ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Christopher Palmberg – Mika Pajarinen

THE GLOBAL DISPERSION OF INNOVATIVE ACTIVITIES – THE CASE OF FINNISH MULTINATIONALS*

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ABSTRACT: The internationalisation of R&D of multinational firms is an important ingredient in the ongoing trend towards globalisation. Previous research on Finnish multinationals has mainly relied on R&D expenditure data. In this paper we provide new insights into how the internationalisation of R&D of these Finnish multinationals is also reflected in their innovative output as measured by patenting. The results indicate that inventor teams have grown in size over time, especially through the entry of US, German, Swedish and UK inventors. Contrary to what the extant literature predicts, the share of patents with foreign inventors is lower for Finnish multinationals when compared with multinationals from other industrialised countries. However, foreign patents of Finnish multinationals score higher in terms of originality and point to the domination of home-base-augmenting R&D strategies over home-base-exploiting ones.

KEYWORDS: internationalisation, Finnish multinationals, inventors, patenting.

PALMBERG, Christopher – **PAJARINEN**, Mika, **SUOMALAISTEN MONIKANSALLISTEN YRITYSTEN INNOVAATIOTOIMINNAN KANSAINVÄLISTYMINEN PATENTOINNIN NÄKÖKULMASTA.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2004, 28 s. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 916).

TIIVISTELMÄ: Monikansallisten yritysten t&k-toimintojen kansainvälistyminen on oleellinen osa menneillään olevaa globalisoitumiskehitystä. Aikaisemmissa suomalaisten monikansallisten yritysten innovaatiotoiminnan kansainvälistymistä käsitelleissä tutkimuksissa on aihetta analysoitu pääosin t&k-menojen avulla. Tässä tutkimuksessa hyödynnetään sitä vastoin patenttitietoja, jotka kuvaavat paremmin innovaatiotoiminnan tuloksellisuutta. Suomalaisten monikansallisten yritysten innovaatiotoiminta on patentoinnin valossa kansainvälistynyt viime vuosikymmenten aikana, etenkin keksijöiden määrä USA:sta, Saksasta, Ruotsista ja Iso-Britanniasta on lisääntynyt. Ulkomaisten yksiköiden osuus patentoinnissa on kuitenkin edelleen alhaisempi kuin monissa muissa teollisuusmaissa. Patenttien teknologista merkitsevyyttä kuvaava tunnusluku oli sen sijaan keskimäärin korkeampi yritysten ulkomaisten t&k-yksiköiden patenteissa kotimaisten t&k-yksiköiden patentteihin verrattuna. Tämä viittaa siihen, että ulkomaisten t&k-yksiköiden toiminta on edesauttanut suomalaisten monikansallisten yritysten teknologisen perustan vahvistumista.

AVAINSANAT: kansainvälistyminen, monikansalliset yritykset, patentointi, keksijät.

CONTENTS

1 INTRODUCTION

Firms increasingly have to develop, produce and market products globally due to rapid advances in information and communication technologies (ICT), decreasing transportation costs and converging consumption patterns across the world. The internationalisation of research and development (R&D) to multiple locations is an important ingredient in this trend towards economic globalisation, especially since the rapid technological upgrading of many developing countries – such as Korea, China and India – which are providing new out-location opportunities to multinational firms. Concretely, this means that researchers and inventors generating these inventions increasingly tend to be located outside the home country of firms. Indeed, several studies have recently documented that a growing share of inventions of multinationals involve foreign inventors. This trend appears to be especially clear in the case of technologically leading multinationals originating from smaller countries (see Patel and Vega (1999); Guellec and van Pottelsberghe de la Potterie (2001); Hayashi (2004) and Cantwell and Kosmopoulou (2004)).

The internationalisation of R&D is an especially important issue for firms located in smaller countries with a limited home market and absolute scarcity in R&D resources. Finland is interesting in this context, since it is a small open economy hosting a limited number of technologically advanced firms with a strong global presence especially in the fields of pulp & paper, engineering, chemicals and ICT. Accordingly, the received literature predicts that the R&D activities of these Finnish multinationals should also be characterised by increasing internationalisation over time. Previous research on the internationalisation of the R&D activities of Finnish multinationals has mainly been based on the global dispersion of R&D expenditures. This research suggests that the internationalisation of R&D of Finnish multinationals foremost is visible on a Nordic and European level, while more widespread internationalisation has been relatively modest (see Pajarinen and Ylä-Anttila (1999); Lovio (2004)).

In this paper we elaborate further on this research by shifting the focus to examine to what degree, and how, the internationalisation of R&D of these Finnish multinationals

is also reflected in their innovative output as measured by patented inventions. More precisely, we seek answers to the following three questions:

1. What is the composition of networks of inventors undertaking R&D of these multinationals in terms of their size and international scope?
2. To what extent do Finnish multinationals innovate at their foreign R&D affiliations? Which has been the nature of this innovative activity?
3. Can we identify significant change over time in the composition of networks, and in the degree and nature of internationalisation of their innovative activities?

This paper finds inspiration in an extensive literature on R&D location strategies of firms. It applies established methodologies and data (patent data) to Finnish multinationals as new cases not previously analysed from these viewpoint. The paper is explorative. It relates to the research project 'Finland's position in the globalisation of innovation' within the PROACT research program. It should be read as an introduction to more focused follow-up studies that use patent data to identify and analyse patterns in the internationalisation of innovative activities of Finnish multinationals.

The paper is structured as follows. The second section of the paper briefly reviews the extant literature on the subject with a focus on broader trends and interpretations of the internationalisation of R&D of multinationals, as well as on the pros and cons of using patent data in this context. The third section presents the patenting profiles of the Finnish multinationals, and analyses patterns of internationalisation of their innovative activities as it is captured through patenting. Finally, the fourth section summarizes and concludes the paper.

2 THE INTERNATIONALISATION OF R&D – THEORETICAL INTERPRETATIONS AND EMPIRICAL OBSERVATIONS

2.1 R&D location theories

The institutionalisation of R&D to large firms can be traced back to rapid scientific and technological advances in the 1950s and 1960s, especially in the fields of chemistry and electronics (Freeman and Soete, 1997). The R&D activities of large firms have traditionally been concentrated to their home country, even though an emergent characteristic of multinational firms has been the internationalisation of activities related to production and marketing to meet consumer demand globally. However, during the past two decades there is mounting evidence that also the R&D activities of multinationals is internationalising. This is above all reflected in an increase in the foreign-owned share of domestic R&D in various countries, in an expansion in overseas R&D expenditures and growth in the number of R&D performing facilities founded or acquired abroad, and in a growing share of publications and patents of these firms with foreign contributors (see Serapio and Hayashi (2004)).

The internationalisation of R&D of multinationals is explainable through broader developments in the global economy. Technological knowledge is becoming an increasingly important determinant of competitive advantage due to the ‘scientification’ of industrial innovation and rapid technological change. The development of information and communications (ICT) technologies increasingly enables multinationals to distribute R&D activities to multiple locations, while the liberalization of world trade and capital markets have contributed to the creation of a truly global factor market for R&D inputs (Pajarinen and Ylä-Anttila, 1999). However, beyond these general explanations there is a rich and expanding literature that interprets the more detailed patterns of internationalisation of R&D from the viewpoint of business theory. This literature has focused on the determinants of the various R&D location strategies of multinationals.

One can identify different phases of theorising around this issue, which have evolved in parallel with real developments in the patterns of internationalisation of R&D of multi-

nationals. The first contributions framed the internationalisation of R&D in the context of the so-called product life cycle model pioneered by Vernon (1966). This model proposes that the technological assets of multinationals are created on the home market, after which they strive to transfer these also to foreign markets. Accordingly, the model predicts that especially the core R&D activities of multinationals are concentrated to their home country, while foreign subsidiaries merely contribute by adapting technologies and products to local conditions during the latter stage of their life cycle. This is compatible with what has been labelled the home-base-exploiting R&D location strategy, whereby a multinational possessing a competitive advantage in a technological field in its home market exploits it abroad in regions which are weak in that specific field.

The mounting evidence starting from the 1980s of the internationalisation of R&D questioned the product life cycle model. Empirical research suggested that especially multinationals based in smaller countries with limited markets tended to localise a growing share of their R&D to various technologically advanced countries and regions. Further, the foreign R&D activities covered a much broader spectrum of tasks than merely adapting the home-base technologies and products to foreign markets. Multinationals were increasingly involved in seeking new technological assets, rather than merely exploiting existing one's (Niosi, 1999). As a consequence, the dominant product life cycle model was partly replaced by other theoretical frameworks. On such framework focused on 'centripetal and centrifugal' forces, such as agglomeration effects, level and scale of foreign production and sales activities of multinationals. These forces either pulled R&D to foreign locations peripheral to the home country, or supported its concentration to a dominant location in the home country (Pearce, 1989).

In terms of R&D location strategies, Kuemmerle (1997) contrasted home-base-exploiting strategies with those of home-based-augmenting. Home-based-augmenting strategies concerned the aims of firms to improve their existing technologies by creating new, or complementary, technologies through foreign R&D activities (compare with the discussion of complementary assets in Teece (1986)). These R&D activities are considered to draw on certain specific advantages of the foreign location that are not easily available at the home base of multinationals. The foundation of competitive advantage of multinationals is thus no longer considered to mainly reside in the home country.

Rather, it is internationally dispersed to many locations with advantages of specific importance to specific multinationals. More attention was also given to other modes of internationalisation of R&D than direct foreign investments that were the focus of much of the earlier literature (Narula and Zanfei, 2003).

Recent real world developments have strengthened home-based-augmenting type of interpretations of the internationalisation of R&D. Specifically, the rapid global growth of various types of inter-firm strategic R&D alliances have eroded the national and organisational boundaries of multinationals even further. The term “alliance capitalism” has been coined to describe this alleged new form of the organisation of R&D and capitalism in general (see Dunning and Boyd (2003)). As a consequence, recent contributions to the literature on the location of R&D have come to elaborate further on this home-base-augmenting viewpoint in the context of the dynamics of innovation and knowledge exchange. In line with the expanding literature on the firm as a learning organisation, the internationalisation of R&D is essentially viewed as a mechanism through which multinationals increase their stock of technological knowledge and diversify to new fields. Important topics in this discussion include the determinants of the absorptive capabilities of firms and the internalisation of spillovers that arise at foreign locations (see Cohen and Levinthal (1990) and Jaffe et al. (1993) for important contributions).

2.2 The internationalisation of R&D viewed through patent data

Initially, the discussion on patterns and strategies of the international location of R&D largely relies on R&D expenditure data collected by national statistical agencies and made internationally comparable through organisations such as UNCTAD or the OECD. This data highlighted overall trends and patterns but it did not capture the broadening spectrum of tasks that foreign R&D of multinationals was dedicated to. The availability of new empirical data was apt to shift the attention away from a relatively simplistic interpretations based on the product life cycle model, towards more complex ones. Especially historical patent data showed that the internationalisation of R&D had started much earlier than suggested by the product life model, and hence questioned the validity of this model.

The possibilities and advantages of using patent data in this context are obvious. Patents cover long time periods and provide insights into the extent, nature and developments over time of the innovative activities of firms. Patents can be characterised as indirect output measures of innovation. They capture the advancement of knowledge and the realisation of inventive activities within firms, even though some inventions might never reach commercialisation and the markets. This is in contrast with R&D data that captures the inputs into innovation in terms of the expenditures that firms assign to such activity. Patent data are therefore particularly interesting for investigating the more detailed trends and patterns of the internationalisation of R&D, and especially how the internationalisation of R&D is reflected in the structure and nature of foreign-based innovative activities of multinationals.

In this paper we use patents granted at the US patent office (USPTO) as our data as provided by Jaffe and Trajtenberg (2002). The patent files of this data contain information on both the individual inventors and the legal owner of the patent at the time of the application, or the assignee of a patent. We are especially interested in the nationality of the inventors and the assignee, since these will sometimes be different. The nationality of the inventor is determined based on the address of this individual, which usually is the laboratory or professional affiliation at which he/she works at. The nationality of the assignee is based on the home country of companies, in our case Finland. Accordingly, when the nationality of the inventor is non-Finnish, this reflects the fact that the invention has been preformed at a foreign laboratory or affiliation. Through this simple logic we thereby have an indicator of the internationalisation of R&D from the viewpoint of the innovative activities of the firm in question.

As suggested in the introduction, patent data has been used extensively abroad to identify and analyse patterns in the internationalisation of innovative activities of multinationals (see e.g. Niosi (1999); Serapio and Hayashi (2004)). However, we are not aware of any such studies focusing explicitly on Finnish multinationals (compare with Lovio (2004)). Hence, reference is here best made to a recent analysis by Cantwell and Kosmopoulou (2004) that also uses patents granted at the US patent office and adheres to the same definitions, types of firms and time periods. They focus on the diversity in the R&D location patterns of the world's largest firms globally by defining foreign patents as those in which the location of the first inventor is different when compared with the country of origin of

the firm. In this context we are especially interested in the distribution of percentages of such foreign patents across different countries, as presented in table 1 below.

Table 1. The percentage of granted US patents of the world's largest firms attributable to inventors at foreign locations (adapted from Cantwell and Kosmopoulou (2004))

	Share of foreign patents*			
	1978-1982	1983-1986	1987-1990	1991-1995
France	7.17	9.19	18.17	33.17
Germany	12.07	14.47	17.05	20.72
Netherlands	47.65	53.99	53.96	55.69
Sweden	26.2	28.94	30.6	42.42
Switzerland	43.78	41.59	42.99	52.47
UK	40.47	47.09	50.42	55.79
Sub total	24.64	27.12	30.38	34.98
United States	6.4	7.53	7.91	8.62
Belgium	56.27	71.21	56.04	67.25
Canada	39.49	35.82	40.12	43.96
Italy	13.85	12.59	11.14	16.47
Japan	1.22	1.26	0.92	1.08
Other countries	22.38	20.4	17.39	8.73
Total of all countries	10.5	10.95	11.28	11.27
Total excluding Japan	12.25	13.88	15.76	16.53

*Affiliation of first inventor

The table presents percentages for European countries and their subtotal averages, as well as percentages for other important industrialised countries and their subtotal averages. The total averages across all countries are presented at the bottom of the table, also by excluding Japan which has a very distinct pattern when compared to the rest of the countries. When investigating developments of the subtotals and totals, it is clear that the innovative activities of multinationals indeed increasingly is internationalising, as discussed already above. The internationalisation is especially apparent in the case of multinationals originating from European countries, while the distinct pattern of Japan and the US drives down the total average figures for the other countries, as well as the grand totals. According to Cantwell and Kosmopoulou (2004) the distinct pattern of the US is largely explainable by the superior strength of domestic research activities, while internationally located Japanese R&D typically serves innovative activities at the domestic headquarters of multinationals.

Finland is not included in the analysis by Cantwell and Kosmopoulou (2004), while relatively similar small open economies such as Sweden, Switzerland and Italy are. Of these countries, the share of foreign patents is particularly high for Sweden and Switzerland. The internationalisation of Swedish innovative activity has been especially rapid when compared to the other countries. These figures reflect the fact that both countries have a longish history of hosting highly internationalised multinationals. In the case of Italy the percentages have remained at relatively low levels throughout. The Netherlands and Belgium also stand out for the same reasons. As an overall conclusion Cantwell and Kosmopulous (2004) state that the largest firms which originate from small countries (such as Sweden, Switzerland, and especially the Netherlands and Belgium) tend to have a much higher percentage of foreign patents than do those of larger countries. This seems to hold irrespective of differences in the volume of foreign R&D expenditures of these countries.

Before proceeding to the case of Finland, a note should be made about disadvantages of using patent data in this context. The propensity to patent varies across firms due to different strategies towards intellectual property rights issues. There are also differences across technologies and industries in the viability of patenting, depending on the pace of technological change, appropriability conditions and the nature of competition. Further, the field of software receive lesser coverage due to its perceived ‘non-technical’ character, with the exception of embedded software (McQueen and Olsson, 2003). This is a limitation of analysis of patenting in the field of ICT, in which software technologies play an important role. It should also be noted that patenting tends to be constrained to applied R&D, while research of more fundamental and basic and non-competitive nature receives lesser coverage (see the seminal paper by Griliches (1990) for a further discussion on the pros and cons of patent data). Historically, the fields of mechanical engineering, chemicals and electronics have been the subject of most patents.

One limiting factor of the data provided by Jaffe and Trajtenberg (2002), used in this paper, is that it only extends to 1999. This is unfortunate, since we know that the patenting of Finnish multinationals has accelerated rapidly since the late 1990s. On the other hand, this is largely due to Nokia which is already well represented in the time periods that we analyse. This limiting factor is also compensated by the fact that our analysis is the first of its kind in Finland and provides original insights in any case.

3 THE INTERNATIONALISATION OF INNOVATIVE ACTIVITIES OF FINNISH MULTINATIONALS

3.1 Patenting of Finnish multinationals 1980-1999

The sample of Finnish multinationals included in the analysis of this paper is based on Lovio (2004), who analysed the global dispersion of R&D expenditures of Finnish multinationals. For this purpose, he selected a list of 16 firms that in the year 2001 covered close to 95 percent of all Finnish R&D undertaken at foreign locations, or practically the whole population of multinationals of relevance. Data on the R&D expenditures of Finnish firms was drawn from a survey conducted by the Confederation of Finnish Industry and Employers. This list was also taken as a point of departure in this paper, although three additional firms were added based on insights from other sources that they have also been extensively engaged in innovative activities globally, even though this is not captured in the R&D expenditure data. In addition, we elaborated on the list by also incorporating the main Finnish subsidiaries of these companies based on reviews of changes in their organisational structure over time.

One issue that complicates the analysis is cross-border mergers and acquisitions. The acquisition of foreign firm implies that the new patents granted after the acquisition should also be counted as assigned to the Finnish parent firm. In this paper we incorporate this complication by assuming that the new patents of acquired firms are assigned to the Finnish parent company either as a result of a name change, whereby the patents in effect enter the data through a new assignee, or as a result of the fact that all new patents of the acquired company are assigned to the Finnish parent by the firm itself.

Growth in number of patents by technology fields

The time period covered in this paper is 1980-1999 since the patenting of the Finnish multinationals was very modest prior to the 1980s. The patent data provided by Jaffe and Trajtenberg (2002) aggregates the detailed technological classes of patents into 36 sub-categories and further into 6 main categories, namely chemicals, ICT, health-care related fields, electronics and electrical machinery, mechanical engineering, and miscellaneous other fields such as agriculture, apparel and textiles, furniture, pipes and joints

etc. The growth in the number of patents across these main technology categories is illustrated in figure 1 below.

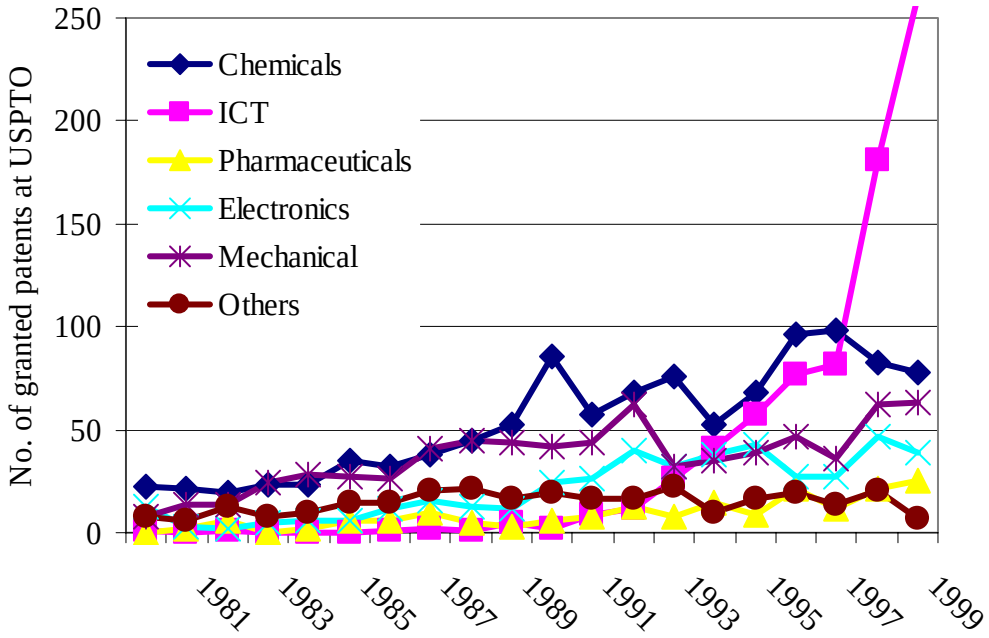

Figure 1. Number of granted patents of Finnish multinationals by main technology categories

The overall growth in the number of patents of these multinationals is visible especially in the fields of ICT and chemicals. The accelerating patenting since the mid 1990s in ICT is mainly due to Nokia as the dominating innovator in this field in Finland. In other respects, the distribution of patents of these multinationals across the technology categories is compatible with trends in patenting globally (compare with Jaffe and Trajtenberg (2002)). The largest shares of patents are found in chemicals, ICT electronics and electrical machinery, and mechanical engineering.

In this paper we will stick to these main technology categories in our analysis, while less attention is given to the R&D internationalisation patterns of individual firms. It nonetheless makes sense to briefly introduce the firms and their patenting profiles across the technology categories, in table 2 below. A short description of the Finnish multinationals is in the appendix.

Table 2. Number of granted patents of Finnish multinationals by main technology categories

	Number of granted patents at the USPTO 1980-1999						
	Chemicals	ICT	Health care	Electricals	Mechanical	Others	Total
Nokia	30	728	2	211	48	31	1050
Stora Enso	24			6	7	10	47
UPM	3				1	1	5
Sonera		6					6
Metsäliitto	6				11	6	23
Kone	7	7	3	39	146	3	205
Metso	444	8		29	248	41	770
Wärtsilä	28		7	8	79	72	194
Kemira	54	1	8	1	6	3	73
Orion	27		99	15	11	2	154
Neste/Fortum	123			9	13	12	157
Ahlstrom	234	1		15	59	71	379
Instrumentarium	6	1	54	61	6	3	131
Raisio	6		2		2		10
Outokumpu	79	2	2	19	95	28	225
Rautaruukki		3		5	6	3	16
Amer		2				4	6
Huhtamäki	3		2			6	11
Total	1074	758	179	418	738	295	3462

Nokia accounts for roughly one third of all patents of these companies, while Kone, Metso, Wärtsilä, Orion, Fortum and Ahlstrom account for roughly half of the remaining patents. Nokias domination in the field of ICT is clearly visible with a 96 percent of all Finnish ICT-related patents at the USPTO. Accordingly, the analyses of patenting in ICT in this paper almost solely concern Nokia. Beyond this, patenting of these Finnish multinationals is relatively evenly distributed across the technology categories with no other firm clearly dominating in a specific field.

In the field of chemicals, the majority of all patents involve Metso, Fortum, Ahlström and Outokumpu. On closer inspection of the data, the chemicals-related patents of the pulp & paper machinery suppliers Metso (and Ahlström) cover technology fields related to pulp & paper making processes, which are embodied in the related machinery. The patents of Fortum related to Neste, as an antecedent company of Fortum that was involved in oil refinery and high-tech chemicals. The field of health care is dominated by the pharmaceuticals company Orion Pharma and the medical equipment company Instrumentarium. Nokia's involvement also in the field of electronics and electrical machinery is evident with roughly 50 percent of all patents, alongside the machinery and equipment companies Kone, Metso and Instrumentarium. The pulp & paper machinery making firms Metso,

Wärtsilä and partly also Ahlström dominate in mechanical engineering. These firms also patent in other miscellaneous fields labelled 'Others'. These patents foremost related to 'Heating appliances', which are important components of pulp & paper making machinery.

The definition of the location of innovative activity by the affiliation of the inventors gives rise to two analytical approaches. The first approach is to analyse the pool of all inventors of the patents of these Finnish multinationals. This approach can address issues related to the size and nationality of inventor teams, and other aspects of the structure of inventor networks. The second approach is to analyse the patents themselves by defining the nationality of patents by the affiliation of the first inventor that appears in the patent files.[1] This second approach has been the more common one. It enables the analysis of the dispersion of innovative activities directly through patents as intermediate measures of innovative output. It also enables the analysis of the qualitative nature of this innovative activity, for example through citation data.

As indicated in the introduction, we opted for a combination of these two approaches, although our main interest is in analysing the dispersion of innovative activities as viewed through the qualitative nature of the patents themselves (i.e. the second approach). This also enables a comparison of our results with much of the extant research, and especially with the recent analysis by Cantwell and Kosmopoulou (2004) to which reference was made above. We start off with the pool of all inventors of the patents of Finnish multinationals. After this we deepen our analysis and shift the focus to the patents themselves, whereby their nationality is defined by the affiliation of the first inventor at which he or she resided at the time of the filing of the patent. We apply these approaches first to analyses across all Finnish multinationals, and thereafter to analyses across the technology categories.

[1] The commonly applied logic here has been that the first inventor is also considered to be the one who has contributed the most to the invention/patent in question, although deviances from this logic probably occur (see e.g. Serapio and Hayashi (2004)).

3.2 Developments across all firms

Size and international composition of inventor teams

Since each of the 3462 patents that we analyse in this paper involves one or more inventor, there are also 3462 inventor teams. Altogether these patents conceal 7147 individual inventors, some of which might be involved in more than one patent. By way of introduction the size and number of inventor teams, and changes over time, is presented in table 3 below.

Table 3. The size distributions of inventor teams of Finnish multinationals

	Size of inventor teams			
	Mean	Std.Dev.	Max	Number of teams
1980-1984	2.04	1.34	7	274
1985-1989	1.89	1.32	9	572
1990-1994	2.09	1.53	11	940
1995-1999	2.12	1.54	12	1676
Total	2.06	1.49	12	3462

The table shows that the mean size and standard deviation of teams has grown over time, in parallel with the general growth in the number of patents and inventor teams of these multinationals. During the latter half of the 1990s the largest inventor teams comprised of 12 inventors in total when compared with 7 in the early 1980s. A logical follow-up question is how this growth in the size of inventor teams is reflected in the entry and dispersion of foreign inventors by their affiliations. This is the viewpoint taken in table 4.

As expected, Finnish inventors account for the largest share, i.e. close to 85 percent of all inventors are Finnish by affiliation. The second largest group is US inventors (6 percent), followed by Swedish (3 percent), German inventors (3 percent) and inventors with an affiliation in the UK (2 percent). This result is in line with what is known about the global dispersion of R&D expenditures of Finnish multinationals (see Koskinen (1999), Tiede ja teknologia (2000), and Lovio (2004)). It is also in line with the dispersion of R&D facilities abroad of these Finnish multinationals. An interesting observation is that inventors from newly industrialised countries in Asia, such as India, China or Korea, have not (yet) played a noticeable role in the innovative activities of these firms judged by patenting. Lovio (2004) also notes that Nokia is the only firm out of

these which had established new R&D facilities in these countries during the period analyse in this paper. Typically R&D facilities of Finnish multinationals have been the results of foreign acquisitions.

Table 4. The international composition of inventor teams of Finnish multinationals

	Distribution of inventors by country of location				
	Total	1980-84	1985-89	1990-94	1995-99
Australia	14	0	1	1	12
Austria	8	0	1	0	7
Belgium	8	0	0	2	6
Canada	51	5	20	13	13
China, Hong Kong	3	0	0	0	3
China, P.Rep.	2	0	0	0	2
Denmark	12	0	0	0	12
Estonia	2	0	0	0	2
Finland	6005	542	964	1646	2853
France	7	0	1	1	5
Germany	190	0	26	89	75
Ireland	2	0	2	0	0
Italy	11	0	3	0	8
Japan	10	0	3	2	5
Mexico	1	0	1	0	0
Netherlands	3	0	0	1	2
New Zealand	2	0	0	1	1
Nicaragua	1	0	1	0	0
Poland	3	0	0	0	3
Portugal	6	0	0	0	6
Singapore	1	0	0	0	1
South Korea	1	0	0	0	1
Spain	3	0	0	0	3
Sweden	188	7	18	77	86
Switzerland	27	1	0	19	7
Taiwan	1	0	0	0	1
United Kingdom	122	0	0	11	111
United States	462	3	39	98	322
Zimbabwe	1	0	0	0	1
Total	7147	558	1080	1961	3548

When looking at developments over time, the most striking result is the rapid entry of US and UK inventors to these teams, especially since the early 1990s. On closer inspection of the data it is clear that this entry is not solely due to any one multinational, such

as Nokia, but appears to be a broader development. In the mid 1980s a similarly rapid entry of German and Swedish inventors is observable. Any far reaching interpretations of these trends should nonetheless be made with care due to the specific viewpoint taken in this paper.

Global dispersion of innovative activity

When the attention is shifted to the patents themselves the increase over time in the level of internationalisation of the innovative activities of Finnish multinationals is also clear (table 5 below). In the early 1980s a very small percentage share of all patents were attributed to first inventors with a foreign affiliation. This share started to increase in the mid 1980s, to reach 21 percent during the late 1990s. When this development is compared to that of multinationals from other countries, two specificities of the Finnish case become clear (see Cantwell and Kosmopoulou (2004) and table 1 in this paper). First, it seems that Finnish multinationals have started of from very modest levels of internationalisation, while subsequent internationalisation has been exceptionally rapid. Second, Finnish multinationals lag behind the multinationals of most other countries, as is evident also from the total averages (the obvious exception is the US and Japan, as discussed above).

Table 5. The percentage of granted US patents of Finnish multinationals attributable to inventors at foreign affiliations

	Share of Finnish/foreign patents*		Total	
	Finnish	Foreign	%	N
1980-1984	96.35	3.65	100	274
1985-1989	86.54	13.46	100	572
1990-1994	82.55	17.45	100	940
1995-1999	79.12	20.88	100	1676
Total	82.64	17.36	100	3462

* Affiliation of first inventor

Nonetheless, the second specificity of the Finnish case should be interpreted by taking into account structural differences between countries, even though we cannot formally account for these in this paper. It makes sense to compare Finnish multinationals to those from other small open economies, namely the Netherlands, Sweden, Switzerland, Belgium, and also Italy. In this comparison Finnish multinationals only fare well in comparison with Italy. On the other hand, it is well known that Sweden, Switzerland,

Belgium and especially the Netherlands have a longish tradition of hosting highly internationalised multinationals involved in global industries, such as electronics and pharmaceuticals. Interestingly, the internationalisation of the innovative activities of Finnish multinationals is on par with that of German multinationals. The lower level of internationalisation of Finnish multinationals becomes evident in comparisons especially with those from France and the UK, which are technologically advanced countries and it this respect might be comparable with Finland.

Nature of innovative activity – the originality of patents

As suggested above, a major issue of interest in the literature on the location of R&D is to what extent foreign R&D exploits the home-base technologies of multinationals, or augments further on it (see especially Kuemmerle (1997)). Home-base augmenting implies that multinationals add new complementary technologies to their existing portfolios by drawing on specific advantages of foreign locations. Accordingly, it seems reasonable to assume that home-base-augmenting should also result in more patents at these foreign locations when compared to home-base-exploiting strategies. Further, given that the foreign locations might provide specific advantages to multinationals, it could also be expected that these patents would score higher in terms of their basicness, or originality.

Even though Finnish multinationals lag behind most other industrialised countries in terms of levels of patenting with first inventors at foreign affiliations, the growth in this share over time suggests that home-base-augmenting strategies are becoming increasingly prevalent to the firms in question. In this paper we propose the so called originality indicator, developed by Jaffe and Trajtenberg (2002) to elaborate on this finding further by capturing qualitative aspects of the patenting profiles of Finnish multinationals.

The originality indicator uses backward citation data, or information contained in the patent files that indicates which previous patents the patent in question cites and thereby draws on during to process of invention. The citation data arises through peer review of filed patents by patent engineers at the USPTO. This peer review process is also essential for establishing the degree of novelty of patents, and thus the legal claims that the assignee holds over the pool of previous patents. The indicator measures the degree that the patent in question cites previous patents from different technology fields such that a

high score on the indicator indicates a high dispersion of citations across different technology fields.[2] The underlying logic here is that patents with a high originality score is based on research covering a broader range of different types of technologies. They are thereby considered more basic and significant in a technological sense when compared to those with a lower score. The mean originality score across all Finnish multinationals is presented in table 6 below.

Table 6. The measure of originality of domestic and foreign patents of Finnish multinationals

Measure of originality of patents*	
Finnish	
1980-1984	0.23
1985-1989	0.31
1990-1994	0.36
1995-1999	0.37
Total	0.34
Foreign	
1980-1984	0.15
1985-1989	0.35
1990-1994	0.37
1995-1999	0.40 **
Total	0.38 ***

* Affiliation of first inventor
** Mean(Foreign)-Mean(Finnish) significant at 10% level
*** Mean(Foreign)-Mean(Finnish) significant at 1% level

According to the table, the degree of originality of the patents of these multinationals has risen throughout the period irrespective of the affiliation of the first inventor. Nonetheless, the rise in the degree of the originality of patents with inventors at foreign locations has been more rapid when compared to those with Finnish locations. More importantly, the degree originality of patents with inventors at foreign locations is higher across the board when compared with patents with inventors at Finnish affiliations. When the total means are compared using the standard t-test, this result also shows up

[2] The originality indicator is similar to the Herfindahl index and is defined formally with the following formula, where k indicates the number of citations within technology class and N_i indicates the number of technology classes.

$$ORIGINAL_i = 1 - \sum_{k=1}^{N_i} \left(\frac{NCITED_{ik}}{NCITED_i} \right)^2$$

in a highly significant p-value. As a consequence, we suggest that there is further indication that innovative activities at foreign locations indeed have been more of the home-base-augmenting type, than home-base exploiting. This interpretation is also broadly in line with the extant literature on patterns of internationalisation of multinationals from other countries, as referred to above.

3.3 Developments across technology fields

Size and composition of inventor teams

The disaggregation of the data by technology fields applies the 6 main technology categories developed by Jaffe and Trajtenberg (2002). The size of inventor teams, and changes over time, across the technology fields is presented in table 7 below.

Table 7. The size distribution of inventor teams of Finnish multinationals

	Size of inventor teams							
	Total	Chemicals	ICT	Health care	Electricals	Mechanical	Others	
Total	2.06	2.31	1.87	3.07	1.69	1.98	1.84	Mean
	1.49	1.66	1.33	2.2	1.11	1.29	1.18	Std.Dev.
	12	12	12	11	8	10	9	Max
	3462	1074	758	179	418	738	295	N
1980-1984	2.04	2.15	2	2.09	2.56	1.92	1.8	Mean
	1.34	1.37	na	0.94	1.75	1.31	1.25	Std.Dev.
	7	6	2	4	6	7	6	Max
	274	108	1	11	16	93	45	N
1985-1989	1.89	1.98	1.33	2.73	1.73	1.74	1.86	Mean
	1.32	1.45	0.5	1.68	1.14	1.09	1.37	Std.Dev.
	9	7	2	7	5	7	9	Max
	572	203	9	30	59	183	88	N
1990-1994	2.09	2.33	1.6	3.54	1.64	2.01	1.79	Mean
	1.53	1.62	0.86	2.73	0.99	1.42	1.02	Std.Dev.
	11	11	4	11	6	10	5	Max
	940	340	90	50	160	215	85	N
1995-1999	2.12	2.48	1.91	3.03	1.65	2.13	1.9	Mean
	1.54	1.83	1.38	2.1	1.11	1.29	1.1	Std.Dev.
	12	12	12	10	8	8	6	Max
	1676	423	658	88	183	247	77	N

When we compare the average totals some noteworthy differences become clear. Inventor teams in the fields of chemicals and health care are larger than average, and the teams in these fields also show a steady increase in their mean size and size distribution. A similar development characterises the fields of mechanical engineering. The larger average inventor teams in health care is foremost due he highly specialised character of pharmaceuticals and clinical research, involving interdisciplinary collaboration amongst various specialists

(see e.g. Palmberg, 2003). ICT-related patents are evidently characterised by lower averages when compared to the total averages, despite the emergence and global breakthrough of Nokia. In the field of electricals the size of inventor teams is, in fact, declining over time. The international composition of these inventor teams by their affiliation is presented in table 8 across the 5 most important locations of inventors of Finnish multinationals.

Table 8. The international composition of inventor teams of patents of Finnish multinationals across technology fields

Number of inventors by country of location and technology field								
		Total	Chemicals	ICT	Health care	Electricals	Mechanical	Others
Total								
	Finland	6005	2084	1167	505	553	1271	425
	US	462	202	107	31	16	51	55
	Germany	190	47	23		91	18	11
	Sweden	188	98	1	7	9	43	30
	UK	122	9	88		23	1	1
	ROW	180	36	28	6	15	74	21
	Total	7147	2476	1414	549	707	1458	543
1980-1984								
	Finland	542	230	2	21	40	174	75
	US	3					1	2
	Germany							
	Sweden	7	1		2		1	3
	UK							
	ROW	6	1			1	3	1
	Total	558	232	2	23	41	179	81
1985-1989								
	Finland	964	363	12	80	93	288	128
	US	39	9		2	1	8	19
	Germany	26	10			7	8	1
	Sweden	18	6				3	9
	UK							
	ROW	33	13			1	12	7
	Total	1080	401	12	82	102	319	164
1990-1994								
	Finland	1646	656	131	173	192	369	125
	US	98	60	1	3	12	10	12
	Germany	89	28	7		43	8	3
	Sweden	77	39	1	1	5	21	10
	UK	11	2	4		5		
	ROW	40	8			5	25	2
	Total	1961	793	144	177	262	433	152
1995-1999								
	Finland	2853	835	1022	231	228	440	97
	US	322	133	106	26	3	32	22
	Germany	75	9	16		41	2	7
	Sweden	86	52		4	4	18	8
	UK	111	7	84		18	1	1
	ROW	101	14	28	6	8	34	11
	Total	3548	1050	1256	267	302	527	146

Note: ROW = The rest of the world.

Again Finnish inventors naturally account for the largest shares across all technology fields and time periods, generally followed by US, German or Swedish, UK and ROW inventors. Nonetheless, on closer inspection there are some interesting differences across the total numbers.

In the field of ICT UK inventors have a comparatively more important role in the innovative activities of Finnish multinationals when compared to the other technology fields. This is most probably largely due to the acqusition in the early 1990s by Nokia of a prominent UK mobile telephone producer (Technophone) with significant R&D activities. Since the mid 1990s the share of US inventors has nonetheless grown very significantly. This is again presumably largely due to Nokias greenfield investments in R&D facilities in the US at the time, which seem to largely explain the overall rapid entry of US inventors to these teams that was evident also in the analysis of developments across all multinationals. Meanwhile the share of ROW inventors has also gown. Beyond the ICT field and Nokia, the other noteworthy increase in the share of US inventors of these inventor teams is found in the field of healthcare during the late 1990s, even though Finnish inventors are the dominant ones, by and large.

Global dispersion of innovative activity

Turning now to the internationalisation of the innovative activities based on the patents themselves, table 9 below presents the share of Finnish and foreign patents by the affiliation of the first inventor. The main interpretation of the table is that the general increase in patents attributed to first inventors with foreign affiliations of Finnish multinationals is relatively evenly distributed across the different technology fields. In the case of ICT there is a significant shift from 0 patents with first inventors with foreign inventors to shares above the total average by the late 1990s. From other research we know that this is in line with the global breakthrough of Nokia in the early and mid 1990s, after the inauguration of the GSM service in various countries (Palmberg and Martikainen, 2004). Apart from ICT, only the fields of electricals and other miscellaneous have higher than average shares of patents attributed to foreign locations, while the domestic nature of innovative activities in health care is confirmed further here.

Table 9. The percentage of granted US patents of Finnish multinationals attributable to inventors at foreign affiliations across technology fields

	Share of foreign patents*						
	Total	Chemicals	ICT	Health care	Electricals	Mechanical	Others
1980-1984	0.036	0	0	0.091	0.063	0.054	0.067
1985-1989	0.135	0.118	0	0.033	0.085	0.12	0.284
1990-1994	0.174	0.174	0.111	0.06	0.275	0.153	0.176
1995-1999	0.209	0.189	0.216	0.17	0.268	0.154	0.338
Total	0.174	0.152	0.201	0.112	0.237	0.133	0.234

*Affiliation of first inventor

In country comparisons it should be noted that the figures presented here only roughly are comparable with similar analysis included in Cantwell and Kosmopoulou (2004), since the categorisation of technology fields that Jaffe and Trajtenberg (2002) developed are different. We can therefore only make very sweeping comparisons to their analysis. With this caveat in mind, it seems that the level of internationalisation of innovative activities in the fields of ICT and electricals is on par with that of Swedish multinationals, while those from UK, France, the Netherlands and Switzerland are characterised by higher levels. Thus, it is mainly these fields and Nokia that keep Finnish multinationals on par with the internationalisation patterns of such larger countries as Italy, France and the UK. Otherwise, if Nokia would be excluded, Finnish multinationals would fare even lower in these comparisons.

Nature of innovative activity – the originality of patents

A comparison of the originality across technology fields is hampered by the fact that the propensity to cite varies by the nature of technology. Certain fields, such as biotechnology, are newer as such and might therefore score higher on the originality indicator when compared to other traditional fields due to inherent properties rather than solely on the basis of the qualitative nature of patents. Jaffe and Trajtenberg (2002) propose various methods to correct for these types of inherent and systematic biases of the data, depending on whether the analysis should take them into account or not. Since we are mainly interested in comparing the qualitative nature of patents by whether they are attributable to inventors at foreign or domestic locations, we do not correct for these possible biases. This caveat should nonetheless be kept in mind when interpreting the table below, that presents the mean originality score across technology fields.

Table 10. The measure of originality of domestic and foreign patents of Finnish multinationals across technology fields

	Measure of originality of patents*						
	Total	Chemicals	ICT	Health care	Electronics	Mechanical	Others
Finnish							
1980-1984	0.23	0.24	0.28	0.20	0.14	0.21	0.27
1985-1989	0.31	0.31	0.49	0.32	0.20	0.31	0.36
1990-1994	0.36	0.35	0.37	0.35	0.39	0.34	0.35
1995-1999	0.37	0.30	0.41	0.34	0.41	0.35	0.42
Total	0.34	0.31	0.41	0.33	0.36	0.32	0.35
Foreign							
1980-1984	0.15	na	na	na	na	0.15	0.28
1985-1989	0.35	0.33	na	0.56	0.21	0.30	0.45
1990-1994	0.37	0.43	0.38	0.35	0.36	0.29	0.38
1995-1999	0.40	0.36	0.44	0.42	0.38	0.31	0.43
Total	0.38***	0.38***	0.44	0.40	0.36	0.29	0.42**

* Affiliation of first inventor

** Mean(Foreign)-Mean(Finnish) significant at 10% level

*** Mean(Foreign)-Mean(Finnish) significant at 1% level

Note: Mean comparison tests were calculated only for the whole sample period, not for sub-periods due to relative small sample group sizes.

According to the table, we can confirm that general increase in the degree of originality of the patents appears to have been relatively evenly distributed across the different technology fields. This holds true both for patents attributable to inventors with a Finnish and a foreign affiliation. The higher degree of originality of patents with foreign affiliations is primarily due to higher than average scores for this indicator in the fields of chemicals, ICT, health care and other miscellaneous fields when compared to patents where the first inventor has had a Finnish affiliation.

When the total means are compared using the standard t-test, this result is strengthened further with significant p-values for patents in the fields of chemicals and other miscellaneous fields (only barely significant). It thereby seems that the internationalisation of innovative activities in the chemicals field most clearly has adhered to home-base-augmenting strategies, while this strategy appears less evident in other fields. On the other hand, the field of chemicals had below average shares of patents with foreign affiliations. The higher than average originality score for ICT-related patents with foreign affiliations is not reflected in a significant p-value. Despite these relatively robust results, further research is nonetheless clearly needed in order to provide further insights into the specificities of patterns and internationalisation strategies of Finnish multinationals in different technology fields.

4 A CONCLUDING DISCUSSION

This paper has elaborated on research on the internationalisation of R&D of Finnish multinationals by focusing on how this is also reflected in their innovating activities at foreign locations, as measured through their inventive output. Further, the paper contributes by assessing the nature of the innovating activities of the multinationals at their foreign locations. The paper drew on the literature on R&D location theories and extant research, and used established methodologies by defining the international nature of innovative activities through the composition and global dispersion of inventors to patents. The sample of multinationals is representative and de-facto covers over 95 percent of all Finnish R&D undertaken at foreign locations. The analysis was limited to the period 1980-1999 due to data availability constraints.

The patenting of Finnish multinationals shows a steady increase over time. However, patenting in the field of ICT has accelerated significantly in the late 1990s due to the emergence and global breakthrough of Nokia. Nokia has also accounted for a dominating share of all ICT-related patents and for roughly one third of all patents included in the analysis. The remaining patents are relatively equally distributed across other technology fields and firms. In the subsequent analysis we first focused on the pool of all inventors underlying the patents, to discuss the changing composition of inventor teams. Thereafter we deepened the analysis by shifting the attention to the nature of the patents themselves by the affiliation of the first inventor, with reference to similar definitions in the extant literature.

The internationalisation of R&D was also captured in the growth in the mean size and standard deviations of inventor teams over time. The distribution of inventors by the nationality of their affiliations at the time of filing of the patents appears to be in line with what is known about the global dispersion of R&D expenditures of these Finnish multinationals. The main share of foreign inventors is accounted for by US inventors, followed by inventors with affiliations in Sweden and the UK. The entry of US inventors to inventor teams is largely due to developments in patenting in the field of ICT, and thereby captures the greenfield investments in R&D that Nokia has made in the US since the mid 1990s.

When we analysed the patents themselves, by the nationality of the first inventor, comparisons could be made to a recent paper by Cantwell and Kosmopoulou (2004). In comparison with multinationals from other countries included in that paper, it seems that the share of foreign patents is lower in the case of Finland when compared to that of multinationals from other countries. This conclusion is significant, since extant research tends to suggest that technologically leading multinationals from small countries should be the most highly internationalised in their innovative activities. On the other hand, we acknowledged the difficulties in comparing across countries due to certain structural and historical differences in the breadth of research infrastructures and general patterns of internationalisation. Even though the level of internationalisation of the innovative activities of Finnish multinationals is lower when compared to multinationals from other small open economies, the Finnish level is on par with that of Italy, the UK and France, and it is higher when compared with multinationals from France. The level would be even lower if Nokia would be excluded from the analyses.

In the theoretical part of this paper we highlighted the long-standing debate over whether the foreign R&D activities of multinationals are of the home-base-exploiting or home-base-augmenting type (see especially Kuemmerle (1997)). In line with much of the extant research, we suggested that the mere fact that Finnish multinationals patent at their foreign locations points to the dominance of home-base-augmenting over home-base-exploiting. However, we suggested a further rough indicator of this, namely the originality indicator of patents as defined by Jaffe and Trajtenberg (2002). With reference to this indicator, we could confirm further that foreign patents of Finnish multinationals tend to be characterised by broader technological roots to complementary technological fields, and thus be of the more original and home-base augmenting type. The originality indicator was significantly higher for patents with first inventor at the foreign affiliations when compare with those with Finnish inventors. This result holds in comparisons across averages over all technology fields. The originality indicator was significantly higher in the fields of chemicals and other miscellaneous fields.

The paper was primarily explorative and intended as an introduction to more focused follow-up studies along similar lines. One such line of research that we aim to pursue is to analyse in greater detail the nature of home-base-augmenting innovative activities of Finnish multinationals. In particular, do foreign patents of these firms cite the patents of

firms in close vicinity to the foreign location in question? Or do these foreign patents primarily draw on the home-base technologies of the firm at the host country? Further extensions also include a closer analysis of the technological fields that foreign patents cite as an indicator of whether Finnish multinationals seek complementary or substituting technologies from abroad etc. The data also has to be updated to cover the most recent years, during which the rate of patenting and internationalisation of many Finnish multinationals has picked up significantly.

References

Cantwell, Johon and Kosmopoulou, Elena. 2004. Analysing the locational pattern of international corporate technological research. In Serapio, Manuel and Hayashi, Takabumi (eds.) *Internationalization of Research and Development and the Emergence of Global R&D Networks*. Amsterdam: Elsevier JAI.

Cohen, Wes and Levinthal, David. 1990. Absorptive Capability: a New Perspective on Learning and Innovation. *Administrative Science Quarterly*, vol. 35, issue 1, 128-152.

Dunning, John and Boyd, Gavin (eds.). 2003. *Alliance Capitalism and Corporate Management – Entrepreneurial Cooperation in Knowledge Based Economies*. Cheltenham: Edward Elgar.

Freeman, Christopher and Soete, Luc. 1997. *The Economics of Industrial Innovation*. Third Edition. London: Pinter Publishers.

Grilliches, Ziv. 1990. Patent Statistics as Economic Indicators: a Survey. *Journal of Economic Literature*, 27,1661-1707.

Guellec, Dominique and van Pottelsberghe de la Potterie, Bruno. 2001. The internationalisation of technology analysed with patent data. *Research Policy* 30,1253-1265.

Hayashi, Takabumi. 2004. Globalization and networks of R&D activities by 19 electronics MNCs. In Serapio, Manuel and Hayashi, Takabumi (eds.) *Internationalization of Research and Development and the Emergence of Global R&D Networks*. Amsterdam: Elsevier JAI.

Jaffe, Adam, Trajtenberg, Manuel and Henderson, Rebecca. 1993. Geographic Localization of Knowledge Spillovers. *Quarterly Journal of Economics* 108(3), 577-598.

Jaffe, Adam and Trajtenberg, Manule (eds.).2002. *Patents, Citations and Innovations: A Window on the Knowledge Economy*. Cambridge, Mass.: MIT Press.

Koskinen, Jussi. 1999. Internationalization of R&D in Finnish Firms. In Pajarinen, Mika and Ylä-Anttila, Pekka (eds.) *Cross-border R&D in a Small Country*. Helsinki: Taloustieto Oy.

Kuemmerle, Walter. 1997. Building effective R&D capabilities abroad. *Harvard Business Review*, Jan.-Feb., 61-70.

Lovio, Raimo. 2004. Internationalization of R&D activities of Finnish corporations – recent facts, management and policy issues. Forthcoming in Ali-Yrkkö, Jyrki and Ylä-Anttila, Pekka (eds.) *Finnish Multinational Enterprises in the Finnish System of Innovation.* ETLA B-series.

McQueen, Douglas and Olsson, Henrik. 2003. Growth of embedded software related patents. *Technovation* 23, 533-544.

Narula, Rajneesh and Zanfei, Antonelli. 2003. The international dimension of innovation. *MERIT-Infonomics Research Memorandum series* 2003-009.

Niosi, Jorge. 1999. The Internationalization of Industrial R&D. From technology transfer to the learning organization. *Research Policy* 28,107-117.

Pajarinen, Mika and Ylä-Anttila, Pekka (eds.). 1999. *Cross-Border R&D in a Small Country – The case of Finland*. Helsinki: Taloustieto Oy.

Palmberg, Christopher. 2003. Science-based innovation and diversification. In Palmberg, Christopher *Turning opportunities into innovations – Essays on the sources, nature and success of innovations*. PhD Thesis. Royal Institute of Technology Publications.

Palmberg, Christopher and Martikainen, Olli. 2004. The GSM standard and Nokia as an incubating entrant. Forthcoming in *Innovation: Management, Policy & Practice.*

Patel, Pari and Vega, Modesto. 1999. Patterns of internationalisation of corporate technology: location vs. home country advantages. *Research Policy* 28, 145-155.

Pearce, Robert. The Internationalisation of Research and Development by Multinational Enterprises. Hampshire: The Macmillan Press Ltd.

Teece, David. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, vol. 11, 271-287.

Tiede ja teknologia. 2000. *Tiede, teknologia ja tutkimus* 2000:4. Helsinki: Statistics Finland.

Vernon, Raymond. 1966. International investment and international trade in the product cycle. *Quarterly Journal of Economics* 80 (2). 190-207.

Appendix

Description of sample firms

Company	Industry	Net sales, mill. euros	Assets, mill. euros	Employees
Nokia	Electronics & Electrical Engineering	30016	23327	52700
Stora Enso	Paper-making	12783	18214	43900
Fortum	Energy	11148	17961	14100
UPM-Kymmene	Paper-making	10475	15375	36900
Metsäliitto	Paper-making	8868	8876	31000
Outokumpu	Metals & mechanical engineering	5558	6327	20200
Metso	Metals & mechanical engineering	4691	4399	29300
Kone	Metals & mechanical engineering	4342	4160	29400
Rautaruukki	Metals & mechanical engineering	2884	2561	13300
Kemira	Chemicals	2612	2491	10400
Wärtsilä	Metals & mechanical engineering	2519	2685	12400
Sonera	Telecommunications	2241	5179	8170
Huhtamäki	Manuf. of packaging products	2239	2466	16300
Ahlstrom	Metals & mechanical engineering	1778	1602	6760
Orion	Chemicals	1629	1410	5620
Instrumentarium	Manuf. of health care equipment	1127	1107	5650
Amer	Manuf. of sports equipment	1102	1008	3830
Raisio	Chemicals, foodstuffs	843	749	2650

Note: Financial data are from 2002.

E L I N K E I N O E L Ä M Ä N T U T K I M U S L A I T O S (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, FIN-00120 HELSINKI

Puh./Tel. (09) 609 900 Telefax (09) 601753
Int. 358-9-609 900 Int. 358-9-601 753
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