center	5	3	8
Development unit	5	6	11
Support unit	1	1	3
Total	**11**	**10**	**21**

Table 4.3. Method of establishment of foreign R&D units established after 1993 (n=21).

	Greenfield	Acquisition	Total
R&D center	8	5	13
Development unit	13	19	32
Support unit	3	2	5
Total	**24**	**26**	**50**

Table 4.4. Method of establishment of all foreign R&D units (n=50).

In the geographical locations of the R&D units not located in Finland some trends were clearly evident. In comparison with the 1993 corporate-level study (Hölsä 1993), seven of the 50 units found in this study were in the Asia-Pacific region (14%), whereas in 1993 only one unit of 53 was located in a region other than Europe or North-America. Most new units had still been founded within these traditionally strong areas, 11 in Europe (~52%) and six in the US and Canada (~29%). As the units in the Pacific region were fairly new, their personnel numbers were still almost insignificant. A comparison with the foreign R&D units of the ten divisions studied in 1994 (Hölsä 1994) reveals that the relative weight of the UK and the Netherlands has decreased. In 1994 these two countries accounted for 31% of all units, whereas their proportion now was only 18%, personnel-wise even less. The absolute number of units in these countries has decreased by two, which can also be a result of the slightly changed study population.

When evaluating the relative importance of different areas for the R&D of Finnish multinational companies, it should be noted that the Nordic countries, and consequently Europe, would appear considerably more important had we included the Finnish R&D units into this study. About 90% of R&D personnel were employed within Europe. It should be remembered that one third of all R&D units were in Finland, and about half of all R&D personnel. The units in Finland were as a rule bigger, older, and more important than the foreign units. All but two of the studied companies had their main R&D center or R&D management in Finland. Tables 4.5 and 4.6 present the geographical distribution of new units and of all units, respectively. For reasons of confidentiality, R&D personnel head counts are not presented here. Nor would doing so considerably increase the descriptive value of the figures, as there are considerable distortions within them as well.

In South/Central Europe for example, one major R&D center has five times the people of all the other units in the area put together.

	Scandinavia	UK and Holland	South and Central Europe	Asia-Pacific	USA and Canada
R&D center	0	0	4	2	2
Development unit	4	2	0	2	3
Support unit	0	0	1	0	1
Total	**4**	**2**	**5**	**4**	**6**

Table 4.5. Geographical locations of foreign R&D units established after 1993 (n=21).

	Scandinavia	UK and Holland	South and Central Europe	Asia-Pacific	USA and Canada
R&D center	1	1	4	2	5
Development unit	13	7	4	4	4
Support unit	0	1	1	1	2
Total	**14**	**9**	**9**	**7**	**11**

Table 4.6. Geographical locations of all foreign R&D units (n=50).

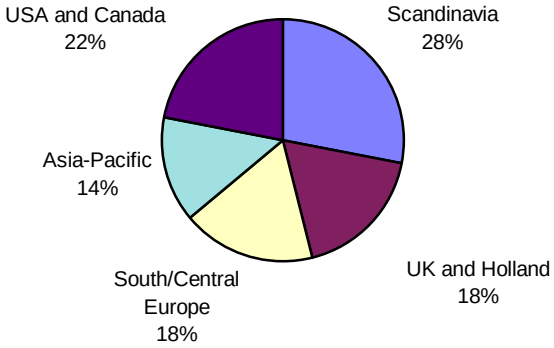

Figure 4.1. Foreign R&D units by location as a percentage of the total (n=50).

In order to perceive the level of internationalization as broadly as possible, we evaluated the companies in three separate dimensions of internationalization, namely organization,

collaboration and exploitation. In each dimension the companies were given one to three points, with one point denoting low, two points partial and three points extensive internationalization. The results, which are naturally very subjective but nevertheless based on our research findings, are presented in Figure 4.2.

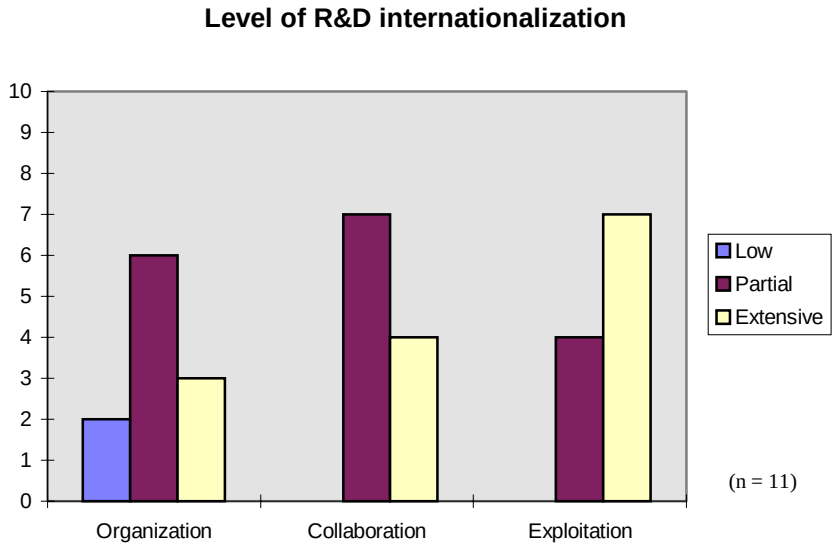

Figure 4.2. Level of R&D internationalization in three separate dimensions. Source: the author's elaborations.

As a whole, we see all the companies in this study as at least partly international in their R&D activities. The noteworthy issue seemed to be that out of these three dimensions, internal R&D organization was actually the least international. Even if half, or more than half in some cases, of R&D personnel were employed abroad, the center of gravity for R&D was still firmly in Finland. The two companies which had concentrated their own R&D activities in Finland (and Sweden) nevertheless had very active connections around the globe, and were especially international in the exploitation of their R&D work by transferring technology to other continents and helping their customers improve their processes by sending frequently R&D personnel to work in the customer's locations. The other dimensions of R&D internationalization are further discussed in the next paragraph.

4.2 Other forms of R&D internationalization in Finland

The strategy of choice for the majority of companies in this study seems to have been consolidation of assets and very strong focus on their respective core businesses. This has not meant plant closures and staff layoffs only, as a strengthening of critical resources has also been evident. In order to boost R&D productivity and responsiveness to customer needs, corporate-level projects have been discontinued and the resources allocated to separate business units or divisions. This trend has naturally contributed to a greater geographical distribution of R&D related activities as well, but is not immediately visible in the number of R&D units, as most of the people involved in these new types of projects usually have a primary job other than R&D. The responsibility for R&D profitability is very much in the line organization, whether these people report to the corporate R&D management or to their local superiors in the sales/product organization. Matrix structures are in use in various firms, but generally the real chain of command goes via people who are responsible for specific products.

Process thinking had made a breakthrough in the studied organizations. Responsibility for projects was not automatically allocated to a certain function, but rather task forces were flexibly formed by the chosen project managers. The managers did not necessarily have R&D backgrounds either. In fact various companies had recognized that marketing people, with a better understanding of the customer's needs, should coordinate the new product development processes. Centralization and dispersion could be found together as in one company, for example, production was centrally managed (and located in just a few places) but marketing had regional managers, who were also responsible for product development in their respective markets. In another company, positions of dedicated 'business managers' had been created. These persons had the combined roles of marketing, technology scanning and project implementation. Such positions obviously place very high demands on the skills of the selected people.

As R&D executives have been faced with dwindling resources and demands for greater productivity in R&D, they have had to turn increasingly to resources outside their own

organization. Sub-contracting, consulting and joint-venture arrangements were generally seen to be an increasingly important means of carrying out R&D activities. In addition to reduced fixed costs, these flexible agreements allow the companies to better exploit the results of their R&D, as the foreign partners often have a better understanding of the local market conditions than the companies themselves would be able to develop. Consulting and sub-contracting were seen as flexible methods of evening out the fluctuations in R&D workload. Through joint-ventures the companies are often able to maintain an interest in technologies that are currently on a 'back-burner', but which may some day prove crucial to them.

Various examples of the way the interviewed executives perceived the use of external resources are provided in the following:

> We had one project in Russia. It would have cost us FIM 200 000 here [in Finland], the Siberian institute did it for FIM 20 000. They used [manual] methods which of course took some time, but surprisingly, not much more than it would have in Finland.

> Recruiting ... has changed in nature. In the eighties, [if there was a job to be done], we just put an ad in the paper. In today's networked environment it doesn't work like that anymore ... We don't hire a person, we find out where the job can reliably be purchased from.

> As we have divested the basic research, or dispersed it to the business units, there is no longer any 'base load' for R&D. We have only the 'golden eggs' in-house, special skills will then be purchased outside as they are needed. ... And Finland offers good quality research for a very low price. Just like eggs, actually.

The main reason behind this trend of networking seemed to be the more effective use of scarce R&D resources. As companies purchase basic research and certain application-

specific solutions from research institutes or independent contractors, they gain considerable savings through the reduced need for training and in-house competence development. Effectiveness is not the sole reason for networking though, as the following citation reveals:

> One particularly good aspect in this networking [security-wise] is that the work is divided into small parts, and the sum of the parts is only known to [the executives]. If a part of it gets into wrong hands, it's not so dangerous. ... The Finnish language is sort of a security feature too. Not so many people in the world know it.

This statement offers one way of contesting the traditional claim that centralizing R&D increases the security of proprietary information. The instantaneous transfer of information in computerized networks is a double-edged sword for information-reliant companies. On the one hand it allows them to affordably duplicate crucial resources across the globe, to use the capacity of expensive laboratory equipment to the maximum and to avoid unintentional duplication of efforts. On the other hand though, the free flow of information makes it ever more difficult to protect and to exploit proprietary intellectual property for any extended period of time.

As the globalization of the world's economies speeds up the process of technological homogenization, products fall into obsolescence ever faster. The less developed countries are no longer willing to accept older technology, nor is it possible for multinational companies to use different technologies in their various locations. The discomfort of the executives was evident in their statements, which emphasized that their companies are more global than either their customers or their suppliers. A couple of examples follow to clarify this:

> We have started to think that even if [the biggest company in the world in the industry in question] is not very centralized at the moment, they nevertheless see from their information systems the exact prices that we use

> to sell to their Australian or Chilean units. It's no use thinking that they won't be expecting the same global service and pricing everywhere.
>
> Our suppliers claim to be global, but when we start negotiations they appear very puzzled... like, in Europe the prices are such-and-such, in North America something else, and then the terms of trade are totally different too... Truly global suppliers in this business just can't be found.

Naturally, managing a network of partners who are not under the company's authority requires competent R&D executives. The interviewees were almost unanimous in voicing their concern for the need of managers that have, along with a strong technical competence, the skills required for managing people. The demands on the quality of R&D personnel are also getting more exacting all the time. Knowing foreign languages, or in any case English, is almost an absolute requirement. Solitary tinkering is no longer encouraged in the networked environment, and therefore a good researcher should have the social skills and other properties of a good team player as well. Internationalization naturally means more traveling, and therefore families have to be willing to accommodate the frequent absences of the researchers.

Just finding such people is not sufficient to ensure success either. Once recruited, they need to be given challenging tasks and, above all, the chance to form their own networks of colleagues. Valuable information could still be lost if these executives leave the organization for one reason or the other. Furthermore, reconstituting or reorganizing the connections in an informal, unsystematic network is considerably more difficult than in a formally structured organization. If the people who act as the hubs in the network depart, long and costly delays could result.

With regard to networking, the R&D managers repeatedly used the expression 'Carrying water to a well is of no use'. By this it is meant that establishing a joint venture or agreeing on joint R&D work, even on a solid technological base and in an environment of trust, is not alone sufficient to guarantee further innovation. The interviewees

preferred an approach of establishing good relations with the local research community, gaining experience from joint projects and having daily interaction with their partners. Only through such an extensive investment of time was a truly independent node in the created network.

> Cooperation is most fruitful when it is truly a matter of give and take... This interaction is created more easily if you live and work at least in the same time zone... We see unused opportunities for cooperation in North America and Australia... People without formal education don't have the connections, old college friends and so on, who would now be working for the university or something...

Managing the R&D network has not reached a very systematic level yet. It is also unlikely to ever do so completely, as the very root of the networks can be found in the informal social connections between old acquaintances. An established reputation of a scientifically credible researcher and that of a 'fair player' are crucial for the trust and commitment necessary in these relationships. The disorganization does not result in disorder, however. On the contrary, the network can be very efficient in short-cutting the formal chains of command and hierarchies, as the following example clearly shows:

> Our more seasoned people just know where to call... Why, just yesterday evening I was called about [a technical problem]. I just called to the top three researchers in this field in the world, and in five minutes I knew for sure that nobody has the solution to this yet.

Such easy relations between industrial corporations and the scientific community were not the norm previously, as was acknowledged by the interviewees, too. The new requirements of the global economy have therefore been a very strong change agent, and have forced the companies to adapt their thinking and procedures.

> One of the things that I am certainly promoting here is that, because of this networking, ...there has to be respect on both sides and if we are extremely good in-house and nobody else knows it, ... it is not very effective in terms of collaborating. OK, money always counts because you can pay for research externally, but those groups like to work with our scientists because we are good. But they need to know we are good. They can find out by working with us and learning over a period of time that we are good. ... I encourage publications ... This is something you have not seen in the past. That is a change. In the past it was not needed, quite frankly. So when you start to network more extensively, you actually require that.
>
> You don't have to make any lasting commitments. ... I see the possibility of a 'virtual corporation'. ... The world is full of services. The universities are becoming very open to collaboration. ... Really, you could develop the product 'outside'. ... Not tying up any assets, knowing exactly what you need, you can always purchase it from wherever suits you.

The fact that the new network structures are not formally organized does not mean that the companies are neglecting the need for efficiency and end-user value in their operations. The simultaneous needs for flexibility and efficiency are very difficult to cope with using traditional organizational solutions. As the first tentative steps towards new, pro-innovation arrangements, some of the studied companies were experimenting with deeper integration of common R&D efforts in the value chain. Thus, 'value added development teams' had been established, and one company was connecting its videoconferencing and information systems to the suppliers' offices. As the customer industries for the majority of these companies are fairly conservative, the firms were willing to participate in the customers' risks that are inherent in establishing new processes and working methods. In various cases there were agreements in place to share 'the pain or the profits' of pilot projects.

To sum up, the internationalization of R&D in Finnish multinational companies has reached a very high level. The organizations have been climbing their learning curves rapidly, and the management's awareness of the international environment is considerable. Resources have to a certain extent limited the chances of establishing a strong presence outside the home country, or continent, but this is no longer perceived as vital anyway. The companies have simultaneously striven for leaner organizational structures and extensive networks of contacts and partners. The strategies of technological excellence and high knowledge intensity require global thinking. As one of our respondents put it:

> In a few years time we will be, have to be, using 'best in the world' solutions in every part of our R&D process. There just isn't any other way. If we're not the best in some particular item, then we will buy it from those who are. Wherever they may be, we'll buy it from them.

5 MANAGEMENT AND DETERMINANTS OF R&D PROCESSES IN FINNISH MULTINATIONAL COMPANIES

5.1 External factors affecting Finnish corporate R&D

The deep recession in the Finnish economy during the early 1990's forced Finnish companies to take a very practical and short-term view on all their activities. Generally though, the importance of continued R&D investments was acknowledged by management, and none of the companies in our study made any drastic cuts to their R&D spending. Nevertheless a refocusing of their R&D activities has become evident, with the purpose of improving R&D efficiency and rationalizing internal R&D activities. Various companies explicitly mentioned dispersing R&D activities to business units, as corporate R&D was generally perceived to be too long-term and impractical. In addition, the greater availability of external R&D resources has made it possible to outsource basic research by purchasing the necessary knowledge from public research institutions and subcontractors. It is difficult to tell whether increased supply or demand has been the original impetus for the phenomenon of R&D networking, but there would appear to be a 'virtuous circle', where increased spending by major corporations results in more independent R&D contractors and the availability of external resources makes it easier for global companies to purchase market-specific R&D locally.

A very interesting pattern in R&D internationalization becomes evident when the companies in this study are surveyed with regard to their level of internationalization and the nature of their competitive advantage. The three companies with the strongest global R&D presence (or in one case, previous experience thereof) are also the three that have the least need for large physical assets in their work. These companies are Cultor, Leaf and Nokia Mobile Phones. Their competitive advantage is obviously very much market specific, as their products require mass-customization to a certain degree, and are not usually customer specific. They would therefore be close to the Schumpeterian end of the scale, if not wholly so. Even though Nokia Mobile Phones has a very strong lead-market in Finland and in the other Nordic countries, this advantage is no longer sufficient

for the extended volumes of its business. Certain technologies are developed outside the Nordic countries, with regard to local and regional standards, and particularly the end-product is heavily modified according to local preferences. Leaf confectionery is marketed differently in every country, even though the basic product innovations and spearhead product categories are the same internationally (but not globally, as Leaf chose to divest its North American businesses, along with which went one R&D center). Cultor only has an R&D presence in its main markets, and this has come to mean that the company is very internationalized in its R&D activities. A reverse logic can be applied here, as it would seem that the most important markets are attracting the best qualified companies to conduct their research in these lead-markets. The comparative advantage would then be considered to be the demand by sophisticated customers, which in turn results in the importing of R&D factors of production.

Another group of companies, namely those which have internationalized their R&D mostly within Europe, is characterized by the fact that although they traditionally have production facilities in Finland, their customer base is totally global. The internationalization of R&D in these companies has not, however, been merely a consequence of their international business activities. Rather, the main locational determinant has been the historically strong background of the European economies in the respective industries of these companies. Wishing to be the technological leaders in their fields, these companies have expanded their business activities by acquiring competing firms with complementary technologies. Relevant examples include the acquisition of Voest Alpine Bergtechnik by Tamrock for its coal-mining knowledge, the merger of Wärtsilä's Diesel and New Sulzer Diesel for Sulzer's slow diesel engines previously missing from Wärtsilä's portfolio, and the earlier purchase of harvester production from Sweden by what is now known as the Timberjack Group. These and other similar incidents are clearly supply-side motivated internationalization activities. The differentiating factor is that these companies have been searching for technological competencies for their own businesses, and have not needed to reckon with their customers' geographical presence. For even if their R&D facilities are heavy and require pilot plants and expensive prototypes, the end-products are still somewhat mobile and

can be distributed globally through a sales network. Apart from the companies already mentioned, Partek Cargotec and, tentatively, Nokia Telecommunications are included in this group.

The third group in this case is formed by companies, which in a way quite literally have their roots in Finland. This is because their main customers have traditionally been, and still are, the major paper companies of Finland and Sweden. These three companies, Valmet Paper and Board Machines, Sunds Defibrator and Ahlström Machinery, are directly dependent on the paper and pulp industries, which in turn derive their success from the abundant Nordic forests. In this fashion the companies in this third group are more Heckscher-Ohlinian than the others. With regard to the above it is therefore not very surprising that the R&D facilities of these companies should be extensively in Finland and Sweden, as is the case with the single concession of Ahlström Machinery having an R&D unit in the USA.

The theory of comparative advantage alone does not sufficiently explain the differences between the studied companies. The companies in the third group also consider their own firm-specific technological knowledge to be the very best in the world, and as it is strongly tied up with the experience of their existing customers close to home, they have no incentive to spread their knowledge resources around the world. Moreover, the paper industry is a classic case of production based on heavy capital goods, and therefore the R&D efforts in these companies have to culminate in immovable pilot plants which can cost hundreds of millions. In addition to this, the customers are naturally risk-averse and shun bold new innovative solutions.

5.2 Internal decision parameters of R&D management in Finland

Why are the Finnish companies doing R&D work abroad? This was, of course, one of the pivotal questions in this study, and the responses we got from the interviewees were as interesting as they were multifaceted. By far the most important reason for the existence of foreign R&D units was closeness to markets, or access to technologically

different markets. More than a quarter of all the units (26%) were established solely for this purpose. In total, market related reasons, with market access mentioned as the most important, accounted for more than half of all the answers. Political reasons were not considered relevant, except for a few cases of market protection in Australia. In the case of a government-owned company earlier locational decisions had been made partly on the basis of domestic employment, but this was not happening any more.

An additional 30% of the primary reasons mentioned could be loosely categorized as resources-related. These had to do with access to scientific and research organizations, quality and quantity of R&D capable sub-contractors and innovation infrastructure in the host country. The availability of skilled personnel was mentioned, but usually was not considered a major factor. Moreover, the problem seems to be more in enticing people to work in the remote areas where some of the units were located, rather than being a country-specific phenomenon. Cost differentials between countries were mostly taken as a temporary (dis-) advantage only. The high taxation level in Finland got a few mentions as a potential barrier for recruitment, should the need for foreign researchers in Finland increase. Currently the need was not perceived to be significant.

It was obvious from the answers we received that seldom, if ever, was there only one specific reason for establishing or acquiring an R&D unit abroad. Furthermore, the decisions could not be considered separately from the other events that were currently taking place in the organization. Depending on changes of strategy, management or corporate ownership, very radical swings in the direction and momentum of the internationalization drive could result. Economic cycles clearly had an effect on the contraction or expansion of international activities. As a generalization it can be said that technological considerations and the role of R&D have gained importance recently, and are now an integral part of the strategies of the studied firms.

Only two companies in the present population operate in the consumer goods business. The others sell heavy machinery, or in one case high technology biochemicals, which in turn are used in further production processes and end-user goods. The two consumer

goods companies clearly have a market orientation in locating their R&D. One of them has even made a major strategic choice with regard to markets and sold its businesses in a major market area, in turn focusing strongly on fewer products and more familiar markets. This move had the additional impact of divesting a major R&D center along with other business units.

As market-related reasons appear to have been the most important determinant of R&D internationalization for Finnish MNCs, one could very easily draw the conclusion that the Finnish markets alone are too small and unsophisticated to support any truly global companies in their product development. This it not quite the case. All the companies studied here have, explicitly or at least implicitly, defined their competitive strategy as becoming a global player through focusing on a specific technological or product niche. Most of them have expanded their technological base through acquisitions and managed to grow into number one or two in their respective markets. Others have kept on focusing on a small enough technological area and maintained their competitiveness there, even if their resources have not allowed sufficient growth to become truly globally recognized companies.

It is interesting to contrast this finding with the results of Casson *et al.* (1992), who in their survey detected a trend of corporate R&D in major companies becoming more diversified in terms of applications. Similarly, Cantwell reports: "...a trend towards a broadening degree of technological specialisation among the leading MNCs, though they are moving into related and hence complementary fields." (Cantwell 1992). The Finnish firms' focusing on core technologies has not resulted in extending the scope of said technologies, but rather in the homogenization of methods and processes worldwide. It is naturally not plausible to attribute this development solely to Finnish companies, or even to give them credit for being the instigators of this trend, but the fact remains that, for example, in tree harvesting the Scandinavian method of cutting the trees into logs in the forest right after felling is gaining headway on the American continent as well. Differences in the unit of analysis (corporations vs. divisions) and the various

dissimilarities in the research methods used can be further assumed to explain the divergent findings.

The standardization of methods could be a result of the relative agedness of the scientific and technological concepts behind them. In many of the studied industries the customer base is fairly conservative and the basic technologies in use are old indeed (e.g. mining, harvesting, engines, papermaking). It could be said, and in fact was said by some of the interviewees, that in these industries "...the skill is in the process. We aim for maximum yield from the whole value chain." As one interviewee put this, optimum processes in turn are achieved through: "...managing the man-machine interface. We have good knowledge in hydraulics, electronics, mechanics and so on, but only the end-product is totally unique. We use standardized components, there's nothing to add value to in the components themselves." It seems therefore that as the basic concepts in use are the same for everyone and no technological 'quantum leaps' are likely, operational effectiveness and cost efficiency becomes more important than following all possible paths of innovation.

In the rapidly changing biosciences and electronics industries the situation was certainly different. The companies in these industries were willing to have various simultaneous projects underway and even to explore dead ends in order to remain current on all major technologies and not to miss any possibly revolutionary innovations. Furthermore, even if Finland might be among the leading countries in some of these technologies, it is by no means leading in all of the various technologies needed in these industries. The companies in these businesses had therefore established or acquired significant research and development capabilities from the Centers of Excellence or lead-markets for their products. Relevant examples include Silicon Valley in California for electronics and software, the state of New York for biosciences and the UK for sophisticated retail markets of confectionery.

The establishment of R&D units abroad has typically been the first stage of R&D internationalization, but the process does not stop there. Rather, having units abroad

forces the organizations to develop skills and capabilities for coping with cultural differences and coordinating truly international activities. de Meyer states with regard to technical learning as a factor of internationalizing R&D: “But learning about different markets, different problem-solving methods, different sources of technological progress, different cultures, different competitors and rapid diffusion of that learning throughout the organization is definitely enhanced by creating an international network of R&D laboratories.” (de Meyer 1992). It would appear that in some cases the process of internationalization, rather than the objective of simply having a presence abroad, has been the real determinant for the establishment of foreign R&D units. de Meyer describes this as “...the urge to belong to a network of information exchange and discussion.”(ibid. 168).

An important benefit of analyzing the different dimensions of R&D internationalization apart from the purely physical structures of the firm is that it gives a better grasp of the true nature of the firm’s degree of internationalization, as defined by Paoli and Guercini (1997, 7-9). In other words, just having units abroad is not sufficient to make a company international. As one executive in our study emphasized:

> We haven’t found any Silver Bullet abroad. There hasn’t been any Big Bang, it’s been more like a slow ripening. We’ve learned the benefits and disadvantages of globalizing R&D. Dispersion hasn’t had any intrinsic value.

As for the Finnish markets, the competence centers or centers of excellence of the technologies used and produced in these companies are mainly in Finland and the other Nordic countries. Finland has the highest penetration of mobile phones in the world, which has obviously been very important for Nokia. The forest sector is traditionally strong in Finland, and has contributed greatly to the development of machinery and heavy equipment industries, which have the strongest representation in this study. The two companies specializing in foodstuffs and related fields owe their success partly to

Xylitol, a Finnish innovation that was first successfully marketed in Finland and appears now to be developing into a global success.

The quality of the Finnish R&D infrastructure was explicitly recognized by the interviewees, as in the following statements:

> Finland is sort of actually rich [in a certain technological area], in exceedingly good people, actually, in good facilities in universities and institutes. Really it's a gem, a jewel.

> Compared with the American system ... I once made a rough estimate, the same job can be carried out in Finland for just 30% of the costs ... And Sweden, for example, there the costs would be something like 60%. We just seem to be more cost-effective here.

> Nordic countries are good places for us to be. Raw material costs are high, which means you cannot waste them. You have to optimize them. You can not just treat them like a commodity. So the Nordic countries are good places to develop these unique ... technologies.

> ...Finnish engineering culture is rather good for development work... people really want to try out new ideas... It's like a sort of desire for freedom or innovativeness... But on the other hand a desire to accomplish things, get them ready and tangible, not just the artistic kind...

5.3 Emerging trends in the internationalization and management of R&D

This section deals with the various trends that emerged from the visions that the interviewed R&D managers had of the future in their businesses. Their prognosis concerned the nature of R&D work, the optimization of the development processes and in general the continuing homogenization of R&D resources. World-class resources and

units are obviously very similar, whether a stand-alone facility in a developing country or a part of a high-technology network in one of the recognized Centers of Excellence. The companies in this study all had more or less clearly adopted the strategy of becoming world-class players in their own niches, and therefore they deemed not to have very much need for other than globally outstanding internal R&D resources.

The studied firms are commonly global number one or two in their respective technologies. As a result of their chosen technological leadership and niche-domination strategies, the studied companies had a strong focus on core competencies. The need to develop ever better end-products in order to differentiate themselves technologically is bringing increasing costs and complexity to product development, and therefore basic research was usually outsourced to a large extent, if not totally. In various cases corporate technology units with ambitious long-term projects had been disbanded because they were too expensive. Technology scanning and networking through suppliers are preferred to the use of internal resources, if the requirements of the project are not absolutely the core skill of the own R&D organization.

Internationalization has continued, but is more focused and tightly managed. Operational excellence and R&D productivity are in the foreground. Companies implement the best practices and standardize processes globally. The pivotal role of common approaches and company-wide standards in efficient global innovation processes has been explicitly recognized by many authors (see Håkanson and Nobel 1992 for a solid example). Having uniform development and management practices is a prerequisite for staying competitive in the global economy. The increasing demands of customers, shortening product development cycles, stiffer competition and particularly the increasing complexity of products and projects is impossible to cope with unless one's own organization is behaving coherently. Apart from the accounts of various authors (e.g. Biemans 1992, Granstrand *et al.* 1992), the increasing complexity inherent in new products and methods was addressed by the interviewees as an ever more important and time-consuming issue. Be it lines of code, number of components or the quantity of people in a project, all these parameters have been growing almost exponentially in recent years. As management

resources have not, and probably cannot grow, as fast as the demands of product development require, new practices for coordination are constantly being developed.

Beise and Belitz (1998) have noticed a similar trend of consolidation and formation of competence centers in Germany: “After periods of expansion, many multinational companies coordinate and restructure R&D units in various locations. After a phase of decentralisation, the groups often begin to consolidate, to eliminate duplicate research and intensify intragroup technology transfer.” Two examples clarifying similar developments in Finnish companies are given below.

> The company in question had a strong core business, but along with that some weaker business units with products from a fairly different, although related technology. In the management’s view it was a question of divesting this branch altogether or making a considerable commitment by acquiring a major player in this technology. They chose the latter route and purchased an Austrian company in 1996. At the same time, a major effort to harmonize R&D practices in the whole corporation had been started under the direction of the newly appointed senior vice president for technology. As a result of restructuring the old and the new businesses, the company currently has two major R&D centers, the one in Finland focusing on the old core technology and the new one in Austria developing the recently acquired technologies. These moves strengthened the Austrian organization considerably, but at the same time uniform practices from the Finnish parent company were implemented throughout the company and the Finnish R&D management was better able to concentrate on their own technological issues.
>
> Another case, if somewhat different in details, still has very much the same basic characteristics of simultaneous internationalization and restructuring of the R&D organization. The company in question has had a fairly well-developed network of European R&D units since the 1970’s. Their basic

> technology is sound, and in the early 1990's they started a considerable investment in a parallel technological solution. They did not, however, have any products at the bigger end of the scale, and as their customer-base was diversifying rapidly, this was becoming a problem. The solution was to be a merger with a competitor who had a well-developed range of larger products. During a single year the company has had to integrate two major R&D centers into its own organization, continue to develop and test the new parallel technology (so-called pre-launching is underway, with sales limited to 10% of the expected final volume), and to maintain the operational effectiveness of the original development and service organization. The results still remain to be seen, but obviously the company has had to face some very turbulent times.

The combination of learning to use external resources, experience in integrating acquired units and standardizing R&D practices has put the companies in a strong position to rapidly change the center of gravity of their activities. In the words of one interviewee:

> In a few years time we will be hardly at all dependent on any specific location. As all the planning, systems and processes are standardized, if we see new markets emerging in say, Brazil, we can very rapidly have a new unit there as well. Then, of course, there's the issue of communication and coordination. We see a system of a few large R&D centers and then various satellite units in major markets as being the most sensible arrangement.

Technology management has become more systematic and is very tightly connected to the basic strategies of the firms. New positions of corporate technology managers are being established, and corporate bodies for coordination throughout the firm were found in all of the studied companies. As the companies have divested businesses that are not directly part of their core business, they have become better able to exploit the synergies between the remaining technologies.

In the opinion of the interviewees, efficient and/or innovative operating procedures from foreign units have so far not been sufficiently transferred across the organization. The strong Finnish cultural background of the management has helped them to implement coordinated management practices mainly unidirectionally. The center-to-periphery model of dispersion of management practices is further confirmed by the fact that in case where the company was Swedish (albeit a subsidiary of a Finnish corporation), standard operating procedures had been transferred from Sweden to the Finnish units.

R&D personnel are not as of yet very international. Only two of the interviewees were of a nationality other than Finnish. Recruiting is mainly done in the host country, and international job rotation is not very popular. However, as one interviewee emphatically put it:

> We are intentionally and visibly aiming to reduce the 'Finnishness' of our R&D. It is not that we don't find good knowledge here, but that in a house like ours, which after all has very global activities, it is not healthy to perpetuate the belief that all wisdom comes from Finland.

The firms are markedly more international in the exploitation of R&D work and in collaboration with other organizations than they are in their own R&D organizations. All companies had at least a basic awareness of the technological level all around the world, and considered themselves to be technologically competitive in the global markets.

The difference between R&D work and other business processes seems to be blurring. Customer service and trouble-shooting is very close to R&D, especially in the process industries. Defining 'pure' R&D units was consequently difficult. As R&D personnel are required to use an increasing portion of their working time on customer service or other closely customer-related tasks, the demands on their language and interpersonal skills have increased. In one particular case, the staff of an acquired R&D unit was mostly unilingual. As this was clearly unacceptable if they were to operate as an efficient part of

the company's R&D network, a crash course in English was provided, and participation was actually mandatory for all personnel in the unit. After this the unit has been granted an increasingly important role in the organization, and one new product family was moved to be its responsibility entirely.

IT solutions and leaner organizations have enabled the simultaneous geographical dispersion and organizational centralization of R&D processes. As for information technology, it was considered a necessary but not sufficient means of communication. Executives expressed opinions that the information content that can be transferred through electronic means is too 'shallow', meaning that tacit and otherwise difficult knowledge cannot be moved over the wires. Videoconferencing and e-mail were extensively used in most companies, but regular face-to-face meetings were nonetheless the norm rather than the exception. The biggest companies and R&D units even stated that the physical capacity of current technology is insufficient to transfer the huge amounts of data that would be needed for the dispersion of their daily work. Therefore some of these units had remained rather focused on their own specific projects, even though generally there were systems and structures in place to ensure that all units had access to all relevant technologies.

Time-to-market was generally considered the most important measurement of R&D productivity, but good means for measuring the often intangible assets and also outputs of R&D are still very much needed. Rapid growth had in many R&D organizations further hindered the measurement of productivity over time. As the average project size was growing both in terms of money and personnel, it had become ever more important to have efficient means for evaluating project viability early on in the development process. The sharing of R&D costs was a concern, as for some companies there seemed to be a tendency in their customers to neglect joint product development on the account of ready access to the global technology pool. As in many cases it was the business units or divisions financing the development work, there was naturally much circumspection about every project.

Clear differences were evident between the consumer-goods companies and the ones producing equipment for industrial customers, requiring heavy investment and expensive pilot plants and other facilities. The investment logic in these capital-intensive industries can be summed up accurately by the following citation:

> Look, it's cheaper for us to pay the return flights for absolutely everybody who wants to have a look at the plant than have even two of these plants in separate locations.

The two firms in the bioscience industry, Cultor and Leaf, on the other hand, have been international in their R&D for a long time, particularly through joint-ventures, alliances and consulting agreements. Their internal R&D work is fairly easily transferable, and they have in fact made various relocations as markets have shifted. It should be noted that these two companies, along with Nokia, are the ones that operate in industries where the 'science-push' component of R&D is most evident. Their R&D organizations therefore contain a central unit which is responsible for long-range research and technology scanning. In Nokia's case this unit has expanded into a wholly independent division, Nokia Research Center, which usually has the initiating role in the establishment of new R&D units through its contacts with various foreign organizations and companies.

As the information content in even heavy machinery is increasing (automation, remote diagnostics and reprogramming), firms have to decide whether they want to develop competencies in information technology or rely on external resources. Products with programmable properties or upgradeable software can be effectively redesigned even while they are engaged in the customer's business processes. This in turn requires R&D personnel to establish stronger links directly to customers, and to design the products for easy access and adaptability during use. The nature of R&D work can in this regard be said to be changing from one-time innovation to continuous improvement. This obviously requires management practices that help to integrate the business processes of the customer and the company's own R&D process.

An efficient and working infrastructure, with easy access to resources is crucial for the effective coordination of R&D work. It would appear that the companies in the study, with their exceedingly complex R&D projects, do not search for the cheapest factors of production in their R&D, but instead use the overall level of a national innovation system as the main criterion for their locational decisions. This, of course, has the implication for national policymakers that failing to introduce consistent improvements in the educational and innovatory capacity of a country can lead to atrophication of the whole innovation infrastructure very rapidly as leading companies desert the no-longer appealing environment.

6 CONCLUSIONS

6.1 Main findings

The nearly unanimous view of the top technology managers interviewed in our study that internationalization is merely one further aspect of their daily work can undoubtedly be considered the most important finding of this study. The business environment has changed rapidly in the nineties, forcing companies to globalize their activities and streamline their operations in order to be competitive. Internationalization does not come free either. The costs of communication, coordination and traveling are constantly increasing as a result of the dispersed business activities. Standardizing the operating procedures and implementing information technology solutions are typical means that management is using to keep a grasp on their increasingly complex operations.

Research and development are by no means exempt from these trends. In their own R&D work the companies are focusing primarily on the few core technologies crucial for their respective market niches, and the designing of bulk components is usually outsourced. Basic research has mainly been outsourced to institutes like universities, which can afford to have a long-term view and have an additional source of resources in public funding. Product development and applied research on the other hand are facing shorter and shorter cycle times, as well as an alarming lack of skilled human resources. The increasing information content in nearly all products requires that experts of various fields participate in the design and improvement of almost any commodity.

National innovation systems would seem to have been inadequate to the explosive growth in the need for intellectual capacity, which is in part why truly global companies have deemed it best to broaden their horizons and establish development activities wherever they might find educated people and a sophisticated information infrastructure. In the words of Håkanson and Nobel (1993): “A high relative portion of foreign R&D is inevitable in a small open economy dominated by large multinational corporations.”

The results of this study for their part tend to confirm the above statement. The studied companies had approximately half of their R&D personnel abroad, and a clear trend was the growing importance of international R&D work. Out of a total of 77 R&D units, two thirds (50) were located outside Finland. Europe was still the favored location, and in particular the R&D presence of the study population in Asia ranged from weak to non-existent. North America had seen some growth during the nineties, and the interviewees felt that it is going to be commercially and technologically even more important in the future. No explicit plans for the expansion of foreign R&D through new units were presented, but should such needs be actualized the North American continent would obviously be the target for expansion.

Market-related reasons were the most important category of reasons for companies establishing R&D abroad. Complementary technological skills and access to a fresh pool of resources typically played a strong secondary role. All in all, the studied companies mostly defined international R&D as vital for maintaining the technological edge and developing their competitive advantages. It seems obvious that as the strategies of the companies have become more focused on technological and operational excellence, the R&D processes penetrate the whole company regardless of national or functional boundaries. At the same time the companies are developing technology strategies and integrating these strongly with their overall business strategies.

In the light of our findings, internationalization can no longer be taken to be only a one-way activity of establishing organizational units and reporting relationships abroad. Rather, as multinational companies are taking the process view in organizing their activities, internationalization becomes a part of that process. People in different physical locations participate in the company's daily activities regardless of their national affiliations. Participants are chosen only on the basis of their competencies and ability to work in a multicultural environment.

Our findings also seem to support the claims of Gerybadze and Reger (1997) about simultaneous globalization of activities and stronger centralized control. Their comment crystallizes our view very accurately: "Large corporations pursue integration strategies in

a world of multiple learning centers, by building up in-house R&D and innovative production systems at locations abroad, under full control of the corporation's headquarters in the country of origin." (ibid. 10).

The above has seemingly been the development path that the surveyed Finnish multinational companies have been following. However, it is worth noting that a few companies in our population had already moved their corporate headquarters many times, depending on the current center of gravity of their business. It is therefore by no means certain that the centrally coordinated R&D processes of a multinational company will in the future be controlled from the historical country of origin. As one interviewee expressed his view: "Centralization doesn't have to be physical. Information technology allows us to coordinate our operations from virtually anywhere on this globe." The sentiments of R&D management would appear to have switched from "We have to keep our core technologies in Finland" to the markedly more global view of "Currently we have no reason to move, but things can and will change.".

6.2 Implications for management

The one common thing that most obviously binds the companies in this study is that they consider R&D to be an integral part of their core businesses. As they strive for operational excellence, R&D simply cannot be left alone. Design for manufacturing, global component sourcing and the worldwide standardizing of product families are very strong trends among these companies, chosen for the study for their leading role in R&D as measured by R&D expenditure and public acclaim.

Establishing a set of standard operating procedures, harmonizing and re-engineering their product development processes across the world, as well as ensuring smooth communication between the various parts of their production processes (more traditionally known as functions) were the means that these companies were using to avoid costly re-designs, to lessen quality problems and above all, to cut the crucial time-to-market. The initiative for these improvements usually came from senior management,

and frequently meant implementing established practices from the home country in the foreign units. Organizational learning was not in actual fact bi-directional in any of the studied companies. One reason for this was that the units which had been acquired from previously existing companies were usually organizationally, economically, or technologically weaker than the acquiring Finnish company, as this was usually the very reason they had been acquired in the first place. In the case of greenfield units, it was very natural to use a Finnish project team to establish the unit and to manage it during the first precarious years.

Apart from the need for companies to more effectively leverage the unique capabilities that they possess in their various foreign units, it would appear necessary for an ever expanding group of companies to start thinking about internationalizing their R&D activities. The globalization of the world economy is not likely to slow down anytime soon, and as innovations spread across the globe ever faster, it is absolutely essential to have access to globally competitive R&D resources and to have a presence in the crucially important lead-markets. Internationalization does not necessarily have to be resource-intensive, for the internationalizing company can choose from a wide variety of different arrangements. A firm can start by exploiting its R&D investment internationally by agreeing to sell licenses or by forming joint ventures with other companies that would alone have insufficient resources for internationalization. Accessing the global technology base requires at the very least active technology scanning and participation in the international technological and scientific community. The leading companies surveyed in this study admitted to having ‘excessive’ travel and meeting budgets for the sole purpose of spreading new knowledge and gaining new information all the time.

The studied companies, which at the time were reporting record profits (with the sole exception of one company) and were generally in possession of formidable financial resources and streamlined organizations, nevertheless felt it necessary to get leverage in their R&D work through networking. These networks involve the suppliers, customers, public research institutes and even competitors. The perceived payoffs in extensive networking are efficiency, better allocation of resources, avoidance of capacity problems

and in general an environment more conducive to innovation. In the view of the R&D executives, spontaneous and frequent face-to-face meetings between as many people as possible are truly the *sine qua non* of innovation and progress.

6.3 Suggestions for further research

On the basis of the information acquired during this study, the internationalization of R&D seems to be an integral part of the globalizing economy. Understanding this phenomenon is therefore vital for the policymakers of nation states and regional political entities such as the European Union. A most obvious need for international research cooperation arises as reliable and comprehensive information about a truly international phenomenon is needed. A logical next step would therefore be to establish a joint research program to map out the internationalization patterns within the larger European economic area. It would be particularly interesting to gather information about the direction that R&D internationalization has taken within this area since the deregulation of capital and labor movements in 1992. A comparison of R&D internationalization between the new members of the EU (Austria, Finland, Sweden) would probably prove fruitful. As more comprehensive data from these small economies becomes available, research comparing them to the nations in the core of the EU with established international R&D activities should and most likely will be carried out.

From a purely Finnish point of view, the industry specificities of R&D internationalization require further study and explanation. It is worth remembering that focusing too strictly on one specific nation state is not very good practice in the study of internationalization. Here, too, comparative research between countries can be expected to reveal important determinants of internationalization. For example, the location-specific advantages of northern countries in R&D of the forestry sector is by no means fully explained yet. A valuable, if very ambitious goal for future research could be to formulate an interdisciplinary theory of factor productivity and strategic management choices. This theory could hopefully be used to explain the characteristics of, for example, the markedly different Finnish forestry and metal industries.

As for methodology, the combined use of qualitative and quantitative methods can be recommended. In Germany, where R&D internationalization has a somewhat longer history than in Finland and the company base available for statistical analysis is much more extensive, sector-specific studies have been further enhanced by interviews. Numerical data alone is not sufficient to explain the complicated issues under scrutiny. Interviews and open-ended questionnaires provide additional depth to the research, but their results are not suited for rigorous analysis. We found the arrangement of first doing semi-structured interviews, the results of which were then partly used to formulate the questionnaires of the later study, very satisfactory.

The iterative approach could be further enhanced by the use of the Delphi-method. It is our belief that in order to truly bring out the best practices for R&D management, a study of this kind should be carried out. A first round of interviews could be conducted among approximately a hundred practising R&D managers. The results of this first round should then be analyzed and discussed by R&D managers of considerable experience and an established track record of successful internationalization.

Research into R&D internationalization and globalization in general has grown rapidly and found many new directions during recent years. A survey across the different schools and lines of thought would be useful to connect various theories from management to macroeconomics. Such interdisciplinary writings are unfortunately not very common, but as our understanding of the various economic and social phenomena involved improves, we can hardly afford but to be eclectic in our thinking.

7 SUMMARY

The aim of this report is to provide information about the internationalization of R&D in R&D-intensive multinational companies, which presumably act as pioneers in internationalization. The role of MNCs is further emphasized by the fact that they account for the majority of all corporate R&D investment. The 11 companies studied here together account for just under 50% of all industrial R&D spending in Finland.

The internationalization process was analyzed in three dimensions, namely organization, collaboration and exploitation of R&D work. The studied companies had continued the internationalization of their R&D activities, but the emphasis had moved from having own R&D units abroad to collaborating extensively through a network connecting suppliers, customers, research institutes and even competitors. 21 new foreign R&D units had been established or acquired between 1993-1998, 11 of these by one corporation.

There were clear differences between the studied companies in the internationalization of their R&D, but almost all had around 50%, or more, of their R&D personnel outside Finland. Two companies, producing machinery for the forest industry, were clear exceptions with R&D facilities only in Finland and in Sweden. The EU area is by far the most important location for foreign R&D, as almost 70% of all foreign R&D units were in Western Europe. North America was mainly seen as a potential future market and source of technology.

The nature of R&D work has changed considerably in these companies during the last five years. Many activities, particularly basic research, has been outsourced. Foreign R&D units have been integrated very tightly to the organization, and cross-functional and international teams have become very common. The R&D units have focused on specific core technologies, while at the corporate level systematic management of internal R&D and top-level technology managers have become common. External relationships with regard to innovation were mostly based on informal social contacts.

The R&D management in the Finnish multinationals felt that their companies' cultural and historical background, as well as the mainly Finnish management has maintained a certain Finnish character in their companies, and will for a long time to come continue to do so. In the current global environment there is, however, no longer any specific reasons to keep R&D activities in Finland, and in fact most interviewees saw the continued internationalization of their R&D as being inevitable. In summary, internationalization was seen as mostly beneficial, even vital for the continued success in their businesses.

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Interviews

1.4.1998	Leaf Group, anonymous interviewee
14.4.1998	Nokia Telecommunications Ltd., anonymous interviewee
16.4. 1998	Cultor Oyj, anonymous interviewee
17.4.1998	Timberjack Group, anonymous interviewee
17.4.1998	Valmet Corp., anonymous interviewee
20.4.1998	Ahlström Machinery Corp., anonymous interviewee
22.4.1998	Ahlström Machinery Corp., anonymous interviewee
7.5.1998	Sunds Defibrator Pori Oy, anonymous interviewee
8.5. 1998	Tamrock Corp., anonymous interviewee
13.5.1998	Leaf Group, anonymous interviewee
14.5.1998	Nokia Telecommunications Ltd., anonymous interviewee
18.5.1998	Valmet Corp., anonymous interviewee
25.5.1998	Nokia Mobile Phones Ltd., anonymous interviewee
26.5.1998	Wärtsilä NSD Corp., anonymous interviewee
27.5. 1998	Timberjack Group, anonymous interviewee
3.6.1998	Partek Cargotec, anonymous interviewee
4.6.1998	Sunds Defibrator Valkeakoski Oy, anonymous interviewee
8.6.1998	Nokia Mobile Phones Ltd., anonymous interviewee
10.6.1998	Cultor Technology Center, anonymous interviewee

APPENDIX

Structure of the interviews

General background

- Personal background of the interviewee
- What is R&D internationalization from the point of view of this company?
- The most important features of the firm's R&D (technology, products etc.)
- Major changes after 1993

Organization

- Organizational position of R&D
- Number and location of R&D-units, reasons for establishment
- Personnel (headcount) and budgets of R&D
- Collaboration with suppliers in R&D, other external R&D
- Collaboration with research institutes in R&D
- EU-programs, other public funding
- Changes in organization after 1993

R&D-process

- The process from innovation to products
- Collaboration with internal resources (production, marketing etc.)
- Who is responsible for R&D work? Where?
- Who has profit&loss responsibility for R&D?
- How is the R&D work organized?

Support processes

- What kind of support processes are there?
- Recruitment, training, job rotation etc.
- Knowledge Management?

Management of R&D

- R&D-strategy (as part of total strategy)?
- Changes in management after 1993
- Management tools (IT, teams etc.)
- Problems and challenges
- R&D productivity, measurements
- Time-to-market, product cycles
- Cultural differences, problems from internationalization
- Single most important issue currently
- Future visions