FINLAND
and the
GLOBALISATION
of
INNOVATION

Jyrki Ali-Yrkkö and Christopher Palmberg (Eds.)

ETLA – Research Institute of the Finnish Economy (B218 Series)

Publisher: Taloustieto Oy, Helsinki 2006

Cover: Virpi Haavisto, Avantage Oy, Helsinki

ISBN 951-628-434-5
ISSN-0356-7443
Printed in Yliopistopaino, Helsinki 2006

PREFACE

This book brings together the outputs of two years of research related to the project 'Finland's Position in the Globalisation of Innovation Activity (FINGIA)' It complements and elaborates further on a previous project entitled 'Multinational Enterprises in the Finnish Innovation System (MEFIS)'. Both of these projects have constituted a part of the PROACT research program commissioned by the Ministry of Trade and Industry and the National Technology Agency of Finland (Tekes). We wish to express our gratitude to the organisers of the PROACT research program and gratefully thank the Ministry of Trade and Industry for funding the project. They have thereby also contributed to strengthening further the tradition of research at Etlatieto/ETLA on globalisation, the internationalisation of firms and the activities of Finnish multinationals.

The content of this book has benefited from numerous discussions with our colleagues in Finland and abroad, as well as from workshops, conferences and peer reviewers. We wish to thank especially Pekka Ylä-Anttila and Raimo Lovio who have provided valuable insights into the internationalisation of Finnish firms and the globalisation of innovation. Further, Tuomo Nikulainen has provided valuable help with data collection on strategic alliances of Finnish firms. Kimmo Aaltonen, Virpi Haavisto and Anthony de Carvalho have given the final, and much appreciated, touches to this book. Last, but not least, we wish to thank the chief technology officers and other firm representatives who generously have shared their time with us for interviews about issues of relevance to the topics analysed and discussed in this book. Without these contributions our understanding of the position of Finland in globalisation would certainly have been meagre.

We hope that this book will highlight new and interesting research results, observations and conclusions on the challenges that Finland faces in the way ahead and thereby also contributes to discussions about the scope and focus of innovation policy now and in the future.

Jyrki Ali-Yrkkö and Christopher Palmberg

Helsinki 3.3. 2006

CONTENT

PREFACE

AUTHORS

Jyrki Ali-Yrkkö: Lic.Sc. (Econ.), is a head of unit at Etlatieto Ltd., a project research services unit of the Research Institute of the Finnish Economy (ETLA). His research interests include internationalisation of companies, determinants of R&D and fixed investment, evaluation of the impact of public R&D, corporate governance, and Nokia's role in the Finnish Economy.

Monika Jain, FCA (India), MBA (Finland), consults Finnish and Indian companies aiming to penetrate the reciprocal markets with market entry strategy, initial business planning and development, distribution set up and corporate governance. She was a practicing Chartered Accountant in India advising SME's on taxation and financial matters before moving to Finland.

Olli Martikainen, Ph.D (Maths), holds a professorship in Mobile Applications at the University of Oulu, and he is also an Associate Research Fellow, at the Research Institute of the Finnish Economy (ETLA). His research interests cover telecommunication software methods and tools, network architectures, performance analysis and new industrial and economic structures in ICT, business management, product development and innovation

Mika Pajarinen, M.Sc. (Economics), is a researcher at Etlatieto Ltd., a project research services unit of The Research Institute of the Finnish Economy (ETLA). His recent research projects relates to corporate finance, entrepreneurship and internationalization of business.

Christopher Palmberg, Ph.D (Industrial Economics and Organization), is a researcher at Etlatieto Ltd., a project research services unit of The Research Institute of the Finnish Economy (ETLA). His recent research projects relates to technological and industrial dynamics in the ICT industry, Finland as a knowledge economy, the internationalisation of R&D and nanotechnology.

Vicky Xiaoyan Long is a Ph.D student at the Institute of Industrial Economy and Organization at the Royal Institute of Technology (KTH) in Sweden. Her Ph.D research focuses on the catching-up of the Chinese ICT industry in the broader context of the transformation of the wireless telecommunications industry.

I

Introduction

FINLAND AND THE GLOBALISATION OF INNOVATION – An overview and synthesising discussion

1 INTRODUCTION

1.1 GLOBALISATION OF R&D AND INNOVATION

Globalisation is a topical issue for policymakers and firms alike, especially in a small open economy, like Finland, that depends on international trade to a significant degree (VNK, 2004). Although countries always have been connected in various ways throughout history, commentators usually claim that globalisation has reached a new phase at the dawn of the 21st century due to the combined effects of liberalisation of world markets and technological change, especially in the field of ICT. Globalisation is a catch-all concept to capture a wide range of forces depending on the perspective taken. We take the relatively narrow definition of globalisation as suggested by Archibugi and Iammarino (2002) as our point of departure, since it contributes to framing the content and aims of this book in reasonably clear way.

> "Globalization implies a high and increasing degree of interdependency and interrelatedness among different and geographically dispersed actors." (Archibugi and Iammarino, 2002, p. 99)

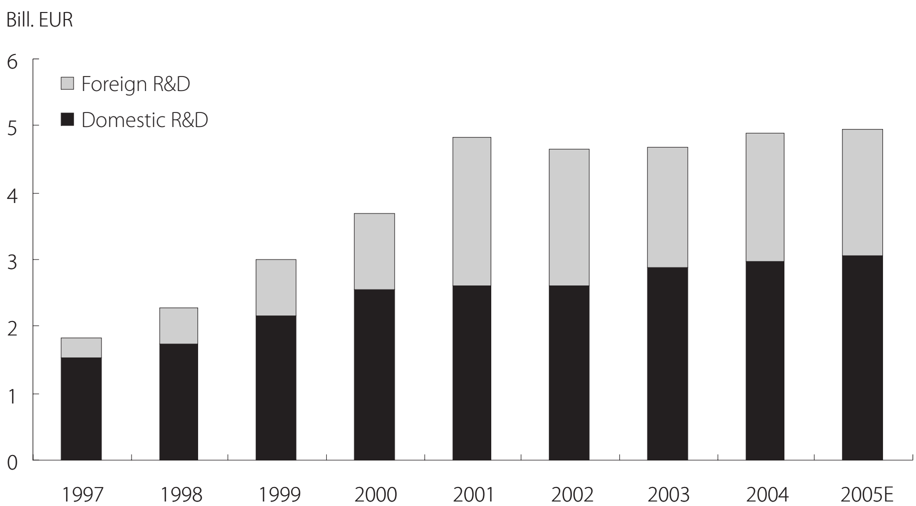
As the title suggests this book focuses on the interdependency of Finnish firms on different and geographically dispersed foreign firms and locations in the globalising world economy. From the firms' perspective, increasing interdependency means that not only goods and services are traded internationally, but also that the entire business system is extending beyond national borders. This increasing interdependency has created both opportunities and threats. On the one hand, firms are trying to benefit from globalisation by establishing foreign affiliates, acquiring equity and loans abroad, sourcing raw materials from other countries, and licensing foreign technologies, and thus contribute to globalisation through their own activities. On the other hand, it also implies increasing competition and collaboration, growing dependency on the global financial market and standard setting in high-technology fields, as well as a greater urgency for firms to be present in multiple geographical markets.

The emergence of a new global division of labour in manufacturing is the most visible sign of globalisation as we define it. In the first years of the 21st century, developed countries have witnessed a massive transfer of manufacturing activities to developing countries. Particularly China has become a global centre for manufacturing activities. However, the rapid change in the global division of manufacturing has hence far overshadowed another, and perhaps even more significant, phenomenon, namely the globalisation of innovation. Evidence from the UK, the US, Sweden and Germany suggests that companies have increased their overseas R&D. According to a recent report by the United Nations, overseas R&D operations have until now been heavily concentrated in the Triad regions of Western Europe, the US and Japan. This is symptomatic of the fact that advanced firms from the developed countries mainly have preferred to established R&D units in other developed countries. However, this global division of labour in R&D and innovation activities now also appears to be changing in line with trends in manufacturing. There is strong indication that the attractiveness especially of developing Asian and South-East Europe has substantially increased. China, India and Russia, in particular, are often mentioned as candidates for R&D locations in the future investment strategies of firms (UNCTAD 2005). Firms are recruiting skilled individuals from these countries, go beyond adaptation of in-house technologies to local markets to a larger degree, and also increasingly engage in the development of new technologies, products or processes. As a result, firms from the developed countries are becoming increasingly dependent on interaction with firms and locations also in the developing countries. This interaction creates new opportunities and challenges for firms.

1.2 SETTING THE STAGE FOR THE BOOK

Global developments in terms of the location of manufacturing, R&D and innovation appear to be reflected also in the recent strategic decisions of Finnish firms. As of yet, research on the globalisation of innovation from a Finnish viewpoint is relatively scant and is mostly focused on the unilateral interna-

Figure 1.1 Domestic and foreign R&D of Finnish manufacturing industry



Source: Confederation of Finnish Industries, EK.

tional expansion of the in-house activities of firms (Ali-Yrkkö, Lovio and Ylä-Anttila 2004, Koskinen 1999). As a way of summarising this extant research, we can also point to statistics that show that the overseas R&D expenditure of Finnish firms has increased substantially from 1997 to 2005, reaching a record high of EUR 2.2 billion in 2001. This level accounted for 45 per cent of the total R&D of the Finnish manufacturing sector (Figure 1.1).

Further, international research suggests that while the majority of overseas R&D units have been established to adapt products to the local market (so-called home-base exploiting activities), the development of new technologies, products and processes (so-called home-based augmenting activities) is becoming an increasingly important reason for conducting R&D abroad (see especially Kuemmerle (1997); Serapio and Hayashi (2004)). These results indicate that firms are increasingly interdependent on foreign locations in their innovation activities, and thereby also actively contribute to changing the division of labour in R&D and innovation. However, as of yet little is known about how Finnish firms interact with foreign firms and locations in the context of a changing division of labour in R&D. This is a deficiency especially in the debate on how Finnish innovation policy should respond to the global nature of innovation activity both in terms of opportunities and threats.

This book provides new research insights on various aspects of the changing division of labour in R&D from a Finnish perspective. The overreaching aim of the book is to contribute to filling the above-mentioned deficiency in our understanding of Finland's position in the globalisation of innovation. It contributes to the extant Finnish research in three novel ways. First, it complements available studies in Finland that hence far mainly draw on survey and R&D expenditure data with patent and qualitative data to also trace the global dispersion of innovation activities as the outputs of these expenditures. It thereby provides new insights into the nature of overseas R&D activities. This is an important viewpoint since it also produces insights into why Finnish firms expand to foreign locations and thus points to the advantages and disadvantages of Finland as a location for R&D and innovation.

A second novelty of the book is that it extends the perspective on the globalisation of innovation from in-house activities also to collaborative activities whereby firms share their R&D with other firms through strategic alliances. There is mounting evidence that strategic alliances are becoming an increasingly important means to internationalise firms' innovation activity. Such alliances also contribute to the changing division of labour in R&D and innovation in a significant, albeit less visible, way (de la Mothe and Link, 2002; Dunning and Narula, 2004). Third, this book also addresses the entry of firms from Asian countries to the league of R&D-intensive firms as exemplified especially by the case of India and China. This entry of Indian and Chinese firms provides Finnish firms with new opportunities for interaction. Nonetheless, it also presents new challenges and threats as the development of Finnish high-technology industries is now also increasingly interdependent on the strategies of firms from developing countries in global competition.

1.3 THE SCOPE OF THE BOOK

The results of the papers in this book are mainly based on data concerning large Finnish firms. The ambition has been to cover firms which account for a noteworthy share of business sector expenditure on R&D while also constituting important actors in their respective industries in terms of turnover, employment, and position in value chains and clusters. When these criteria are combined the sample consists of some 25 of the largest firms, all of them primarily based in Finland although some are also very multinational. The firms represent the major companies in the Finnish ICT and electronics, forest-related, metal and engineering industries. Thanks to the significance of these firms our data provide an excellent view of the internationalisation of R&D activities of Finnish industry. Together they account for approximately 90 per cent of the total overseas R&D.

This book is composed of seven papers organised into three sections to reflect the three novel viewpoints it takes on the position of Finland in the changing division of labour in R&D and the globalization of innovation, namely (i) the global dispersion of in-house R&D, (ii) collaborative R&D through strategic alliances, and (iii) the rise of Asia – new opportunities and challenges. It should also be noted that each paper uses slightly different subpopulations of the 24 large firms that were the point of departure for the book as a whole, and the focus shifts to a different population of Indian and Chinese firms in the third section. Each paper is intended as a stand-alone contribution and contains specific discussions and conclusions of policy relevance. In the following the papers will be briefly summarised in terms of their basic approach and main results ahead of the broader synthesising discussion that strives to give comprehensive conclusions to match the over-reaching aim of the book.

2 AN OVERVIEW OF THE MAIN RESULTS

2.1 THE GLOBAL DISPERSION OF IN-HOUSE R&D

The *first section* focuses on the extent and nature of the global dispersion of the in-house R&D and innovation activities of the firms covered by this book, while also providing new insights into the advantages that the firms identify at specific geographical locations. The first paper of this section, entitled *"The global dispersion of innovative activities – The case of Finnish multinationals,"* approaches this issue quantitatively by analysing granted US patents. Patent data are interesting because they capture the outputs of R&D and innovative activities of firms and thereby complement traditional studies on the internationalisation of R&D (see e.g. the Special Issue in Research Policy from 1999). Further, patent data are also a rich source of information that enables various analyses of the changing composition of inventor teams and the nature of their inventive activities.

In comparison to large firms in other small open economies it seems that, measured in terms of inventors, the innovative activities of the Finnish firms are less internationalised. This is in contrast with current research that suggests that firms from smaller countries tend to have a much bigger share of patents with foreign origin compared to larger countries. However, a closer analysis shows that the number of such patents is growing and thereby indicates that Finnish firms increasingly tend to be engaged in activities geared towards the development of innovations at their foreign affiliates. This is backed up by the fact that inventors based in the US, UK, Germany and Sweden are entering the inventor teams of the firms as these teams grow in size. Further, patterns of citations indicate that the patents with a foreign origin are more significant in terms of their technological content when compared with those of Finnish origin.

As suggested, the global dispersion of inventive activity of large Finnish firms produces insights into how they interact with foreign locations, which in turn is largely determined by locational advantages for R&D. Such locational advantages are the focus of the second paper of this first section entitled *"Locational advantages in R&D – Insights from large Finnish firms"* which draws on in-depth interviews with the Chief Technology Officers (CTOs) of the firms. Locational factors are usually considered to be based on various demand or supply factors characterising a geographical location. Demand factors relate to the size and nature of markets. Supply factors relate to the costs and quality of engineers, scientific and technological centres of excellence and infrastructures (Patel and Vega, 1999). In addition, the paper suggests that so-called intermediating factors might sometimes be very important as they facilitate learning and efficiently couple demand and supply factors at foreign locations and thus increase the efficiency of R&D.

Based on this categorisation the paper provides evidence that the proximity of customers and the availability and skills of engineers are especially important locational advantages in a general sense. In specific locational decisions firms simultaneously consider multiple demand, supply and intermediating factors. Finland's locational advantage relates to a combination of the availability of highly skilled engineers at relatively low costs, straight-forward co-operation especially with universities, as well as pragmatism in decision-making and trust throughout networks of firms and other actors. Nonetheless, the paper also highlights and discusses future and policy-relevant challenges in all of these dimensions that will be imperative towards supporting the location of significant inventive activity in Finland also in the future.

2.2 COLLABORATIVE R&D THROUGH STRATEGIC ALLIANCES

In the *second section* of the book, the focus shifts from the in-house activities of firms to collaborative R&D and innovation in the form of strategic alliances. It contains three papers which all draw on a new and unique database (the SAFIF database) of the strategic alliances of firms in an attempt to more explicitly map and interpret how and why Finnish firms interact with other firms globally in their R&D and innovation activities. In all of the papers, the level of analysis is inter-firm relationships characterised by formal agreements and long-term commitments to reach a common strategic goal. The first paper, entitled *"Alliance capitalism and the internationalisation of Finnish firms,"* provides a broader analysis of the role that strategic alliances play in the overall internationalisation strategies of the firms. The concept 'alliance capitalism' has been coined to capture the intensified interdependencies that globalisation is creating especially between firms, and it thereby also relates very closely to the definition of globalisation that we use in this book (Dunning, 1997; Dunning and Boyd, 2003).

The paper shows that the number of strategic alliances involving Finnish firms has, indeed, grown rapidly, especially since the late 1990s. Further, the largest share of this growth is accounted for by alliances of the more explorative kind that also involve R&D collaboration. It seems that the firms mainly interact with North American, European and other Nordic firms, corresponding roughly to the distribution of Finnish exports and FDI. But Asian firms are also entering these alliances especially related to production and marketing activities. Further, the paper draws on interviews with the CTOs. These reveal that the main motives for forming alliances concern the sharing of costs and risks as well as the exchange of complementary knowledge and other assets. The results are thereby in line with extant research from other countries. But the paper also highlights challenges that might be quite specific and policy-relevant to the case of Finland.

Firms might interact with each other through different types of strategic alliances. Sometimes joint ventures are considered as close substitutes for wholly-owned subsidiaries since both involve equity investments. Joint ventures can therefore be taken to represent the traditional mean that firms have to extend their R&D and innovation activities abroad. Current research shows that especially looser types of non-equity alliances are the ones which have grown most rapidly as they provide greater flexibility for firms (Hagedoorn, 2002). This prevalence of non-equity alliances over equity-based ones is also confirmed for the case of Finland in the second paper of this section entitled *"Internationalisation through strategic alliances – Determinants of non-equity alliances of Finnish firms".* This paper seeks to explain the prevalence of non-equity over equity alliances in the internationalisation strategies of the Finnish firms. It highlights the effects that different types of uncertainty have on the organisational choices that the firms make in alliance formation. The results confirm further that the sharing of risks, especially in connection with R&D and marketing activities, is a primary motive as the firms are more prone to enter non-equity alliances. Conversely, production-related activities are more often associated with equity alliances. These results thereby suggest that strategic alliances are a particularly relevant means for firms to internationalise their innovation activities while various equity-based arrangements are more attractive when manufacturing is the object of internationalisation.

In-house activities and strategic alliances are of course for the most part highly complementary, especially in the case of innovation activities where the dependency on external knowledge is high. Framed in this way, strategic alliances provide opportunities for firms to take advantages of the changing division of labour in R&D and innovation while maintaining their indigenous specialisation in particular technology fields. Arguably this division of labour is changing most rapidly in the ICT industry due to the ongoing convergence between data communications and telecommunications that is largely driven by the emergence of Internet-related technologies. From a Finnish viewpoint, an especially topical issue is how the telecommunications industry – that has contributed significantly to the renewal and growth of the whole Finnish economy – can take advantages of the opportunities and adjust to the challenges.

This issue is addressed in the third and final paper of this section entitled *"Indigenous competencies versus R&D alliances of the Finnish telecom industry"*. In this paper a subset of the SAFIF database is used to analyse the external technological diversification of key ICT firms by examining the content of their strategic R&D alliances and changes over time. This external diversification is compared to their patenting across technology fields under the assumption that patenting captures in-house indigenous/internal diversification. The paper shows that the Finnish telecommunications industry indeed is diversifying both internally/indigenously and externally, even though strategic R&D alliances have contributed less to this diversification. The industry is overall still quite focused on the more 'traditional' technology fields that underlie the industry even though especially Nokia has entered many alliances in 'newer' Internet-related technology fields. These results get further confirmation by the fact that European companies are the most frequent partners even though Internet-related technologies mainly are brought to the market by US firms. The entry of Asian firms is also visible and their importance seems to be growing over time. More generally, the paper raises important and policy-relevant questions about the compatibility of the Finnish technological specialisation pattern vis-à-vis a changing division of labour in R&D and innovation in the telecommunications industry.

2.3 THE RISE OF ASIA – NEW OPPORTUNITIES AND CHALLENGES

As suggested already in the introduction particularly India and China are often mentioned as candidates for new R&D locations. The CTOs that we interviewed also suggested that these countries are providing new opportunities for the R&D and innovation activities of Finnish firms, not least due to the availability of a growing pool of highly skilled engineering manpower at low costs. Further, the entry of Asian firms is also visible in the data on Finnish alliances, especially in the context of the ICT industry. Clearly then the possible rise of Asia toward the forefront in R&D and innovation provides new opportunities to Finnish firms, although the downside of excessive relocation of R&D to these countries has also been acknowledged (VNK, 2004). Likewise, it also provides a range of new challenges in so far as Indian and Chinese firms emerge as major competitors in the future.

The *third section* of the book turns to addressing some of these new opportunities and challenges albeit from the vantage point of Indian software firms entering Finland as well as Chinese firms entering the global ICT industry. Hence this third section provides diametrically different perspectives on all of the previous papers and acts as a good spring-board into the final synthesising and concluding discussion. Of the two papers, the first, entitled *"Offshoring software development – Case of Indian firms in Finland,"* analyses Indian software companies operating in Finland. Using qualitative data based on interviews, it analyses the scale and operation modes of Indian software companies in Finland. Since the late 1990s, more than a half dozen Indian software companies have established their offices in Finland. The paper considers their establishment motives, operations and experiments in Finland. The initial motives of these companies to come to Finland include seeking customers and augmenting knowledge. Practically all the companies interviewed have seen Nokia as the most important and attractive customer in Finland. From the viewpoint of the customers the results support the view that the most important motive for offshore outsourcing is lower costs. But not all outsourcing decisions are based on costs. Companies have speeded up their product development process by using external R&D sources. In the future, Indian vendors will probably move up in the value chain to areas such as designing and architecture functions. This will mean that on-site work will increase but offshore work will also increase through both offshore outsourcing and in-house operations. However, Indian companies are not the only ones in the offshore outsourcing market. For instance, Russian offshore companies are also interested in the Finnish market and they are potential competitors for Indian outsourcing companies in the future.

In the second paper of this final section, entitled *"Navigating IPR thickets from a latecomers perspective – The case of the emerging Chinese ICT industry,"* we move to the Chinese ICT industry. The paper finds relevance in the fact that the trade specialisation patterns of China and Finland are converging due to the emergence of the Chinese ICT industry, elevating them to head-on competitors but also to viable collaborative partners in R&D and innovation. The Chinese ICT industry has benefited from inward FDI from developed countries as these have generated spillovers and other externalities, and Nokia has set-up both manufacturing and R&D units there as well. This paper nonetheless starts from the premises that the emergence and future competitiveness of the Chinese ICT industry crucially depends on how the Chinese firms also manage to catch up to the incumbents from the developed countries in terms of IPR stakes and patents over indigenous technologies. The paper contributes by analysing the patenting behaviour of Chinese firms in the field of ICT combined with interviews with R&D and other managers of the firms. Through this focus and approach, it also provides insights into the environment within which Finnish ICT firms interact with their Chinese counterparts, and highlights both new opportunities and challenges in this context.

The paper does indicate that Chinese ICT firms indeed are building up relatively indigenous patent-related IPR stakes on international markets, although the absolute level of patenting still is very low in relation to the large size of the country. The public promotion of the so-called TD-SCDMA 3G standard in China has evidently also strengthened the indigenous knowledge base of Chinese firms by supporting learning, even though incremental innovation through re-engineering still seems to be very important. The most significant Chinese ICT firms with the international market as their target are in the process of penetrating the 'patent thickets' of the incumbents due to the leverage that they have in terms of their knowledge base. Meanwhile the firms with a stronger domestic focus appear to follow quite different IPR management strategies to cope with the underdeveloped patent system. Hence, it seems that Finnish firms also need to apply a dual approach towards interacting with the emerging Chinese ICT industry. The relevance of patent-pooling and cross-licensing of technology in line with international rules of the game is clear in interactions with the larger and internationalised firms, while the building-up of trust and local partnerships is pivotal in the interactions with smaller firms in the large Chinese market.

3 A SYNTHESISING AND CONCLUDING DISCUSSION

This book takes different viewpoints on how these Finnish firms interact with foreign firms and locations, as the viewpoint shifts between the global dispersion of R&D to collaboration through strategic alliances, and the entry of Indian and Chinese firms in the ICT industry. These different viewpoints provide interesting snapshots of Finland's position in the globalisation of innovation in light of the global trends mentioned above. These snapshots are new in a Finnish context and, thus, the conclusions that follow should also contribute to further considerations about suitable policy and managerial responses to ensure that Finland succeeds in global competition also in the future. These conclusions can be synthesised as four broader and partly overlapping observations, while further discussions are found in each of the seven constituting papers.

According to all viewpoints taken in this book, a *first observation* is that Finnish firms go beyond the mere adaptation of their in-house technologies to local markets at their foreign site (home-based exploiting R&D), and increasingly also engage in developing new technologies, products and processes (home-base augmenting). This is evident in the analysis of the extent and nature of the patents of these Finnish firms with inventors registered at affiliates abroad as well as in the qualitative analysis of locational advantages. It is also evident in the growth in the number of international alliances involving Finnish firms. Moreover, the entry of Indian software firms into the Finnish market is an indication of the new opportunities that Asia's rise creates for explorative R&D abroad. This book does not provide updated times series of the changing nature of overseas R&D to the existing literature (see especially Koskinen (1999)). Therefore, it is difficult to provide quantitative estimates of how broad-based this tendency is. Nonetheless, based on qualitative insights it seems that there is firm-level heterogeneity in the degree to which home-base augmenting is starting to dominate over home-base exploiting.

The *second observation* is closely related. Specifically, the increasing relevance of home-base augmenting R&D that can be observed is pushing the firms into closer interactions with foreign firms and locations. In other words, the boundaries of the in-house activities of the firms are becoming fuzzier as innovation activity becomes decentralised across multiple geographical locations. This is creating new managerial challenges relating to the multinational coordination of R&D projects, the recruitment and in-house training of R&D personnel, unintended knowledge spillovers, and to cultural barriers. Evidently cultural similarity is still considered as a locational advantage for the fluidity of communication in complex engineering work. However, the need for closer interaction is above all visible on a multinational level through the evident growth of international alliances involving Finnish firms. This trend is particularly clear in the case of the ICT industry even though strategic alliances also are becoming pervasive in other industries.

Two aspects of this growth in the alliance activity of Finnish firms are especially noteworthy. First, it is largely due to the increasing involvement of Finnish firms in non-equity alliances with a high R&D component. Collaborative manufacturing-related activities tend to be organised as equity-based joint ventures, closer to traditional means of internationalisation such as FDI. This observation seems to suggest that Finland primarily participates in "alliance capitalism" as an explorer of new technologies rather than an exploiter of already existing technologies. In large part this is a natural consequence of the fact that a few firms in the ICT industry, and especially Nokia, dominate in terms of the number of alliances. These firms are pushing the technological frontier of their industries, and R&D collaboration is especially important due to standardisation and requirements for interoperability between products and services. Nonetheless, by and large, it seems that Finnish firms mainly exchange their technological assets for complementary manufacturing- or marketing-related assets throughout alliance networks in order to gain access to, and set up production on, foreign markets.

The second general aspect of the growth in the alliance activity of Finnish firms relates to the challenges that arise. Strategic alliances clearly represent a new mode of interaction with foreign firms and locations, and thereby provide an alternative route for the internationalisation of R&D when compared with FDI. As a consequence, the firms also recognise new managerial challenges in this context. The most pressing of these relate to the management of intellectual property rights (IPRs), especially in vertical alliance relationships where the foreign partner has a dominating position in terms of large size or competitive position in the downstream markets. Vertical alliances appear more conductive for innovation since firms might not be head-on competitors. Nonetheless, such alliances might end up in complex and highly uncertain negotiations over who owns the rights over jointly developed technologies. This issue could be given even greater consideration in innovation policy when smaller Finnish firms are involved in alliances with foreign multinationals. IPR issues will undoubtedly become a key issue in global competition, especially in the case of firms from small high-cost countries that hardly can compete through prices.

The third observation relates to developments in the ICT industry which is especially important to Finland due to a high degree of specialisation in telecommunications. The Finnish telecommunications industry has been studied quite extensively in the past (see e.g. Ali-Yrkkö et. al., (1999); Paija (2001); Rouvinen and Ylä-Anttila (2003)). This book provides new insights into these developments when framed in the broader context of the globalisation of innovation and the changing division of labour in R&D. The industry is presently undergoing a disruptive phase due to convergence between data communications and telecommunications, driven above all by digitalisation and the emergence of new Internet-related technologies. This disruption creates new entry opportunities for firms in developing countries, while also shifting the locus of R&D and innovation from the traditional core of the ICT industry towards adjacent fields where data communications and software firms have a stronger position. From a Finnish vantage point these developments are clearly visible in the patterns of diversification of major telecommunications firms as they are complementing their indigenous knowledge with external R&D collaboration through strategic alliances. A key question is whether the broader Finnish ICT cluster also manages to diversify itself indigenously toward adjacent fields to face the challenges that lie ahead. This book suggests that there are weak spots, especially in the field of new Internet-related technologies and applications when the global activities of Nokia are discounted.

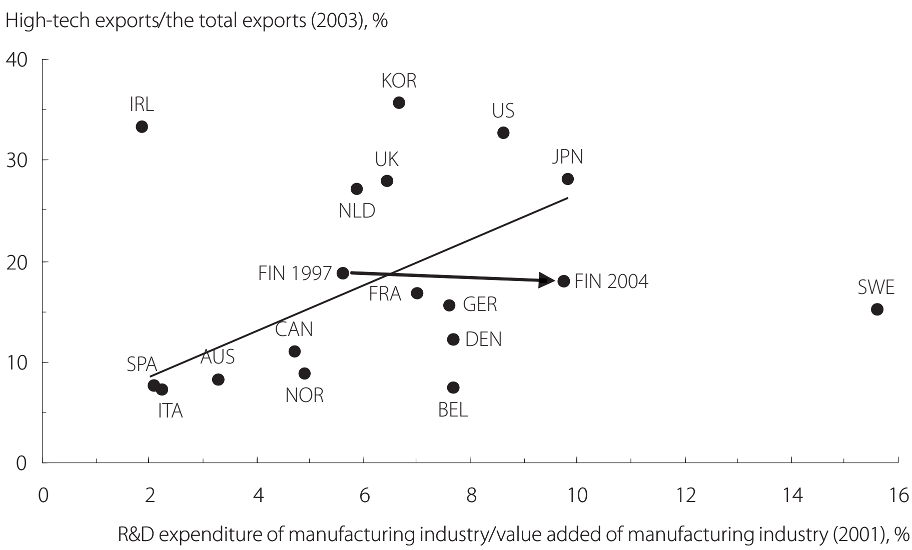
Another aspect of the developments of the ICT industry is best visible from the vantage point of Indian and Chinese firms. The case of India is interesting due its strong presence in the field of software. Indian software firms are now moving up in the value chain to provide increasingly sophisticated outsourcing services to firms also in Finland through their local presence. In the case of China we see a similar development as Chinese ICT firms are endeavouring to develop their IPR stakes on international markets, while increasingly also tending to the management of their IPRs domestically through various means. From a Finnish viewpoint these developments imply that firms not only face competitive challenges from established firms abroad; they also have to adjust to tightening global competition in new technology fields where Finland has been a pioneer in the past, and this competition is now also extending to the home market. The case of the third generation (3G) Chinese mobile telecommunications standard TD-SCDMA is also a good example of this tightening global competition. Pending on the policy towards 3G licences that the Chinese government will take, Finnish firms will have to develop technologies compatible with the TD-SCDMA standard due to the mere size of the Chinese market. Meanwhile the standard is also strengthening the indigenous knowledge base of Chinese firms in 3G markets elsewhere in the world.

The *fourth observation* relates back to square one in the sense that a majority of the R&D and innovation activities of the firms studied in this book still resides in Finland despite the fact that an increasing share of R&D expenditures is channelled to locations abroad. In other words, Finland does also possess locational advantages in the globalisation of innovation both for Finnish and foreign firms. Traditionally, locational advantages are categorized in terms of demand and supply factors. Nonetheless, it is more relevant to consider the combination of various factors as they interact to create specific advantages for the localisation of different types of firms, R&D and innovation activity. So-called intermediating factors also matter and they might compensate for high labour costs and a limited market that characterises small countries and enhance the efficiency of R&D.

In Finland it seems that locational advantages above all relate to a combination of supply and intermediating factors in the sense that the smallness of the market is compensated by the availability of a pool of highly skilled, though relatively low-cost, engineers, as well as pragmatism and trust throughout networks of firms and other actors that enhances the efficiency of R&D. This finding is interesting since it suggests that policies should be broad-minded and acknowledge the many – and sometimes even counteracting – factors that contribute to locational advantages. For example, on the one hand high taxes will diminish cost-based locational advantages. On the other hand, high taxes might also be a necessary prerequisite for upholding high standards and equality in education, as well as a functioning welfare system. This, in turn, contributes to various intermediating factors that matter for creativity and innovation in different sectors of the economy.

Apart from these observations, based on developments until now, the book also raises an important issue concerning the future location of Finnish R&D. If the transfer of manufacturing activities to the developing countries continues at present rates a key question is the degree to which R&D will also

Figure 3.1 R&D and high-tech exports



follow suit, given the complementarities between manufacturing and R&D. The relationships between manufacturing and R&D activities in the context of the globalisation of innovation are worthy of further research beyond what has been possible in this book. A break-up of R&D into its more detailed components would be a crucial element in such an analysis. It might, for example, be the case that certain types of R&D investments in Finland affect the outputs of firms at their foreign manufacturing sites as figure 3.1 might suggest. Clearly, Finland should and can remain a highly attractive location only for certain types of R&D in the changing division of labour at the global level. From this perspective Finland does also have to remain an attractive location for manufacturing activities – manufacturing matters for the growth of the economy and will do so also in the future. It is not necessarily beneficial to specialise in costly and high-risk R&D if a significant share of the outputs of such activities are realised abroad.

REFERENCES

Ali-Yrkkö, J., Paija, L., Reilly, C. & Ylä-Anttila, P. 2000. *Nokia – A Big Company in a Small Country.* ETLA – The Research Institute of the Finnish Economy, B:162, Helsinki: Taloustieto Oy.

Ali-Yrkkö, J., Lovio, R. & Ylä-Anttila, P. 2004. *Multinational Enterprises in the Finnish Innovation System*. ETLA B:208, Helsinki: Taloustieto Oy.

Archibugi, D. & Iammarino, S. 2002. The globalization of technological innovation: definition and evidence. Review of international Political economy, 9:1, 98-112.

Dunning, J. 1997. Alliance capitalism in international business and the world economy. Routledge: London.

Dunning, J. 2003. Relational assets, networks and international business activity. In Dunning, J. and Boyd, G. (eds.), *Alliance capitalism and corporate management*. Cheltenham: Edward Elgar.

Dunning, J. & Narula, R. 2004. Multinationals and Industrial Competitiveness. Cheltenham: Edward Elgar.

Hagedoorn, J. 2002. Inter-firm R&D partnerships: an overview of major trends and patterns since 1960. *Research Policy* 31, 477-491.

Koskinen, J. 1999. Internationalization on R&D in Finnish Firms. In Pajarinen, M. & Ylä-Anttila, P. (Eds.): *Cross-Border R&D in a Small Country*, Helsinki: Taloustieto Oy, Finland.

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

Lovio, R. 2004. Internationalization of R&D Activities of Finnish Corporations – Recent Facts and Management and Policy Issues. In Ali-Yrkkö, J., Lovio, R. & Ylä-Anttila, P. (Eds). *Multinational Enterprises in the Finnish Innovation System*. Etla B:208, Helsinki: Taloustieto Oy.

de la Mothe, J. & Link, A. (eds.). 2002. *Networks, Alliances and Partnerships in the Innovation Process*. Boston: Kluwer Academic Publishers.

Paija, L. 2001. *Finnish ICT Cluster in the Digital Economy*. Etla B:176, Helsinki: Taloustieto Oy, Finland.

Rouvinen, P. & Ylä-Anttila, P. 2003. Case Study: Little Finland's Transformation to a Wireless Giant. In Dutta, S, Lanvin, B. & Fauna, F. (eds.) The Global Information Technology Report 2003-2004. New York: Oxford University Press.

Serapio, M. & Hayashi, T. (eds.). 2004. Internationalization of Research and Development and the Emergence of Global R&D Networks. Amsterdam: Elsevier JAI.

UNCTAD, 2005. World Investment Report 2005. Transnational Corporations and the Internationalization of R&D. Genova: United Nations.

VNK, 2004. *Osaava, avautuva ja uudistuva Suomi. Suomi maailmantaloudessa-selvityksen loppuraportti*. Valtioneuvoston kanslian julkaisusarja 19/2004.

II

The Global Dispersion of In-house R&D

THE GLOBAL DISPERSION OF INNOVATIVE ACTIVITIES –
The case of Finnish multinationals

Palmberg, Christopher and **Pajarinen**, Mika. **THE GLOBAL DISPERSION OF INNOVATIVE ACTIVITIES – THE CASE OF FINNISH MULTINATIONALS**

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 innovation 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 ja **Pajarinen**, Mika. **INNOVAATIOTOIMINNAN GLOBALISOITUMINEN SUOMALAISTEN MONIKANSALLISTEN YRITYSTEN NÄKÖKULMASTA**

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.

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 China and India – which are providing new outlocation 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 this viewpoint.

The paper is structured as follows. The second section 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 multinationals. 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 (Niosi, 1999).

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 2.1.

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

Table 2.1 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	30.60	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	6.40	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	20.40	17.39	8.73
Total of all countries	10.50	10.95	11.28	11.27
Total excluding Japan	12.25	13.88	15.76	16.53

* Affiliation of first inventor is foreign.

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 receives 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

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 Industries (EK). 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, 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 3.1.

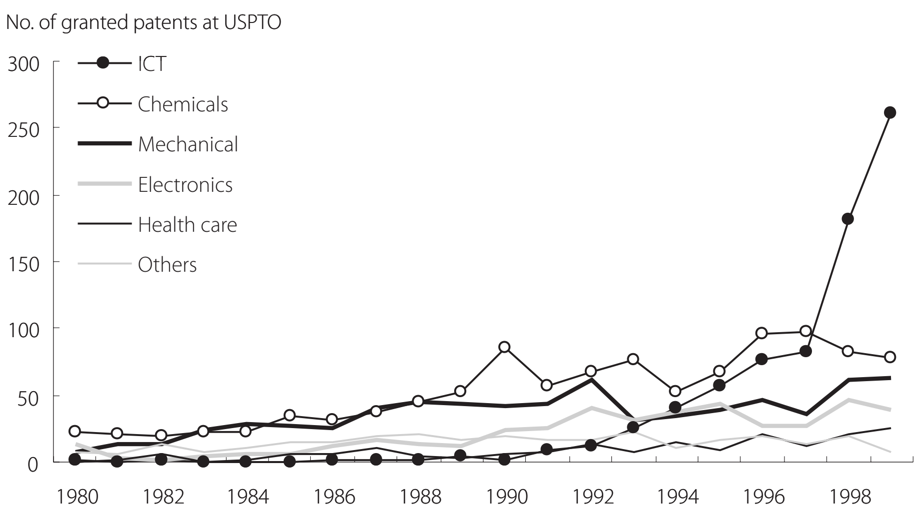
The overall growth in the number of patents of these multinationals is visible especially in the fields of ICT and chemicals. The accelerating patenting since the mid 1990s in ICT is mainly due to Nokia as the dominating innovator in this field in Finland. In other respects, the distribution of patents 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 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 3.1. A short description of the Finnish multinationals is in the appendix.

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

Figure 3.1 Number of granted patents of Finnish multinationals by main technology categories



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 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 interme-

Table 3.1 Number of granted patents of Finnish multinationals by main technology categories

	Number of granted patents at the USPTO 1980–1999						
	Total	Chemicals	ICT	Health care	Electronics	Mechanical	Others
Nokia	1 050	30	728	2	211	48	31
Stora Enso	47	24			6	7	10
UPM	5	3				1	1
Sonera	6		6				
Metsäliitto	23	6				11	6
Kone	205	7	7	3	39	146	3
Metso	770	444	8		29	248	41
Wärtsilä	194	28		7	8	79	72
Kemira	73	54	1	8	1	6	3
Orion	154	27		99	15	11	2
Neste/Fortum	157	123			9	13	12
Ahlstrom	379	234	1		15	59	71
Instrumentarium	131	6	1	54	61	6	3
Raisio	10	6		2		2	
Outokumpu	225	79	2	2	19	95	28
Rautaruukki	16		3		5	6	3
Amer	6		2				4
Huhtamäki	11	3		2			6
Total	3 462	1 074	758	179	418	738	295

diate 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.

3.2 DEVELOPMENTS ACROSS ALL FIRMS

Size and international composition of inventor teams

Since each of the 3 462 patents that we analyse in this paper involves one or more inventor, there are also 3 462 inventor teams. Altogether these patents conceal 7 147 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 3.2.

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 3.3.

Table 3.2 The size distributions of inventor teams of Finnish multinationals

	Size of inventor teams			
	Mean	Std. Dev.	Max	No. 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	1 676
Total	2.06	1.49	12	3 462

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 3.3 The international composition of inventor teams of Finnish multinationals

	Total	Distribution of inventors by country of location 1980–1984	1985–1989	1990–1994	1995–1999
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	6 005	542	964	1 646	2 853
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	7 147	558	1 080	1 961	3 548

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 3.4). 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 2.1 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).

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.

Table 3.4 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	1 676
Total	82.64	17.36	100	3 462

* Affiliation of first inventor.

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 3.5.

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 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 in section 2.1.

Table 3.5 The measure of originality of domestic and foreign patents of Finnish multinationals

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

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

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 3.6.

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

Table 3.6 The size distribution of inventor teams of Finnish multinationals

	Size of inventor teams							
	Total	Chemicals	ICT	Health care	Electronics	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
	3 462	1 074	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
	1 676	423	658	88	183	247	77	N

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 electronics 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 3.7 across the 5 most important locations of inventors of Finnish multinationals.

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

Table 3.7 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	Electronics	Mechanical	Others
Total	Finland	6 005	2 084	1 167	505	553	1 271	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	7 147	2 476	1 414	549	707	1 458	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	1 080	401	12	82	102	319	164
1990–1994	Finland	1 646	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	1 961	793	144	177	262	433	152
1995–1999	Finland	2 853	835	1 022	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	3 548	1 050	1 256	267	302	527	146

Note: ROW = The rest of the world.

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 health care 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 3.8 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, 2005). Apart from ICT, only the fields of electronics 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.

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 electronics 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.

Table 3.8 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	Electronics	Mechanical	Others
1980–1984	3.60	0.00	0.00	9.10	6.30	5.40	6.70
1985–1989	13.50	11.80	0.00	3.30	8.50	12.00	28.40
1990–1994	17.40	17.40	11.10	6.00	27.50	15.30	17.60
1995–1999	20.90	18.90	21.60	17.00	26.80	15.40	33.80
Total	17.40	15.20	20.10	11.20	23.70	13.30	23.40

* Affiliation of first inventor is foreign.

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 3.9 that presents the mean originality score across technology fields.

According to the table, we can confirm that the 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,

Table 3.9 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.

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. The level would be even lower if Nokia would be excluded from the analyses. 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 and France, and it is slightly higher when compared with multinationals from Germany.

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 produce patents at their foreign locations points to the importance 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.

APPENDIX

THE FIRM SAMPLE

Table A1 Description of sample firms

Company	Industry	Net sales, mill. euros	Assets, mill. euros	Employees
Nokia	Electronics & electrical engineering	30 016	23 327	52 700
Stora Enso	Paper-making	12 783	18 214	43 900
Fortum	Energy	11 148	17 961	14 100
UPM-Kymmene	Paper-making	10 475	15 375	36 900
Metsäliitto	Paper-making	8 868	8 876	31 000
Outokumpu	Metals & mechanical engineering	5 558	6 327	20 200
Metso	Metals & mechanical engineering	4 691	4 399	29 300
Kone	Metals & mechanical engineering	4 342	4 160	29 400
Rautaruukki	Metals & mechanical engineering	2 884	2 561	13 300
Kemira	Chemicals	2 612	2 491	10 400
Wärtsilä	Metals & mechanical engineering	2 519	2 685	12 400
Sonera	Telecommunications	2 241	5 179	8 170
Huhtamäki	Manuf. of packaging products	2 239	2 466	16 300
Ahlstrom	Metals & mechanical engineering	1 778	1 602	6 760
Orion	Chemicals	1 629	1 410	5 620
Instrumentarium	Manuf. of health care equipment	1 127	1 107	5 650
Amer	Manuf. of sports equipment	1 102	1 008	3 830
Raisio	Chemicals, foodstuffs	843	749	2 650

Note: Financial data are from 2002.

FOOTNOTES

[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)).

[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.

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

REFERENCES

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

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

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

Freeman, Christopher & 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 & 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 & Hayashi, Takabumi (eds.) *Internationalization of Research and Development and the Emergence of Global R&D Networks*. Amsterdam: Elsevier JAI.

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

Jaffe, Adam & 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 & 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 & Ylä-Anttila, Pekka (eds.) *Finnish Multinational Enterprises in the Finnish System of Innovation*. ETLA B-series.

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

Narula, Rajneesh & 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 & 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 & Martikainen, Olli. 2005. The GSM standard and Nokia as an incubating entrant. *Innovation: Management, Policy & Practice*, vol. 7, No. 1, 61-78.

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

Pearce, Robert. 1989. The Internationalisation of Research and Development by Multinational Enterprises. Hampshire: The Macmillan Press Ltd.

Serapio, M. & Hayashi, T. 2004. *Internationalization of research and development and the emergence of global R&D networks.* Amsterdam: Elsevier, Research in International Business vol.8.

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.

LOCATIONAL ADVANTAGES IN R&D – Insights from large Finnish firms

Ali-Yrkkö, Jyrki and **Palmberg**, Christopher. **LOCATIONAL ADVANTAGES IN R&D – INSIGHTS FROM LARGE FINNISH FIRMS**
ABSTRACT: This paper focuses on the locational advantages for R&D activities. It is based on in-depth interviews of the Chief Technology Officer (CTOs) of large Finnish firms. According to the results proximity to customers, the availability and skills of engineers are especially important locational advantages in this context. Nonetheless, firms base their locational choices on a combination of both demand and supply factors, where various intermediating factors relating to the broader institutional setting for R&D also are important. Finnish current strengths include the availability of highly skilled engineers at relatively low costs, straight-forward co-operation especially with the university sector, and social capital. Nonetheless, it is inevitable that the growth in overseas sales and production also increasingly will pull R&D, especially of the applicative kind, abroad. Even though cost differentials in R&D are not of primary concerns in the locational decisions of firms, it is probable that their importance will increase especially in the ICT industry as many Asian and Eastern European countries now provide advanced low-cost R&D environments. Finally concern can be raised about the sustainability of social capital in tightening IPR competition.

KEY WORDS: globalization, R&D, locational advantages, large firm

Ali-Yrkkö, Jyrki ja **Palmberg**, Christopher. **T&K-TOIMINNAN SIJAINTITEKIJÄT – SUOMALAISTEN SUURYRITYSTEN NÄKEMYKSIÄ**
TIIVISTELMÄ: Tutkimuksessa selvitetään yritysten tutkimus- ja tuotekehitysyksiköiden sijaintipäätöksiin vaikuttavia tekijöitä. Aineistolähteenä on suurimpien suomalaisyritysten teknologiajohtajien haastattelut. Tulosten mukaan keskeiset t&k-yksiköiden sijaintiin vaikuttavat tekijät ovat asiakkaiden läheisyys, osaavan työvoiman saatavuus sekä tämän työvoiman teknologinen osaamistaso. T&k-yksiköiden sijaintiin vaikuttavat siis sekä kysyntäpuolen että tarjontapuolen tekijät, mutta myös erilaiset välittävät tekijät kuten toimintatavat eri maissa ja yrityksen historia. Lisäksi tutkimuksessa tarkastellaan Suomen nykyistä ja tulevaa asemaa t&k-toiminnan sijaintipaikkana. Suomen etuja t&k-sijaintipaikkana ovat henkilöstön hyvä teknologinen osaaminen, suhteellisen alhaiset t&k-kustannukset muihin teollisuusmaihin verrattuna ja suoraviivainen yhteistyö yliopistojen ja yritysten välillä. Tästä huolimatta ulkomaanmyynnin ja -tuotannon kasvu tulee tulevaisuudessa kasvattamaan ulkomailla tehtävää t&k-toimintaa. Kustannustekijät eivät ole tärkeimpien tekijöiden joukossa sijaintipaikkapäätöksissä, mutta erityisesti ICT-alalla niiden merkitys tulee nousemaan. On todennäköistä että ICT-alan t&k-toiminta erityisesti tietyissä Aasian maissa sekä Itäisen Keski-Euroopan maissa tulee kasvamaan.

AVAINSANAT: globalisaatio, t&k, sijaintiedut, suuryritys

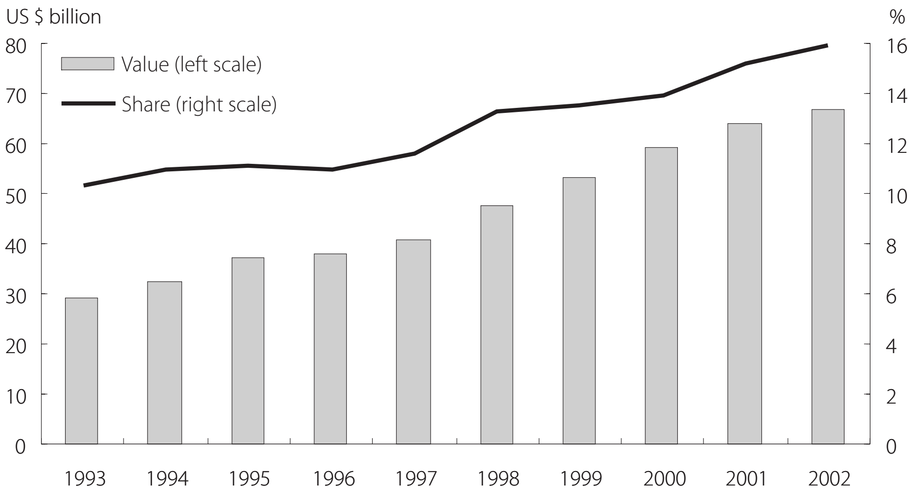
1 INTRODUCTION

1.1 BACKGROUND

The past years have witnessed a massive transfer of manufacturing activities from industrialised countries to developing countries. Particularly China has attracted production facilities from the US and Western Europe. However, current offshore activities are not limited to manufacturing operations alone. The empirical evidence indicates that technology-driven foreign direct investments also have increased (e.g. Jungmittag, Meyer-Krahmer & Reger 1999, Sheenan (2004)). Experience from Sweden suggests that particularly the largest companies tend to increase R&D abroad (ITPS 2005). Despite the fact that industrialized countries currently still are the main host locations of overseas R&D there is a clear trend towards locating more R&D to low-cost countries (ITPS 2005, DIHK 2005). This trend is also highlighted in a recent report by the European Commission stating that *"Europe is losing its attractiveness for international R&D investment" (EC, 2005, p. 4)*. It is also detectable in recent figures on R&D-related foreign direct investments on a global scale.

Finland is a geographically peripheral country at the Northern outskirts of Europe and hence faces compounded challenges in this context. Recent competitiveness indicators by IMD and WEF suggest that Finland is amongst the most competitive in the world. Nonetheless, there is evidence that the R&D activities of Finnish firms also, to an increasing extent, are dis-

Figure 1.1 The value and share of R&D by foreign affiliates[1]



Source: UNCTAD (2005).

persing globally (see e.g. Ali-Yrkkö et al. (2004), Palmberg and Pajarinen (2004)). This is in many ways a necessary development of technologically advanced firms in a small open economy. But especially in terms of industrial and innovation policy is does also raise the question whether the knowledge-oriented strategy that Finland has pursued so successfully in recent years can be propagated also during the coming years. This question is important not only from the viewpoint of retaining domestic R&D activities in Finland, but also for attracting foreign R&D.

The extant literature frames the discussion of the internationalization of R&D in terms of so-called locational advantages that firms identify and act upon as the disperse their R&D activities globally (Dunning and Narula, 2004). In Finland, only a few studies have analysed the internationalisation of R&D. The results by Koskinen (1999) suggest that (i.) giving support to local production and marketing and (ii.) getting closer contact with important market are the two major motives for overseas R&D. Despite that these demand-side factors appeared to be clearly more relevant than supply-side factors, the results indicated that bigger companies also located R&D units abroad in order to acquire and develop new technologies, products and processes. These results echoed in a study by Räsänen (1999) and Lovio (2004).

1.2 AIM AND STRUCTURE

The aim of this paper is to complement the extant research with qualitative analysis by approaching the issue at hand based on interviews of Chief Technology Officers (CTOs) of leading Finnish companies. In addition to analysing the factors affecting the location of existing R&D units, our data enables us to also consider the present and possible future strengths and weaknesses of Finland as a location for R&D activity. This overall aim of the paper can be concretizised further by the following key research questions that we address in this paper:

1. What kind of locational advantages/disadvantages do large Finnish firms identify and how do these contribute to the international dispersion of their R&D activities?
2. Which types of locational advantages/disadvantages are specific to Finland and to what degree do these explain why these firms retain some of their R&D in Finland now and possibly also in the future?

The paper proceeds as follows. In section 2 we describe the existing literature and present our conceptual framework. In section 3 we describe our data and present the results of our qualitative analysis. Section 4 summarizes the paper and presents conclusions.

2 A CONCEPTUAL FRAMEWORK

2.1 INTERNATIONALIZATION OF R&D ACTIVITIES

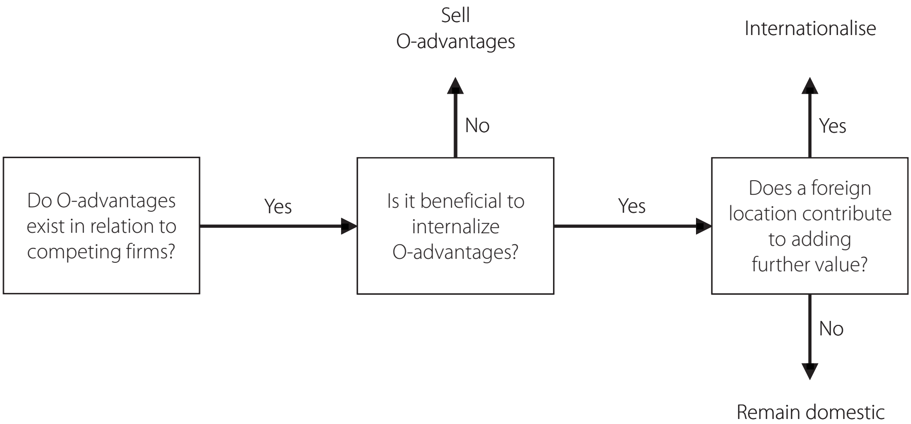
Interpretations for why firms internationalise their R&D activities have their origins in the field of international business theory. This field emerged out of a need to seek explanations for the significant proliferation of multinational firms as a parallel development to the growth in international trade. International business theory essentially seeks to explain why firms find incentives to internalize their activities across national borders through foreign direct investments (FDI) and become multinationals. It has thereby found natural ancestors in transaction costs economics and conventional trade theory, blended with resource and knowledge-based views on the firm. A seminal reference in this context is the so-called OLI-theory developed primarily by Dunning (1981, and 1997) (see also Lindström (2003)).

The OLI theory takes its departure in the notion of comparative advantages and a resource-based view of the firm, both of which underline the distinct competencies as the basis for competitiveness. Dunning (1997) refers to (i) ownership-specific (O) advantages in this context. These O-advantages usually take the form of intangible assets which are, at least for a certain period of time, under privileged possession by the firm in question. The nature of such assets might vary by firms and industries, but typically relate to in-house technologies which constitute the basis for the product and business orientation of firms.

Dunning (1997) suggests that internationalisation presupposes that firms also find it advantageous to further exploit or explore these O-advantages rather than to sell them. These advantages are called (ii) internalization (I) advantages. They reflect either greater in-house efficiency of the firm or a better ability to exercise monopoly power over its O-advantages. Finally, trade theory comes into the picture through his discussion on (iii) locational (L) advantages of firms. Locational advantages can range from the geographical distribution of natural and created resource endowments and markets, to some combination of input prices and qualities, or trade barriers, tax incentives, and institutional contexts which are shaped by industrial and innovation policies. These can give further leverage to the O- and I-advantages of firms, and thereby will affect the extent and content of the FDI of firms. The OLI-theory is summarized in figure 2.1.

As suggested the OLI-theory is a useful overall framework for interpreting the emergence and logic of multinationals, and the determinants of FDI more specifically. Recently it has also been modified to account for the noteworthy growth in the number of cross-border strategic alliances between firms through a discussion of relational (R) advantages that firms also might

Figure 2.1 A schematic presentation of the OLI-theory



build through collaboration (see e.g. Dunning (1997); Palmberg and Pajarinen (2005). Nonetheless, for the purpose of this paper some elaboration of the specific nature of locational advantages of firms is necessary, especially from the viewpoint of R&D activities.

2.2 LOCATIONAL ADVANTAGES IN R&D

Previous research on locational advantages in R&D activities is foremost based on empirical observations. The first studies in this field used aggregate data on the foreign content of R&D expenditures of various countries. Subsequently there has been a surge in studies that use patent data to trace broader discrepancies in the extent and nature of innovative activities carried out at the home base and host countries of multinational firms. More recently, survey data and case studies of particular multinationals have complemented these with more in-depth and qualitative analysis (see e.g. Niosi (1999)).

Even though previous research mainly is empirically oriented, the insights can also be framed in a broader theoretical context as done in table 2.1 in a highly stylized way. The table will also constitute the conceptual framework for interpreting our qualitative insights on locational advantages as perceived by large Finnish firms. It is discussed in greater detail below and will be elaborated upon further in the empirical section of this paper.

The earliest studies in the 1970s and 1980s tended to focus on *demand factors* and approached the internationalization of R&D through the product life cycle theory, originally developed by Vernon (1966) to explain international investment and trade patterns in the world economy. The product life cycle theory viewed overseas R&D as the outcome of the final phase of the life cycle of products when a firm sets up production abroad to exploit cost differ-

Table 2.1 Determinants of R&D-related FDI – theoretically flavoured insights

Demand factors
Adapting R&D, products and processes to local demand
Providing technological support to off-shore manufacturing plants
Supply factors
Monitoring scientific and technological developments
Obtaining access to scientists, engineers and designers
Generating entirely new products and core technologies
Intermediating factors
Facilitating the efficient coupling of demand and supply factors
Aligning activities with local cultures and norms

Source: Adapted from Patel and Vega (1999).

ences in the production of standardized products. Overseas R&D was hence viewed as a means for firms to transfer home-based technologies to foreign subsidiaries and to adapt products to foreign markets. R&D thus reacted to demand factors on the foreign markets that firms serve, both through the size and nature of this demand. Implicit in this logic is also the complementarities between R&D and production that a firm can benefit from at the foreign location due to agglomeration effects, or economics of scale and networking that can lower the cost of production.

Even though demand factors persistently have proved important for the locational decisions of the R&D of firms more evidence in the 1980s and 1990s showed that firms also increasingly develop new products at host locations through their globally dispersed R&D (see Research Policy Special Issue from 1999). Overseas R&D can thereby take on different roles in the overall strategy of firms, and these different roles will determine which type locational advantages that firms value the highest. This argument culminated in the work by Kuemmerle (1999) who found the size of the market and relative quality of the scientific and technology base of the host country determines the nature of overseas R&D. Overseas R&D of the exploitative type tended to locate according to the traditional demand factors. However, overseas R&D of the more explorative type that augments the knowledge base of the firm tended to locate according to *factors that enhanced the supply* of various inputs into R&D and innovation (see also Mariani (2002)).

The literature on such supply factors as locational advantages is rich and burgeoning. It basically argues that specific nations and regions might be particularly advantageous due to potential spillovers from existing and productive R&D organisations. Such organizations include research institutes, universities, and competitors. Additional dimensions that make a country or regions attractive as locations for overseas R&D are supporting industries or clusters, as well as regional or national industrial or innovation policies (see e.g. Cantwell (1989), Florida (1997)). The underlying logic here is that firms find locational advantages in the quality differences across countries and regions in these dimensions, and disperse their R&D globally to scan emerging technologies and new innovation opportunities. Nonetheless, cost differences across these dimensions will also matter, for example in terms of the labour costs of researchers and R&D engineers, available tax incentives or other types of public policy subsidies.

This dichotomization of determinants for overseas R&D into demand or supply factors is naturally quite simplistic. In reality firms will naturally base their decisions on a combination of multiple demand- and supply-related factors where various *intermediating factors* will also come into play. This viewpoint was raised as certain trends in overseas R&D emerged that pointed to the importance of 'softer' locational advantages related to common cultures and norms between firms and their host countries or regions. In particular, large firms in small open countries appeared to give greater weight to overseas R&D than firms based in larger countries. Firms might also favour culturally similar locations while hesitating to set-up overseas R&D in culturally highly dissimilar locations despite evident demand and supply factor advantages (Jones and Davis, 2000). They might also favour particular locations simply due to a path-dependant history of close collaboration at that location.

However, this viewpoint also emerged from changing theoretical perceptions of the nature of firms. An important reference in this context is Foss (1997). In particular, the so-called resource-based viewpoint of the firm increasingly relaxed the common assumption of knowledge as a public good and thereby invited for alternative interpretations for why firms exist in the first place. In the context of multinationals, firms are increasingly viewed as learning organizations that use overseas R&D to create and replicate new knowledge for their global expansion (see especially Kogut and Zander (1993, 2003)). Accordingly, locational advantages also increasingly include a multitude of issues that facilitate such learning and enable firms to efficiently couple demand and factors at their R&D locations. These intermediating factors are obviously trickier to identify and label. As already suggested they might relate to cultural and institutional issues embedded in the traits of different regions or countries.

3 DATA AND EMPIRICAL RESULTS

Our qualitative data is based on interviews of the of the 17 leading Finnish firms. Thus, our data is not the representative sample of the entire population of firms in Finland. However due to the significance of these firms in the Finnish innovation system, our data provides us an excellent view of private R&D activities of throughout Finnish industries.

In 2004, the sum of net sales of these firms exceeded EUR 85 billion employing more than 250 thousand persons. The firms invested EUR 4.4 billion totally in R&D, of which the share of domestic R&D activities was EUR 2 billion corresponding nearly 60 percent of the total private sector R&D in Finland. Furthermore in terms of overseas R&D, we estimate that the sample firms account for more than 90 percent of the total overseas R&D of Finnish firms.

The interviews were semi-structured based on a predefined framework, which sought to capture the overall organisation and internationalisation of R&D of the firms. In addition to the role of technology in mergers and alliances, special focus was given to motives of overseas R&D and locational decisions.

To interpret and summarise the qualitative data we used content analysis. Content analysis is commonly used in the social sciences to detect patterns in textual information and has also recently been elaborated upon in various software environments (Krippendorff, 2004). In this paper we go some

Table 3.1 Key figures of the interviewed firms in 2004

	Net sales (mill. eur)	Number of employees
Nokia	29 267	55 505
Vaisala	181	1 063
Tietoenator	1 525	12 773
Telia-Sonera Finland	2 024	6 427
Uponor	1073	4 475
Storaenso	12 396	45 307
UPM	9 820	33 433
Metso paper	3 976	8 660
Raisio	627	1 412
Huhtamäki	2 092	15 531
Ahlström	1 568	5 755
Suunto	77,2	530
Wärtsilä	2 478	6 378
Kone	5 532	33 021
Valtra	870	2 000
Fortum	11 665	13175
ABB Finland	1 365	6 388
Total	86 536	251 833

ways towards applying this methodology by identifying interpretations of locational advantages that are shared by a majority of the interviewees while downplaying diverging opinions. These shared interpretations constitute of the sub-headings in italics in the following section, and connections are made to the previous conceptual framework when appropriate.

3.1 PRESENT AND POSSIBLE FUTURE LOCATIONAL ADVANTAGES IN R&D

3.1.1 DEMAND FACTORS

The proximity to customers

As the product life cycle suggests demand factors frequently emerge as locational advantages for R&D activities also in our data (Vernon, 1966, 1979). In other words, overseas R&D of the included Finnish firms mainly appears to be of the exploitative kind whereby firms transfer their technologies abroad through their foreign affiliates in response to specificities of demand in their various markets. This general observation might be a natural outcome of the rapid growth of R&D intensity of Finnish industries and of their high technological competitiveness especially in fields like ICT, electronics, engineering and forest-based products.

> "In other words, the majority of this product development takes place in close proximity to the customer, and is often part of the process of building the client's business activities together with the customer."

> "...the more applicative part of R&D – the part that is even slightly closer to applications – quite there is an advantages of locating it in closer proximity to leading customers."

> "The Chinese appreciate that one is present and that there is local content."

As the citations above indicate the interviewees stressed qualitative aspects of this demand, rather than the size of markets, and highlighted the importance of proximity to leading customers. This proximity improves the understanding of customer needs and qualifications. Local customers often demand incremental changes to products during innovation and geographical proximity helps to response to these needs, especially on culturally distinct foreign markets.

In some cases the proximity to customers might also be very important for the development of products of the more radical kind in terms of their novelty – this seems to be the case especially in the engineering industries. One interviewee highlighted the role of one of its overseas R&D unit as follows:

> "America plays an eyes-and-ears role."

As suggested above, the product life cycle model has been criticised for assuming excessively strong complementarities between R&D and production in the sense that overseas R&D is a natural outgrowth of overseas production. Our interviewees also highlighted this issue by providing snapshots into the differentiated nature of locational advantages depending on the type R&D that firms engage in. In general, it seems that R&D of the more applied type adheres to the logic of the product life cycle and follows production abroad. In cases of more basic, longer-term and explorative R&D other locational advantages come to play, as also shown by Mariani (2002). These relate to various supply side and intermediating factors discussed further below. However, the relationships between production and R&D would demand much closer analysis than has been possible in this paper.

Future perspectives

From a more futuristic perspective several interviewees also pointed out that the proximity of customers as a location determinant will become more important. Almost all our sample companies are going to expand further their overseas sales. This will undoubtedly also imply that firms continue to disperse their manufacturing globally closer to emerging and rapidly growing markets. This might thus also increasingly relocate R&D away from Finland. Some firms did acknowledge this, especially in the case of R&D of the more applicative kind where there are strong complementarities between R&D and production.

> "...in terms of logistics, it wouldn't be sensible to have just one large European plant; instead, we should be spread out across different parts of Europe in order to contain transportation costs and ensure close proximity to the customer, which means that even in terms of product development we have to position ourselves close to the customer up to a certain extent."

> "With respect to [our products] which we manufacture in a sterile facility, it is crucial that R&D takes place near the production plant."

The importance of proximity to customers in applied R&D raises some important questions related to evolution of industrial clusters in Finland in a broader context. There are many examples of Finnish technological strengths and successful firms that have evolved out of close user-producer relationships between suppliers of components and systems integrators developing larger product systems, especially in ICT and engineering (see e.g. Hernesniemi et al. (1995)). As these system integrators now also are becoming highly internationalised and partly relocate their activities, supplier firms might also be forced to follow suit.

> "The amount of we have do in Finland certainly depends on how many demanding large customers we have in these regions."

> "Indeed, the advantage then is being close to leading customers. And, unfortunately, there are not many of those in Finland since our main activity is not geared towards Finland's leading companies...an increasing amount of our development activity is also shifting closer to our large customers."

This also raises the question what kind of R&D activities can be viable supported in a small open developed country like Finland in the future. It would be very important in future research to consider what type of R&D is strongly complementary to production, and how sensitive different types of R&D is to the relocation of manufacturing at the firm and industry level. Further, it should also be noted that even though R&D in close proximity to customers helps firms to understand user needs and the nature of demand, it might also provide disadvantages. Sometimes established customers on the home market might be overly focused on price aspects while not identifying new opportunities to innovate.

> "Well, sure, innovativeness inevitably suffers [if we listen to our customers too much]. On the other hand...in order to be truly innovative, you should have pretty good knowledge of the industry the customer operates in."

3.1.2 SUPPLY FACTORS

Technological knowledge and the availability of skilled labour

In the case of R&D of the more basic, longer-term and explorative type technological knowledge becomes an important locational advantage. Technological knowledge takes many forms in specific geographical contexts. Based on the interviews, two interrelated factors appear as especially important. The first relates to the availability of skilled scientists, researchers and engineers. The second concerns expertise that has accumulated in certain technological areas that firms draw upon in their R&D and innovation activities, often in collaboration with other firms, universities or research organisations.

> "...a certain amount of know-how and its development is certainly available in the field of environmental protection. But then there are certain sub-fields where, in my opinion, there nonetheless is little expertise in Finland even though we tend to believe otherwise."

> "The main goal is to exploit the expertise that exists there."

> "Being Finnish is an advantage, that is, an advantage with respect to expertise. We can easily obtain high-quality know-how from Finland."

> "Engineering education in Finland is strong, in that the average engineer, hired in most any market, is pretty good."

The availability of skilled scientists, researchers and engineers was considered an important locational advantage for R&D by a majority of all firms. The interviewees partly referred to general skill levels of graduates as these often receive on the job training and education once they become employed at the firms. However, the interviewees also stressed the importance of specialised skills in particular technology fields.

From an educational policy viewpoint these differentiated needs imply a trade-off between educating generalists and highly specialised graduates that can be particularly challenging to master in a small country with limited resources such as Finland. However, specialised expertise in particular technology fields also accumulates at universities and research organisations. Technological knowledge tends to cluster in certain locations due to spillovers and externalities between firms, universities and research organisations and the interviews highlights the importance of such clustering as a locational advantages. This is clearly in line with extant research such as Cantwell (1989) and Florida (1997).

The proximity of universities and research institutes

The results by Mariani (2002) indicate that R&D labs often locate close to high education institutions such as universities and research organisations. This general insight also hold true in the case of the firms included in this study. The proximity of high education units increases the likelihood that R&D units of companies are established at a particular location. In addition the interviewees stressed the importance of the overall functioning of the R&D systems of which universities and research organisations are part of. The interviewees also relate the functioning of the R&D system to innovation policy practices and highlight positive aspects of Finland in this context.

> "Indeed, it's true that it is easy to collaborate with others here [in Finland], for example with research institutes and universities. These relations are good."

> "In Finland, we're more used to using local firms, universities, schools of higher education, research institutes, and traditions; we know where to get what we need, and we certainly have tried to do the same in Germany and to some extent in America, though this has definitely remained limited."

> "There is a good college and university department there [the location where the company in question has established an R&D facility]."

> "Well, obviously, our channels to these research institutes, which can be used to complement our level of know-how, has a bearing in and of itself."

The role of universities is two-fold. On the one hand, due to the proximity of universities a large pool of skilled labour (i.e., graduated students) is often available. On the other hand, companies may locate their R&D labs close to universities because companies want co-operate with them. Moreover, the proximity of universities and research organisations has probably attracted other companies too. Locating a R&D unit in an area where other similar types of firms or suppliers/customers are in close proximity, offer a good potential for informational or knowledge spillovers. These spillovers are sometimes perceived as more important than concrete research results applicable to certain products, a requirement that university groups not always can live up to.

As the citations also suggest, the experiences of our sample firms related to co-operation with Finnish technical universities are mostly positive. The straight-forward and transparent relationships between industry and the university sector is highlighted as an especial strength of Finland and public technology programs are considered as a good means to facilitate these relationships – this observation is in line with previous studies on university-industry collaboration in Finland (see e.g. Ali-Yrkkö and Hermans (2003)).

> "These national programs have been great. They have been used to build a base which produces many good outcomes."

> "We have participated in EU projects and are increasingly aiming towards Tekes projects. EU projects are totally chaotic. None of us is inclined to participate in them again. They're starting to be a waste of time."

More critique was expressed towards the business schools in Finland. Companies co-operate with these schools to a lesser degree. It is remarkable that a number of companies highlighted the importance of managerial and marketing skills as complements to technical knowledge even though they do not actively seek collaboration with the business schools.

> "There are certainly many opportunities in that area [business know-how]. What is perhaps concerning in that is that the business schools appear to be on the sidelines in this respect. They're not involved in economic development. Maybe it's a problem related to business know-how. That is, if on the technical side this collaboration thing and data transfer are good, then business schools work on their own detached academic stuff."

> "We've got to quit thinking that the engineers make the innovations. They don't make them, they just make technical inventions. [...] Then there's the marketing side, which I certainly see as perhaps being the weakest aspect based on my personal experience. Of course, there is some competence in that area, but we're not present there, those innovations do not come from marketing. When all is said and done, the innovations should come from there, and the engineer should then just produce them."

Critique was also expressed towards the Technical Research Centre of Finland (VTT). By and large the interviewees expressed their acknowledgement of the applied nature of R&D projects that they had been involved together with VTT. Nonetheless, sometimes they expressed concern about the competitive position of VTT especially vis-à-vis universities. One concern related to the price level of R&D services, especially in situations where the same project could have been undertaken in collaboration with research groups at the universities in Finland or abroad.

> "VTT is extremely expensive. It is just hopelessly expensive,...we would rather do the work ourselves or collaborate with a university department."

Cost differentials in R&D

Since the global recession in the early 21st century, numerous multinationals have established R&D units in low-cost countries such as in India[2]. At least in principal, by transferring R&D activities from high cost countries to low cost countries companies are able to increase their R&D inputs without increasing the amount of R&D expenditure. This leverage effect typically arises due to labour-cost differentials between countries, or the salary scientists, researchers and engineers receive.

Even though offshoring R&D to low-cost countries offer potential cost advantages our empirical evidence suggests that the role of such advantages is significantly smaller for R&D activities compared with manufacturing activities. One explanation for this is that cost-differentials in R&D between Finland and other industrialised countries are relatively small. Further, qualitative differences also matter relatively more in R&D in terms of the efficiency and quality of the outputs that scientists, researchers and engineers produce.

> "If we think about England, Germany or Finland or even France, America and Australia, then they all play in the same class."

> "The problem Indians have is that, somehow, their execution is slow; indeed, they know everything, it's unbelievable how much knowledge they have; those guys have read each and every book in the field...but they don't know how to use that information, at least not yet."

> "Costs in Finland are half those in America and much lower than in Germany and England."

> "The USA and Germany certainly are expensive places, but more important in my opinion is that we focus on doing things right instead of merely getting it at a cheap price."

> "In that case, we should place someone there [in the low-cost country] who constantly monitors the situation to ensure that the project advances in the direction that benefits us here. This is, in my opinion, the problem. We should always make sure that the results we receive are brought rapidly to the product manufacturing stage."

Nonetheless, the global division of labour in R&D is changing rapidly in the sense that low-cost countries now also are emerging as high-skilled countries. Due to this trend leading developing countries such as China, India and some Eastern European countries have become potential locations also for R&D activities of firms from the industrialised countries. It seems that particularly in the ICT sector, the lower labour cost level of R&D attracts companies to establish R&D units in such countries. These lower costs might also relate to an active industrial policy that subsidizes R&D offshoring through tax benefits.

> "It is only a fourth of Finnish costs. In other words, there is a very significant difference."

> "Finnish suppliers are pretty good. But then again, the Indians are really good. That's certainly where their strength is; of course with a cheap workforce a little extra can also be done."

> "For example, the city of Singapore would finance 50 percent of the company's research for many years ahead, if we were to shift operations there. Wages would also be half of those here."

Future perspectives

Even though cost diffenrentials across countries in R&D activities has not been among the most important locational advantages, particularly in the ICT sector the cost factor will increase its importance in the future. The digital infrastructure combined with the availability of skilled labour in developing countries enables companies to transfer particularly programming and coding rapidly from one country to another. One interviewee presented it as follows:

> "Work [R&D] that that supports the knowledge economy can be done anywhere, though not just anywhere."

Some interviewees also highlighted the importance of moving from mastery in specific technology fields towards over-reaching systemic knowledge to creatively connect and integrate various technologies. This relates to an acknowledgement that instead of single products or components, companies' long-run performance increasingly depends on their tacit ability to combine and synthesise components to larger coherent wholes. To produce increasingly complex products, companies should be able to link the diverse knowledge of suppliers, producers and users in different locations.

> "The question is not about whether we know how to manufacture a handy small box, but rather about system delivery as a whole. This could provide an opportunity. This exists in Finland, and if we were proficient in this area it could be a way to push Finland forward."

> "Leading the way in system know-how and general architecture know-how is, perhaps, an area where we still have possibilities. It seems like far-off countries have much longer workdays, much longer than in Finland, and people with strong educations. But it still seems like the one thing that should be done, developing visions for where this world is heading towards, might be something that we have better preconditions to understand compared to competitors."

> "We nevertheless need strong national competence, so that we can benefit from international expertise. Taking a Finnish perspective, not everything should be done through international collaboration. If the others are at a different level, then we aren't a partner in the discussions. We should have a certain type of strong expertise, which would allow international networks to lift us up even higher. We should have something to give. This is a sort of trade. He who gives also receives."

Some interviewees also expressed a need to identify public means to explicitly orchestrate the building of such knowledge related to complex systems e.g. through public-private partnerships, task forces or think-tank ventures. This type of orchestration could prove particularly important for overcoming technological disruptions when new technologies emerge with the potential to seriously challenge existing knowledge bases and business practices.

> "In my opinion, taking a mega-jump should be considered, that is, putting together critical research groups comprising 10–30 people, half perhaps from industry and the other half from research institutes. Their task would be to look far ahead, not three years ahead, but more like 5–10 years ahead."

> "...It would be extremely important to have a kind of network within the firm, supported by partners, the government and all parties, to help understand the market opportunities that are opening up in the world. Technology is, of course, pretty nice, if you're a technology firm, but of course it doesn't suffice. Rather, you need those antennae in order to understand what you need and where."

3.1.3 INTERMEDIATING FACTORS

Norms and the broader cultural context

As both the extant literature and the citations referred to above suggest, there are various intermediating factors that contribute to the locational advantages of firms by mediating between demand and supply factors. Such intermediating factors might, for example, determine the efficiency of R&D activity when various other demand and supply factors are discounted. Often firms make their locational decisions based on multiple factors and sometimes such intermediating factors might be imperative towards the final decision. Again it seems that Finland provides certain locational advantages in this context that relate to norms and the broader cultural context. This observation is in line with extant research on the importance of national cultural as a factor behind the locational decisions of firms in R&D (see e.g. Jones and Davis (2000)).

> "Finns always have a certain kind of pragmatism. This becomes apparent in our EU-related activity as well as within our organization."

> "This can be seen in all activities – there is a "just do it" mentality in Finland in that when something is broken you fix it."

> "Finland is fairly competitive, but the competitiveness is based on a certain kind of conscientiousness and desire to do things right. This helps us maintain our good position in terms of competitiveness."

> "One thing at least that should be preserved is the creation of Finnish clubs in Tekes programs, so that Finnish networking takes place [...], it is so straightforward and, at least at the start, less scamming occurs in Finland."

The interviewees emphasised the importance a pragmatic approach to problem solving, a characteristic of Finnish engineering that appears to be quite specific when compared with other countries. Various reasons were proposed to explain this. Some attributed it to the exceptionally severe recession in the early 1990s that enforced such pragmatism upon decision makers in firms. Others suggested that it is a deeper characteristic of Finns that has emerged out of the hardships of historical developments since the 19th century. Reference could also be made to the concept 'social capital', or the strengths of inter-firm networks of trust as well as a homogenous population. (Ruuskanen, 2001).

Managerial path-dependency

The majority of the existing literature focusing on the location of R&D units ignores company's history as a locational advantage. The current location of units and sites has often been born as a combination of greenfield operations and acquisitions. In many cases, development groups or departments have originally located inside manufacturing units and over the years these groups have expanded and become R&D units. Developments such as these have also been quite common in the case of the Finnish firms included in this analysis. They point to the importance also of path-dependency phenomena as an intermediating factor in the locational decisions of firms. Sometimes disadvantageous demand and supply factors for R&D activities might be compensated by the advantages of not relocating them due to past locational or other managerial decisions.

> "...we have the facilities here in Finland, sterile facilities and their required machinery and equipment, to enable us to produce everything here. Longer-term goals are made in close proximity to the headquarters and managers of the business divisions. These are related to strategic goals and longer-term development projects, which are harder to delegate to a manager at a small subsidiary abroad."

> "A strength with regard to Finland is that we started here and have operated here for a long time. It is hereditary."

> "A kind of historical accumulation has occurred in our know-how, which has built up over the span of decades; it is difficult to transfer that sort of thing."

Past locational decisions mostly appear to relate to the accumulation of tacit knowledge at particular geographical sites that is difficult to relocate in practice. This type of knowledge is typically also embedded in laboratory facilities and local patterns of co-operation, both within the firms and with external partners. In addition to tacit knowledge, past R&D investment decisions determine the current location of the R&D activities of the firms. In some industries R&D activities require large investments in laboratories or pilot factories. A relocation of these units would also cause high costs which might outweigh favourable demand and supply factors of other locations, even in a longer-term perspective.

Future perspectives

The global operation mode of companies has raised new challenges concerning human resources. One of these challenges relates to the movement of employees between units around the globe. This issue was also highlighted in our study. A number of interviewees pointed out that it is difficult to get foreign employees to move to Finland.

> “Certainly, it is important that we attract foreign stars to Finland, and that we examine all possible functions and activities. Of course, we should also ensure that we have Finnish staff who have strong experience working abroad, enabling them to operate in certain cultural settings, and who preferably have contacts abroad.”

> “We would have liked to see more worker mobility. ...people have different family and other ties which limit their mobility.”

> “The problem lies in trying to recruit someone to Finland. Foreigners don’t come here, they don’t come here for tax reasons, it’s so simple, and then there’s the language barrier.”

Practically all interviewees agreed that the role of IPRs (Intellectual Property Rights) is increasing. Due to the global operation mode, companies increasingly protect their intellectual capital by patents, copyrights and trademarks. It seems that these multinational companies increasingly apply the same IPR policy in Finland as abroad. Traditionally, in Finland co-operation has been based more on trust than on written agreements. But now the Anglo-Saxon practices with detailed contracts and tight IPR terms are rapidly becoming common also in Finland. Although concerns about these kinds of issues should not be taken too far, some interviewees did acknowledge that social capital in the inter-firm relationships between Finnish firms is eroding as a result.

4 A CONCLUDING DISCUSSION

This study focused on the motives of overseas R&D and on the location advantages related to R&D activities based on insights from large Finnish firms. Furthermore, we also examined advantages and disadvantages of Finland as a present and possible location for R&D activities. To analyse these issues we used qualitative data based on the interviews of CTOs of large Finnish firms. In 2004, these companies accounted for 60 percent of the total private R&D in Finland and more than 90 percent of the overseas R&D of Finnish firms.

The results of the study are three-fold. *First*, it is clear on a general level that firms base their locational decisions about R&D activities on a combination of different demand and supply factors. This paper has also highlighted the importance of what we call intermediating factors, which might be very important in determining the efficiency of R&D activities when the various other demand and supply factors are discounted. The major factors determining the location of R&D units are the proximity of customers, technological knowledge and the availability of skilled labour. Locating R&D unit close to customers may help to improve the understanding of customer needs. Usually, these units are more exploitative meaning that they transfer technologies from the home country in order to response the nature of demand of customers in various markets. On the other hand, the availability of skilled labor with technological knowledge are particularly important location factors in R&D units focused on augmenting or developing new knowledge, technologies, products and processes for the entire corporation. Important intermediating factors are norms and the broader cultural context, as well as managerial path-dependency relating to the locational history of firms and the 'stickeness' of tacit knowledge.

Second, our results give specific and policy-relevant insights into the advantages of Finland as a location for R&D activities. The advantages primarily related to supply and intermediating factors while the limited size of the home market sets natural limits to the importance of demand factors. In particular, our evidence indicates that technological knowledge and the availability of skilled and relatively low-cost R&D engineers seem to be strengths in Finland. Another advantage of Finland is related to co-operation with universities and research organisations. This co-operation appears to be easier and less bureaucratic in Finland compared to many other countries. Further, norms and the broader cultural context contribute to a certain degree of pragmatism in R&D as well as trust and social capital which together enhance the efficiency of R&D activities. Sometimes Finland is also favoured as a location simply due to path-dependency in managerial decisions of firms.

Third, Finland also faces challenges in the future due to present and emerging locational disadvantages in global competition. One such challenge relates to the fact that our sample firms evidently will expand further their overseas sales as a natural response to globalisation. This will undoubtedly also imply that firms will continue to disperse their manufacturing globally closer to markets. In so far as there are complementarities between R&D and manufacturing, this will also 'pull' R&D along to global sites irrespective of favourable demand, supply or intermediating locational advantages. The connection between R&D and production in the context of the internationalisation of R&D is clearly an issue that would require additional research. Further, even though cost differentials – especially amongst industrialized countries – do not appear to be the most important locational advantages in R&D, it seems clear that the cost factor will grow in importance especially in the ICT industry. This trend is also clear due to the technological upgrading of developing countries in Asia (foremost China and India) and Eastern Europe that increasingly provide low-cost environments for advanced R&D.

Finally, concern can be raise about the adverse effects on social capital in the inter-firms relationships of Finnish firms of the increasingly tough stance that large foreign multinationals especially from Anglo-Saxian countries take on IPR issues and the importance of written contracts.

FOOTNOTES

[1] Based on a sample of 30 economies.

[2] See e.g. Business Week, (December 8, 2003).

REFERENCES

Ali-Yrkkö, J., Hermans, R., Hyytinen, A., Lindström, M., Paija, L., Pajarinen, M. & Ylä-Anttila, P. 2004. Suomi ja Eurooppa kansainvälisessä työnjaossa – Analyysi toimialojen ja klustereiden kilpailukyvystä. Valtioneuvoston kanslian julkaisusarja, 20/2004, Helsinki: Valtioneuvoston kanslia.

Cantwell, J. 1989. Technological Innovation and Multinational Corporations. New York: Blackwell.

DIHK, 2005. R&D Offshoring: Examination of Germany's Attractiveness as a Place to Do Research. Deutsche Industrie- und Handelskammertag, Berlin, Germany.

Dunning, J. 1981. International production and the multinational enterprise. London: George Allen & Unwin.

Dunning, J. 1997. Alliance capitalism in international business and the world economy. London: Routledge.

Dunning, J. and Narula, R. 2004. Multinationals and Industrial Competitiveness – A New Agenda. Cornwall: Edward Elgar.

EC. 2005. Key figures 2005 on Science, Technology and Innovation. Towards a European Knowledge Area. European Commission.

Florida, R. 1997. The globalization of R&D: results of a survey of foreign-affiliated R&D laboratories in the USA. *Research Policy* 26, 85-103.

Foss, N. 1997. Resources, Firms and Strategies – A Reader in the Resource-based Perspective. Oxford: Oxford University Press.

ITPS. 2005. Forskning och Utveckling I Internationella Företag. S2005-005, Stockholm, Sweden.

Jones, G. & Davis, H. 2000. National culture and innovation: implications for locating global R&D operations. *Management International Review*, First Quarter, 40, 1, 11-39.

Lovio, R. 2004. Internationalization of R&D activities of Finnish corporations – Recent facts and management and policy issues. In Ali-Yrkkö et al. (eds.) Multinational Enterprises in the Finnish Innovation System. Helsinki: Taloustieto Oy.

Kogut, B. & Zander, U. 1993. Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of international Business Studies* 24: 625-645.

Kogut, B. & Zander, U. 2003. A memoir and reflection: knowledge and an evolutionary theory of the multinational firm 10 years later. *Journal of International Business Studies* 34: 505-515.

Koskinen, J. 1999. Internationalization of R&D in Finnish Firms. In Pajarinen, M. & Ylä-Anttila, P. (eds): *Cross-border R&D in a small country*, Helsinki: Taloustieto Oy.

Hernesniemi, H., Lammi, M. & Ylä-Anttila, P. 1995. *Kansallinen kilpailukyky ja teollinen tulevaisuus*, ETLA B:105, Helsinki: Taloustieto Oy.

Krippendorf, K. 2004. *Content Analysis: An Introduction to Its Methodology*. 2nd edition. Thousand Oaks CA: Sage.

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

Lindström, M. 2003. Locational sources of competitiveness: Finnish companies' international business operations in the Baltic Sea region. Helsinki: Taloustieto Oy.

Mariani, M. 2002. Next to production or technological clusters? The economics and management of R&D location. *Journal of Management and Governance* 6: 131-152.

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

Palmberg, C. & Pajarinen, M. 2004. The global dispersion of innovative activities – The case of Finnish multinationals. ETLA Discussion papers, No. 916.

Palmberg, C. & Pajarinen, M. 2005. Alliance capitalism and the internationalisation of Finnish firms. ETLA Discussion papers, No. 991.

Patel, P. & Vega, M. 1999. Patterns of internationalisation of corporate technology: location vs. home country advantages. *Research Policy* 28, 145-155.

Ruuskanen, P. 2001. Sosiaalinen pääoma – käsitteet, suuntaukset ja mekanismit. Helsinki: Valtion taloudellinen tutkimuskeskus, VATT-tutkimuksia 81.

Räsänen, V. 1999, Effects of Internationalization on R&D Processes. In Pajarinen, M. & Ylä-Anttila, P. (eds): *Cross-border R&D in a small country*, Helsinki: Taloustieto Oy.

Sheenan, J. 2004. Globalisation of R&D: An OECD Perspective. Presentation in GUIRR Meeting on Globalization, Competitiveness and Workforce. Washington, DC, 3-4 February 2004.

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

Vernon, R. 1979. The product life cycle hypothesis in a new international environment. *Oxford Bulletin of Economics and Statistics*, November, vol. 41, issue 4, 255-267.

UNCTAD. 2005. World Investment Report. Geneva: United Nations.

III

Collaborative R&D Through Strategic Alliances

ALLIANCE CAPITALISM AND THE INTERNATIONALISATION OF FINNISH FIRMS

Palmberg, Christopher and **Pajarinen**, Mika. **ALLIANCE CAPITALISM AND THE INTERNATIONALISATION OF FINNISH FIRMS**
ABSTRACT: The global surge in strategic alliances has led observers to coin the concept "alliance capitalism" and suggest that they amount to a new logic of international business organisation and strategy. From the viewpoint of Finland, as a small and open economy, these developments can have far-reaching implications for the internationalisation strategies of firms, industrial renewal and competitiveness. Extant research points to a high degree of internationalisation of Finnish firms as measured by high-tech exports, international patenting and FDI. Nonetheless, little is known about the extent, nature and challenges of their alliance activities. This paper applies international business theories to give new insights into the role that alliances play in the overall internationalisation of major Finnish firms, the main motives and challenges that firms perceive in this context. It uses a new database on strategic alliances and traces the broader developments and nature of the international alliances of these Finnish firms. This is complemented with in-depth interviews of R&D managers. The results point to a rapid increase especially in the number of explorative alliances of ICT firms, and suggest that Finland participates in "alliance capitalism" mainly as an explorer rather than exploiter of technologies. The main motives for forming alliances relate to risk and cost sharing and to complementary assets. Managerial and IPR issues provide the greatest challenges. The paper concludes with a discussion on implications for innovation policy.

KEYWORDS: strategic alliances, internationalisation, Finnish firms.

Palmberg, Christopher ja **Pajarinen**, Mika. **ALLIANSSIKAPITALISMI JA SUOMALAISTEN YRITYSTEN KANSAINVÄLISTYMINEN**
TIIVISTELMÄ: Kansainvälisten strategisten allianssien voimakkaan kasvun myötä on alettu puhumaan "allianssikapitalismista". Tällä viitataan yritysrajojen hämärtymiseen ja kansainvälisen verkostoitumisen lisääntymiseen myös yritysten strategisissa ydintoiminnoissa. Suomen kaltaisen pienen avotalouden kannalta nämä kehitystrendit tuovat uusia haasteita yritysten kansainvälistymisen, teollisuuden uudistumisen ja kilpailukyvyn näkökulmasta. Aiempi tutkimus on osoittanut, että varsinkin suomalaiset suuryritykset ovat kansainvälistyneet merkittävästi viime vuosina korkean teknologian viennin, kansainvälisen patentoinnin ja ulkomaisten suorien sijoitusten avulla. Selvästi vähemmän tiedetään kuitenkin suomalaisten suuryritysten kansainvälisen allianssitoiminnan laajuudesta, tunnuspiirteistä ja haasteista. Käsillä oleva tutkimus paneutuu näihin asioihin ja analysoi allianssitoiminnan taustamotiiveja ja haasteita kansainvälisen liiketoiminnan teorioita hyödyntäen. Tutkimuksessa nojaudutaan uuteen suomalaisten suuryritysten alliansseista koostuvaan tietokantaan sekä yritysten teknologiajohtajien haastatteluihin. Tulokset osoittavat, että suomalaisten yritysten kansainvälinen allianssitoiminta on kasvanut merkittävästi, varsinkin ICT-yritysten t&k-toiminnoissa. Yleisvaikutelma on, että Suomi osallistuu "allianssikapitalismiin" pikemmin teknologian kehittäjänä kun teknologian hyödyntäjänä. Riskien ja kustannusten jakaminen sekä allianssikumppaneiden toisiaan täydentävät osaamisalueet ovat tärkeitä taustamotiiveja; allianssitoiminnan hallinnoiminen sekä IPR-kysymykset koetaan puolestaan merkittävimmiksi haasteiksi. Lopuksi keskustellaan allianssitoiminnan vaikutuksista innovaatiopolitiikalle.

AVAINSANAT: strategiset allianssit, kansainvälistyminen, suomalaiset suuryritykset.

1 INTRODUCTION

Barely a day goes by without announcements of strategic alliances between firms. These strategic alliances range from bilateral to multilateral and complex constellations of alliances which typically are designed to exploit, or explore further, the in-house technologies of firms in various ways. They can be defined as formal collaborative agreements between firms, which are characterised by a longer-term commitment to reach a common strategic goal. Alliances thereby complement the in-house activities of firms, and often also extend to competitors. Defined in this way alliances delimitate a subset of inter-firm collaboration that excludes 'ordinary' buyer-seller or subcontracting relationships, unilateral licensing, franchising, and buyback arrangements where the partners often have opposing goals – i.e. the seller wants to sell expensively while the buyer wants to buy cheap (Glaister and Buckley, 1996).

The documented global surge in alliances, especially since the 1980s, has led analysts and researchers to coin the concept "alliance capitalism" to capture this development (Gerlach, 1992; Dunning, 1997; Dunning and Boyd, 2003). Alliance capitalism refers to the increasing interdependence of economic entities and the partial erosion of hierarchical control over value-added activities in favour of network-based collegial entrepreneurship. Dunning (1997) suggests that alliance capitalism is an integral part of ongoing globalisation and that it is reflected in intensified interdependences between shareholders, consumers, workers, firms and governments. Cross-border alliances are often portrayed as a means of firms to internationalise their activities in response to globalisation. They can contribute to the global presence of firms while possible negative liabilities of unilateral equity-based foreign direct investments (FDI) – as the traditional means of internationalisation – can be avoided (Narula and Zanfei, 2005).

This paper takes the viewpoint of interdependencies between firms and provides insights into alliance capitalism and internationalisation from the viewpoint of cross-border alliances of Finnish firms. The case of Finland is interesting since previous analysis points to a recent rapid internationalisation of firms as measured by high-technology exports, international patenting, and FDI (see e.g. Ali-Yrkkö et al., (2004); Palmberg and Pajarinen, (2004)). These measures capture the international extension and global dispersion of their in-house activities based on a unilateral commitment. Recently, Palmberg and Pajarinen (2005) have provided first quantitative insights into the extent and fundamental determinants in the involvement of Finnish firms in international alliances. This paper elaborates further on these first insights through a more extensive and in-depth analysis of the nature and challenges of international alliance activity of major Finnish firms. The overreaching aim of the paper can be broken down into the two following questions:

1. Which role do alliances play in the overall internationalisation of major Finnish firms, and what is the extent and nature of their alliances activities?
2. Which are the main motives of these firms to enter alliances and what kind of challenges do firms face in their alliance activities?

The paper is structured as follows. Section 2 provides general interpretations of the internationalisation of firms, suggests how "alliance capitalism" is affecting firms in this respect, and discusses the main motives for alliance formation. The empirical part of this paper relies on firm-level indicators on internationalisation, and on a combined analysis of a new database of alliances and firm-level interviews. Section 3 identifies internationalisation profiles of the firm sample, and analyses the trends and main features of their international alliances. Section 4 complements the statistical analysis with firm-level interviews to provide greater insights into the characteristics, motives, and challenges of alliances. Section 5 ends the paper with a summarising discussion and provides a couple of general policy implications.

2 THEORETICAL INTERPRETATIONS OF ALLIANCE CAPITALISM

2.1 ALLIANCES AND INTERNATIONALISATION

As suggested above "alliance capitalism" can be considered as a necessary reaction to the consequences of globalisation by providing a route for the internationalisation of firms. It therefore makes sense to briefly discuss general interpretations of the internationalisation of firms and consider more specifically how cross-border alliances contribute to this. A seminal reference is the OLI theory, developed by Dunning (1981, 1997) (see also Lindström (2003)). The OLI theory is an eclectic synthesis of transaction cost economics, resource-based theories of the firm, market failure and trade theory. It aspires to provide an overall framework for interpreting the rationale for multinational firms in general, and the determinants of their engagement in value-added international activities in particular. The OLI theory identifies certain fundamental dimensions in this context and suggests that a firm will internationalise its activities when the following three conditions apply (Dunning, 1997):

1. It possesses ownership-specific (O) advantages in the particular markets it serves. These O-advantages usually take the form of intangible assets which are, at least for a certain period of time, under privileged possession by the firm in question. The nature of such assets might vary, but typically relate to in-house technologies which constitute the basis for the product and business orientation of firms.
2. Assuming that this first condition applies, the second condition is that the firm itself also finds it beneficial to further exploit or explore these O-advantages rather than to sell them. They are called market internalization (I) advantages. They reflect either greater in-house efficiency of the firm, or a better ability to exercise monopoly power over its O-advantages.
3. If both conditions above apply, the firm has to find that a foreign location can add further value to its O-advantages. These advantages are called locational (L) advantages. They range from the geographical distribution of natural and created resource endowments and markets, to some combination of input prices and qualities (e.g. labour, materials/components, capital), or trade barriers, tax incentives, and institutional contexts which are shaped by industrial and innovation policies.

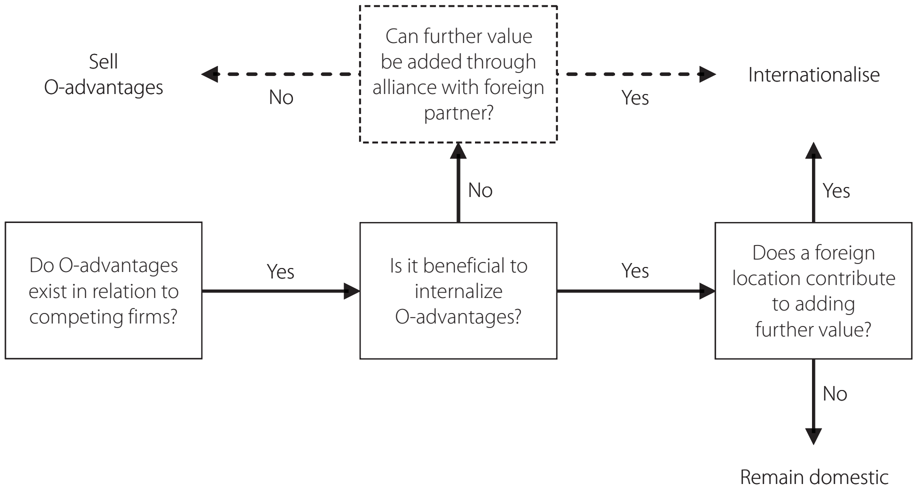
The predictions of the OLI theory are quite straightforward. At any given moment in time the greater O-advantages a particular firm conceives itself of having in comparison to competing firms, the larger the incentives it has to further exploit and explore their O-advantages on the markets, and the more a particular foreign location might add value to them, then the more likely this firm is to internationalise it's activities. Accordingly, the main crux of this theoretical framework is to highlight necessary (albeit not always sufficient) configurations of OLI advantages for internationalisation. While the OLI theory is a useful overall framework in this respect, it has been criticized in the details. In the context of this paper, the primary limitation is the focus on the internationalisation of in-house activities at the neglect of internationalisation through collaborative action, e.g. through alliances.

Dunning (1997) has offered considerations of how "alliance capitalism" affects the OLI configurations of firms and discusses how alliances contribute to their internationalisation. According to him the reasons behind the gradual emergence of "alliance capitalism" since the 1980s are to be found in the intertwined consequences of globalisation and rapid technological change. First, products are increasingly technologically complex and systemic as they often constitute a part of a broader product system (the ICT sector is a case in point). This raises R&D expenditures of developing new products and the related risks, while increasing the interdependencies between firms. Second, the significance of generic technologies, such as ICT, bio- and nanotechnologies, is increasing the need of firms to be present and coordinate their activities in various technological fields, some of which always will be outside the scope of their hierarchical control. Third, and perhaps most significantly, trade liberalisation and increasing competition on a global scale is shortening product life cycles and highlighting the importance for firms to monitor and be present on multiple geographical markets (Dunning, 1997; Narula and Zanfei, 2005).

As a consequence of these developments firms are, at least partly, forced to relinquish hierarchical control over their O-advantages through alliances, and abandon what Dunning calls "hierarchical capitalism". Alliances emerge as an alternative route towards internationalisation. They offer new avenues for firms to acquire and build on their O-advantages, albeit with lesser resources, liabilities and risks compared to what hierarchical capitalism would require. A theoretical distinction is also often made between vertical alliances that span the same value chain in which firms operate, and horizontal alliances that span different value chains and therefore often also involve competing firms. If this distinction is used, vertical alliance might be considered as a looser variant of internalisation even though the partners to an alliance remain formally separated (Nooteboom, 1999). For an illustration of the reappraisal of the OLI theory along these lines, see figure 2.1.

The reappraisal of the OLI theory leads to the insight that internalization and alliances are two alternative routes to internationalisation. However, it is not always clear how alliances can compensate for the advantages of internalization. Essentially, this is an empirical question which demands close analysis of the O-advantages of specific firms. In Dunning (2003) some empiri-

Figure 2.1 A reappraisal of the OLI theory in the face of alliance capitalism



cal guidance is given through introducing the concept of relational (R) advantages to capture the portfolio of alliances that firms are engaged in. These R-advantages can, for example, be measured by the number of repeated alliances with the same partners, by the density of alliance networks, or through assessments of the degree of trust amongst the partners. The implications are then that the greater R-advantages a firm possesses, the less likely a firm is to internalize their O-advantages across national borders through FDI and vice versa.

Some additional insights might also be gained through a reassessment of L-advantages of firms (compare with Dunning (1997)). In this context it would seem reasonable to assume that alliances add flexibility, and that the immobile assets of countries will not only affect the extent of internationalisation but also the way in which firms choose to approach foreign locations. Alliances enable firms to circumvent FDI, as their incentives to internalize value-added activities across borders diminish. But the opportunities for forming alliances with firms from a particular country might also increase inbound FDI due to spillovers and other types of externalities.

2.2 DETERMINANTS OF ALLIANCE FORMATION

The relevance of the OLI theory stems from its over-reaching scope in interpreting why firms internationalise their value-adding activities. It provides a framework for assessing the role of alliances in the overall internationalisation of firms. Nonetheless, it is clearly much too general to provide more detailed interpretations of why firms form alliances in specific circumstances, and what kind of challenges firms face in their alliance activities.

In the following we aim to synthesize the vast literature in the field of economics and managerial theories of the firm that discusses motives underlying alliance formation, especially in relation to exploiting or exploring the in-house technologies of firms. Our synthesis is summarized in table 2.1 below in terms of five broader and partly overlapping alliance motives, including references to their theoretical counterparts. The synthesis draws on Glaister and Buckley (1996), and Hagedoorn et al. (2000).

The *sharing of risks* is often considered one of the primary advantages of alliances over other means of internationalisation since neither partner thereby bears the full risks. Risk sharing might concern the direction and costs of R&D, the availability of component supplies during production, or market entry strategies. In these cases transaction cost economics is an important starting point (Williamson, 1985, 1999). Transaction cost economics considers how different attributes of transactions between firms relates to the way in which these transactions are optimally organized. If the transaction in question is subject to uncertainties, for example in the case of R&D, transaction costs will be higher and an alliance might be appropriate in so far as in-house internalization is deemed unviable for various other reasons (compare with Casciaro (2003)). However, alliances can also contribute to risk sharing by enabling technological, product and/or market diversification into uncertain areas (see especially Giuri et al. (2002) and the discussion therein).

In this context *cost reductions* is usually understood in terms of product rationalization and economies of scale, although risk sharing also reduce costs (i.e. the transaction cost framework). Product rationalization enables economies of scale as a firm specializes in the development of certain technologies and a fewer number of products. Alliances can cover agreements whereby competing firms identify their comparative advantages with respect to each other and decide to coordinate production accordingly, agree on preferential access to particular foreign locations or markets, or achieve a division of labour through specializing in particular components of larger systems. These motives are typical in production-intensive industries, while cost reduction

Table 2.1 Strategic motives underlying alliance formation and their theoretical counterparts

Strategic motive	Theoretical counterparts
Risk sharing	TCE
Cost reduction	TT, IO
Shortening innovation/entry times	IO
Pooling complementary assets	RBV
Influencing market structure and competition	IO

Note: TCE=Transaction cost economics, TT=Trade theory, IO=Industrial organization, RBV=Resource-based view of the firm.

through risk sharing is more common in R&D-intensive industries. Theoretical counterparts to these types of motivations are mainly found in mainstream economic trade theories, although explicit reference to alliances seldom is made (see Caloghirou et al. (2003)).

The motive of *shortening innovation/market entry times* finds backing in game-theoretic models of the variant where the timing of innovation or entry is emphasised (see Reinganum (1989) for a seminal contribution). Firms are modelled in the context of a technology race where the winner of this race, in terms of innovation/entry, earns a right to temporary monopolistic return. The analytical focus has been on determining the number of firms to enter the race, the aggregate R&D investment and its distribution across firms and time, as well as the effects of market power, technological advantage and uncertainty. Alliances enter the story by providing a shortcut to shorter innovation or entry times, for example through complementary assets (see discussion below) that collaborative partners can offer in terms of R&D inputs and access to foreign markets.

The importance of *complementary assets* for innovation is often taken as the main rationale for inter-firm collaboration. The exchange of complementary assets might be considered as another dimension of risk sharing, but it also underlines the strategic and bilateral nature of alliances. The discussion of complementary assets relates to the resource-based view of the firm, originally presented by Penrose (1959) and subsequently developed by various contributions from economics and organizational sciences. Teece (1986, 1992) defines complementary assets as assets external to an innovating firm which nonetheless are important for the commercialisation of innovations. They have to be utilized in conjunction with the in-house assets of the innovation firm, and might comprise of complementary components, technologies, access to retail or after sales chains etc. In high-tech industries alliances often facilitate the mutual transfer of technologies or patents and thereby also offer a means to manage IPR issues through cross-licensing agreements between firms (Grindley and Teece, 1997).

In the industrial organization literature alliances are often implicitly interpreted as a mean for firms to *influence the structure of industries and competition* in a broader sense. The theoretical starting point here is that the alliance propensity of firms is determined by the market structures and competitive set-up, and thereby also influences these dimensions of industries. The theoretical models are also cast in a game-theoretic framework in which the decision whether to collaborate with another firm through an alliance depends on cost reduction and production/innovation output considerations from a welfare maximization viewpoint. These types of issues are analysed under various assumptions of competition, and nature of alliances (see Caloghirou et al. (2003)).

In the 'real world' these insights might explain especially why firms opt for entry into larger constellations of alliances, and thereby aspire to tilt markets and competition in their favour. The ICT industry offers a good example of the advantages that firms might achieve through alliance membership. Many alliances constellations in the ICT industry are institutionalised as standard-development forums or associations designed to promote a particular technological standard, and thereby shape the future evolution of markets and the industry at large (the Symbian alliance for developing software for smart-phones is a good example of this) (Palmberg and Martikainen, 2006). Nonetheless, standard-setting alliance constellations are also quite common in other industries.

3 INTERNATIONALISATION PROFILES AND ALLIANCES OF MAJOR FINNISH FIRMS

3.1 THE FIRM SAMPLE

The sample included in the ensuing empirical analysis consists of 24 major Finnish firms. Inclusion to the sample was based on firm size and industry affiliation. Our point of departure was the most recent ranking list of the 500 largest Finnish firms produced by the business magazine Talouselämä. We limited ourselves to the ICT, chemical, forest-related, and metals & engineering industries as the most important ones to the Finnish economy, and selected 4–5 of the largest firms in each of these industries. Further, the sample was complemented with the three largest diversified multi-industry firms in Finland which could not easily be assigned to a particular industry.

Table 3.1 lists the firms included in the sample along with a few basic indicators to capture their size, overall degree of internationalization by the share of foreign employees and R&D intensity. Nokia stands out in the table with the largest number of employees and size of turnover, as well as in terms of technology-orientation through the highest R&D intensity. Beyond Nokia and the forest-related firms, the size distribution levels out somewhat with a few smaller firms from each industry. By and larger the firms are relatively internationalized with a mean share of foreign employees of 55 percent, although there are some extreme cases with shares over 80 percent (Dynea, Uponor, Huhtamäki, Amer and Kone). It should be noted that the sample also contains a few firms with shared nationality due to cross-border mergers and acquisitions, such as Novo, TeliaSonera, Tietoenator, and Instrumentarium. Instrumentarium is nowadays wholly foreign-owned, although its activities largely remain in Finland. It nonetheless has a strong Finnish history and is thereby included in the analysis.

As suggested previously this paper looks at alliances from the viewpoint of their exploitative or explorative role in the internationalisation of in-house technologies. With reference to the OLI theory our implicit assumption is thus that they possess technology-related O-advantages which they have various incentives to exploit or explore internationally, either through internalization and FDI or through various collaborative arrangements with foreign firms, of which the focus here is on alliances.

Judging by their R&D-intensity, and common knowledge of the firms in questions, this assumption seems reasonable. Most firms have an R&D-intensity above 1 percent to classify them as medium-technology firms in commonly used technology-intensity taxonomies (see Hatzichronoglou (1997)).

Table 3.1 Basic indicators of firms included in the sample (all figures are 1998–2004 averages)

Firm	Industry	Employees	Turnover, mill. euros	Foreign employees	Foreign sales	R&D intensity
Elisa	ICT	6414	1285	9 %	8 %	1.81 %
Nokia	ICT	52353	26200	56 %	98 %	10.37 %
Novo	ICT	2093	302	5 %	11 %	n/a
TeliaSonera	ICT	8466	1989	9 %	3 %	3.23 %
TietoEnator	ICT	10265	1161	45 %	54 %	n/a
Dynea	Chemical	3278	1063	91 %	91 %	1.36 %
Kemira	Chemical	10283	2538	54 %	66 %	1.80 %
Orion	Chemical	5334	1362	16 %	46 %	5.80 %
Raisio	Chemical	2677	793	40 %	44 %	2.25 %
Uponor	Chemical	5919	1184	85 %	87 %	1.56 %
Ahlström	Forest-related	8973	1953	76 %	84 %	1.50 %
Huhtamäki	Forest-related	17479	2110	85 %	96 %	0.54 %
Metsäliitto	Forest-related	26252	7504	60 %	47 %	0.39 %
Stora Enso	Forest-related	42715	12143	65 %	69 %	0.72 %
UPM-Kymmene	Forest-related	34464	9481	38 %	39 %	0.46 %
Amer	Metals & eng.	4045	1003	86 %	94 %	2.16 %
Hackman	Metals & eng.	2971	331	50 %	51 %	2.73 %
Instrumentarium	Metals & eng.	4959	908	67 %	87 %	7.21 %
KCI Konecranes	Metals & eng.	4268	679	66 %	90 %	1.14 %
Kone	Metals & eng.	26565	3594	90 %	94 %	1.51 %
Metso	Metals & eng.	25344	4090	59 %	90 %	3.24 %
Outokumpu	Metals & eng.	17050	4776	62 %	70 %	0.86 %
Rautaruukki	Metals & eng.	13133	2855	39 %	47 %	0.64 %
Wärtsilä	Metals & eng.	12560	2532	72 %	98 %	3.12 %

Note: n/a = not available.

The main exceptions are the software developers Novo and Tietoenator which do not report their R&D. This is largely due to the specific nature of software patenting and development activities that usually do not count as R&D proper.

3.2 INTERNATIONALISATION PROFILES OF THE FIRMS

As we have seen, alliances represent one route to internationalisation among other, more traditional ones such as FDI. At the outset we thereby seek to establish the relative role that international alliances play in the overall internationalisation profile of the in-house technologies of the sample firms. One useful taxonomy towards this end is the one developed by Archibugi and Iammarino (2002), based on a set of variables that we will also use. The taxonomy makes a distinction between i) the international exploitation of nationally developed technology, ii) the global exploration of technology through innovative activity abroad, and iii) international collaboration to complement in-house technological development whether exploitatively or exploratively.

Archibugi and Iammarino (2002) propose that the share of exports and international patent applications cover the international exploitation of in-house technology of firms in so far as these indicate the degree to which in-house technological developments aim for international markets. Further, they propose that the share of patents of firms with international inventors as well as FDI indicate the extent to which a firm is engaged in the exploration of new technology and innovations abroad. The size of international inventor teams of patents and share of international alliances capture international collaboration in a reasonably extensive way. In our case these variables are gathered at the firm level and the resulting data is presented based on a principle component analysis to identify profiles through cross-correlations between the variables.[1]

The analysis produces three relatively clear so-called principle components which account for 74 percent of the cross-correlation between the variables to capture the taxonomy by Archibugi and Iammarino (2002). The results are presented in table 3.2.

We label the first component 'Multiple sources'. It captures firms which are involved in internationalisation of technology on a broad front, and essentially covers all three routes of internationalisation included in the taxonomy by Archibugi and Immarino (2002). This first component receives the highest scores for patent-related indicators. Firms with this profile are characterised by a high share of patents applied for abroad. They also explore new technologies through their foreign affiliations as indicated by the high share of inventors with foreign addresses in their patent portfolios. Further, they are engaged in international collaboration as indicated by the large average size of their foreign inventor teams. In this profile international alliances are also significant. Nonetheless, alliances do not appear to play a very pronounced role when compared with the other internationalisation routes.

We label the second component 'Export-oriented' internationalisation. It has a markedly different structure when compared with the first one, and reflects a profile where firms mainly internationalise through exporting their in-house technology abroad from their national base in Finland. The other variables do not load significantly under this component, although interna-

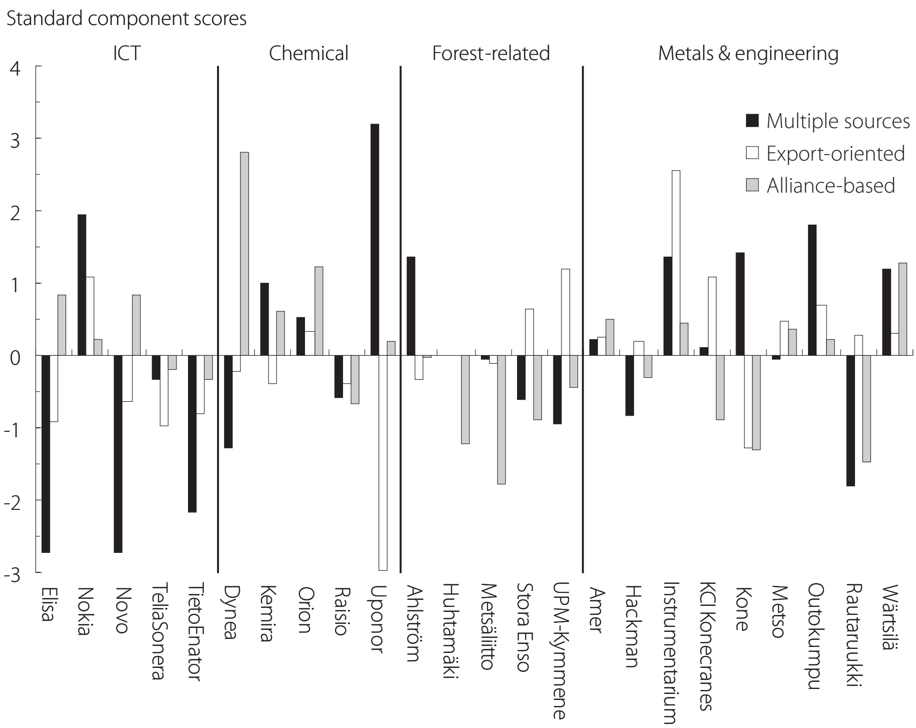
Table 3.2 Principal component analysis: internationalisation profiles of large Finnish firms

Taxonomy	Variable	Multiple sources	Export-oriented	Alliance-based
International exploitation	Share of foreign patents	**0.5298**	0.1828	0.0281
	Share of exports	0.2042	**0.7508**	-0.0542
Global exploration	Share of patents abroad	**0.4962**	-0.2727	-0.077
	Share of foreign M&A	**0.3631**	0.1199	**-0.6815**
International collaboration	Share of int. alliances	**0.3292**	0.2096	**0.7177**
	Share of foreign inventors	**0.4374**	**-0.5198**	0.1043
Cumulative explanation		38 %	57 %	74 %

tional alliances appear to play a somewhat greater role than international patenting and acquisition of foreign firms. This component thereby captures firms which mainly engage in exploitation of their technology-related O-advantages through exports as a very traditional internationalisation route. We label the third component 'Alliance-based' internationalisation. It also has a distinct structure through the high loading for the variable on the share of international alliances. Judged by the high but negative loading for the share of foreign acquisitions it seems that foreign acquisitions and alliances have a diametrically different role in these types of firms and industries. The other variables do not contribute to this profile in any noteworthy way.

The identified internationalisation profiles can be given further content by investigating how they are distributed across the firms and their industrial affiliations. In a principal component analysis this can be achieved through calculating the so-called standardised component scores for each firm in the sample to indicate how it positions itself in terms of the three principle components identified above. Since the scores have an overall mean of 0 and standard deviation of 1 they should be interpreted as deviations from the average standardised internationalisation profile of the firms (Figure 3.1).

Figure 3.1 The distribution of internationalisation profiles across firms and industries



The distribution of the components across firms and industries suggests a relatively clear pattern. The ICT industry stands out with high scores for the 'Alliance-based' internationalisation profile. As can be seen from the figure, this is largely due to Elisa, Novo, and Nokia. Nonetheless, Nokia has also internationalised through other routes when compared with the other ICT firms and scores high in terms of the 'Multiple sources' and 'Export-oriented' profile. In general, the result concerning the ICT firms is compatible with the nature of this industry. Due to rapid technological change, standardisation and the systemic nature of innovation, alliances become important (Palmberg and Martikainen, 2006). The negative loading on all components for TeliaSonera and TietoEnator is mainly due to a measurement problem as these firms do not patent abroad and hence are not appropriately captured by our variables.

The 'Alliance-based' profile is also prevalent in the chemicals industry, although the 'Multiple sources' profile stands out significantly more due to the specific profile of Kemira and Uponor. It thus seems that the internationalisation of firms in this industry occurs on a broader front. When the profiles for the ICT and chemicals industries are compared with the forest-related and metal & engineering industries, some broader differences emerge. International alliances appear to be relatively less prevalent in these latter, more traditional, industries as suggested by a relatively larger share of firms with negative component scores for the 'Alliance-based' profile. The forest-related and metals & engineering industries are characterised by a combination of Multiple routes' and the 'Export-oriented' internationalisation profiles. This result is compatible with extant research that points to a greater role of alliances in R&D-intensive industries (Hagedoorn, 2002).

3.3 TRENDS AND CHARACTERISTICS OF ALLIANCES

We now move over to analysing in greater detail the trends and characteristics of the international alliances of the sample firms as a quantitative backdrop for qualitative interpretations based on the interviews. The data on alliances was collected through systematic reviews of the press reports of these firms, complemented with a review of relevant articles in the largest Finnish business newspaper during 1995–2004. The data contains information on the partners and characteristics to the alliances (see appendix 1 for further details of the SAFIF database).

The first viewpoint here is the development in the total number of newly formed international alliances, and by main types in terms of whether they are explorative or exploitative in nature. We define an explorative alliance as one which contains an R&D component as it involves the joint development of new technologies with the purpose of commercialisation through innovation.

Explorative alliances can thereby be of the R&D type only, or various combinations of R&D, production and/or marketing. In contrast, exploitative alliances cover those alliances which do not contain an R&D component. They thereby assumedly mainly aim to exploit the technology-related O advantages of firms through joint production or marketing efforts.

Judged by the number of newly formed alliances there has been a steady increase in international alliance activity over time, reaching a peak in 2000 with over 90 new alliances (Figure 3.2). After this peak there is a relative decline which appears to level out to around 70 alliances per year. These figures sum to a total of 481 alliances. Upon breakdown by type of alliances, it becomes clear that this foremost is due to the drop in the number of exploitative alliances, while the number of newly formed explorative alliances remains at a level of around 50 per year. It thus seems that the firms increasingly favour explorative over exploitative alliances as time goes by. This trend is compatible with the overall rise in R&D intensity in Finnish industries.

When looking at the distribution of alliances across the sample firms, the dominance of Nokia is also quite evident. According to our data Nokia has been involved in 230 (48 percent of the grand total) international alliances. The remaining ICT firms have been involved in around 30–40 alliances on average during this time period, followed by the rest of the firms with 8 alliances on average. The ICT firms are also those characterised by the most rapid increase in the number of new alliances over time, which largely explains the total figures. The majority of the alliances of the ICT firms are of the explorative type, while the share of exploitative alliances is relatively much higher especially in the more traditional chemicals and forest-related industries. By

Figure 3.2 The number of newly formed international alliances 1995–2003

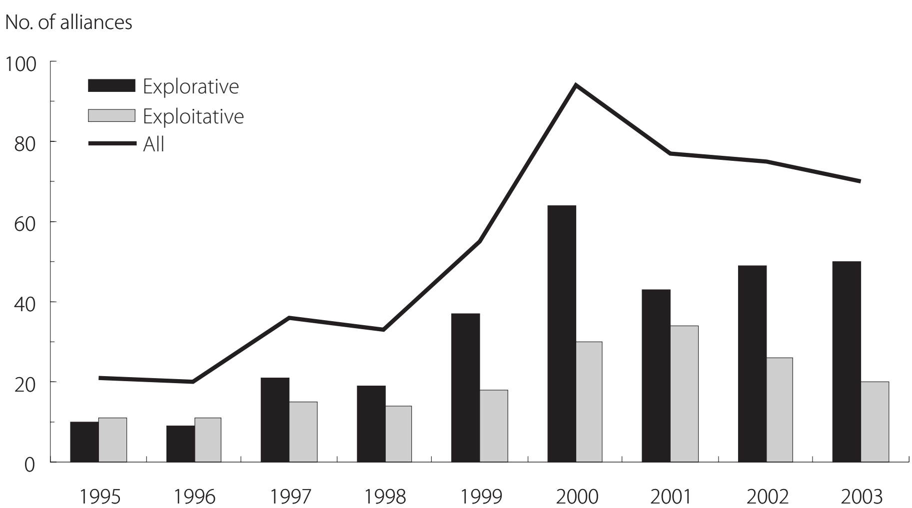
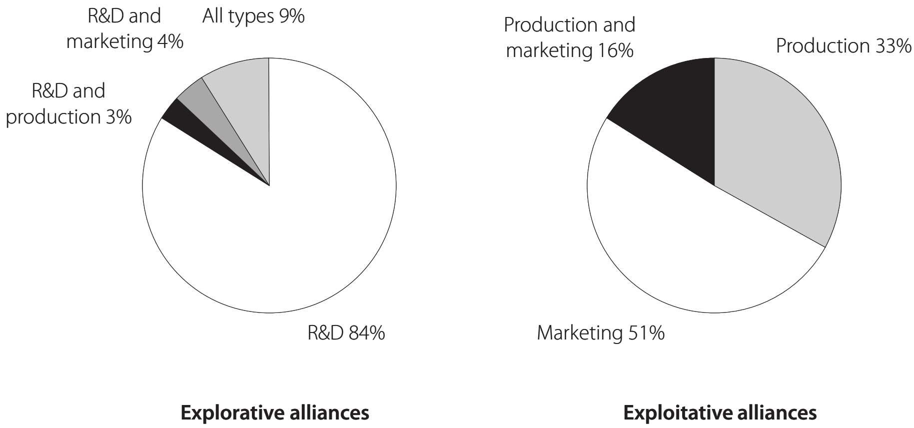


Figure 3.3 The distribution of alliances by type



the face of, the entry of Finland into alliance capitalism is thus primarily explainable by the increasing alliance-intensity of major ICT firms in Finland, and by exploration of their technology-related O-advantages (compare with Palmberg and Pajarinen (2005)).

The content of exploitative and explorative alliances can be examined in some greater detail through their classification into R&D, production, and marketing alliances, or some combination of these types of activities (Figure 3.3). Judged by this distribution, explorative alliances mainly comprise of R&D alliances. These R&D alliances range from equity-based R&D joint ventures to looser types of non-equity based R&D pacts, to joint development and cross-licensing agreements. The remaining share is distributed across a mixture of R&D, production and/or marketing alliances with the highest share comprising of all these components. Again, these observations hold true especially for the ICT firms.

In the case of exploitative alliances, the distribution across alliances types is more even. A slight majority of all these alliances are of the marketing type, followed by production alliances. Nonetheless, alliances which cover both production and marketing are also relatively numerous, with a percentage share similar to combinative alliances of the explorative type. These results indicate that a noteworthy share of all alliances combine R&D, production and marketing activities in various forms.

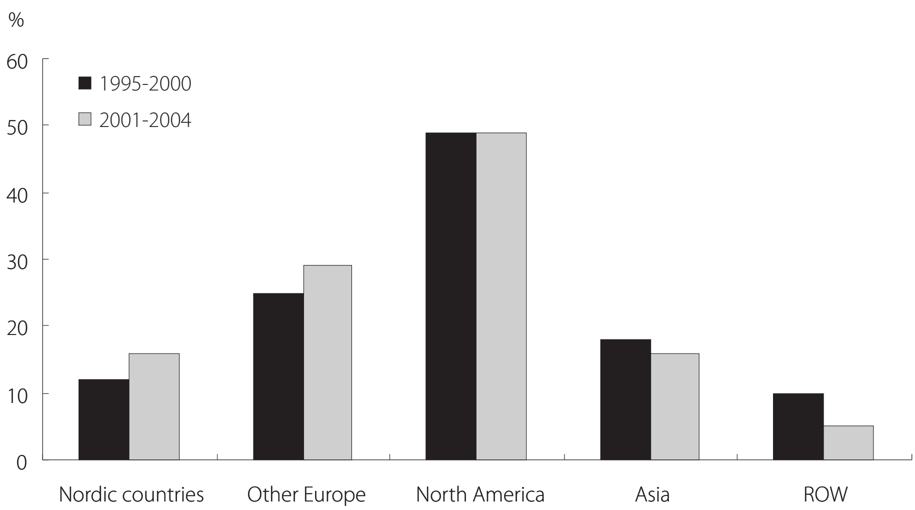
3.4 THE DISTRIBUTION OF ALLIANCES BY PARTNER CHARACTERISTICS

As suggested by the OLI theory there are grounds to assume that locational (L) advantages in terms of the country of origin of the partners, also affect the alliance activities of firms. Certain locations host advanced firms due to various favourable combinations of input prices, trade barriers, tax incentives or other institutional context related to the industrial and innovation policies of specific countries. Hence, just as such L-advantages will affect the decision of firms to internalize their O-advantages through FDI, it is conceivable that they will also affect the cross-border alliance activities of firms. Although our data does not allow for a detailed analysis of such L advantages, we can use the country affiliation of the foreign partners to highlight the changing geographical distribution of the alliances over time. We do this be dividing countries into five main regions, namely the 'Nordic countries', 'Other Europe', 'North America', 'Asia' and 'Rest of the world' (ROW).

From the distribution it is clear that North American partners are the most frequent ones, and mainly firms with a US affiliation (Figure 3.4). US firms are seconded by firms from Europe, as well as Asian firms. Again the case of Nokia drives the results due to its intense involvement in alliances especially with US firms. If Nokia is left out, the share of firms from the Nordic countries and other European countries increases relative to that of North American firms. In other respects the distribution remains relatively similar.

Over time only slight shifts can be noticed. The share of North American firms remains unchanged, while a slight increase in the share of firms from the Nordic and other European countries is visible. The share of Asian firms drops somewhat in the 2000s, although this trend is the opposite in the case of the Finnish ICT firms. By and large, the geographical distribution of alliances is compatible with the direction of exports and FDI of Finnish firms with the exception that the share of North American and Asian partners is

Figure 3.4 Geographical distribution of alliances by country affiliation of partners

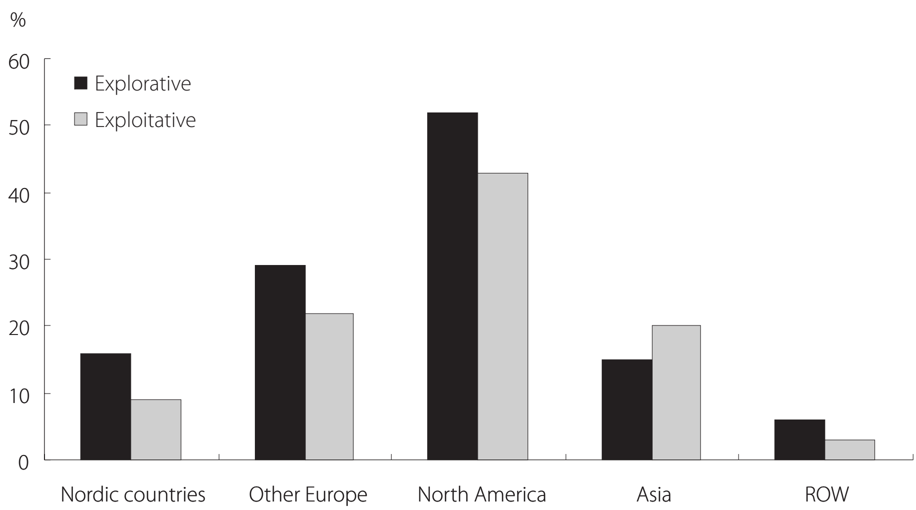


larger here when compared especially with FDI (Bank of Finland, 2003; Suhdanne, 2005). Hence, it seems that different kind of L-advantages matter in the case of alliance activities when compared with traditional routes to internationalisation.

The geographical distribution of alliances by country affiliate of partners does not change to any greater extent when the figures are broken down by the type of alliances, even when the case of Nokia and the other ICT firms is accounted for (Figure 3.5). In the case of explorative alliances the dominance of North American (mainly US) partners is again quite clear, followed by European and Nordic partners. Further, over time only marginal shifts are evident, although with the similarly specific pattern for ICT firms which extend their alliance activities towards Asian firms.

In the case of exploitative alliances the dominance of North American partners persists, followed by Nordic and other European partners. However, the geographical shifts over time are more marked when compared with explorative alliances. Our sample firms increasingly appear to become engaged in European alliances in their exploitative activities, while the share of such alliances with North American and Asian firms, and ROW, appears to decline quite rapidly. This is an interesting result since it seems to contradict the prevailing trend of out-locating manufacturing to low-cost Asian countries through FDI. Hence, it also seems that different types of L-advantages come to play in exploitative alliances when compared with explorative alliances.

Figure 3.5 Geographical distribution of alliances by main type and country affiliation of partners



4 TRENDS, MOTIVES AND CHALLENGES IN ALLIANCE FORMATION

4.1 A BRIEF NOTE ON THE METHODOLOGY

The interviews covered 15 firms, of which 10 also are included in the SAFIF database of alliances. They should thereby provide a relatively representative qualitative interpretation of the broader trends and characteristics of alliances that we analysed in the previous section. The interviews were semi-structured based on a predefined framework which sought to capture the overall organisation and internationalisation of R&D of the firms. Special focus was given to the role of mergers, acquisitions and alliances in the exploitation and exploration of technology-related O-advantages of the firms. The interviews lasted around one and a half hour on average. They were all recorded and transcribed to enable in-depth analysis.

The interviews were conducted in various constellations of three researchers, thus enabling ex-post researcher triangulation. The questions related to the alliance activities of the firms focused on the issues discussed above, i.e. on the recent surge and pervasiveness of alliances in the overall internationalisation of firms, on various motives that firms allude to in alliance formation, as well as on the major challenges that firms face during their alliance activity. The quantitative analysis of the broader trends and characteristics of the alliances thereby guided the design and interpretation of the interviews, and vice versa, to achieve complementary functionality between the methodologies (for a further discussion of multi-method research see Tashakkori and Teddlie (1998)). We have also chosen to use citations from the interviews to back-up our interpretations. These citations are presented anonymously throughout the ensuing text to retain the confidentiality of the interviewees.

Since the interviewees primarily were persons in charge of R&D or technology developments, either at the corporate or divisional level. Therefore there might be a partial bias in their interpretations of alliances against non-R&D related issues that nonetheless might be important, especially in the case of exploitative alliances which have a stronger focus on developments in the downstream markets (see Appendix 2 for a list of the interviewees). Sometimes it was apparent that the interviewees could not reveal sufficient details about the nature and challenges of the alliance activities due to non-disclosure agreements that they have with their partners. This might also introduce a partial bias in their interpretations of highly explorative alliances which often fall into the non-disclosure category. By and large we nonetheless feel that the interview data provides a valid picture of the alliance activity of the firms.

4.2 INTERPRETATIONS OF THE SURGE IN INTERNATIONAL ALLIANCES

The recent surge in the alliance activity of firms that is evident in the quantitative analysis of this paper is also clearly acknowledged by an overwhelmingly majority of the interviewees. Alliances have become a natural part of the R&D and business strategies of the firms that we covered. Generally speaking, firms engage in alliances as a necessary response to globalisation and rapid technological change. Strategic alliances represent a new mode of internationalisation in this context, which appears to complement rather than displace FDI. The interview results are thereby broadly in line with the discussion in Dunning (1997) on the erosion of hierarchical capitalism, although some scepticism can be raised against the idea that a 'new' mode of alliance capitalism is replacing the 'old' mode of hierarchical capitalism. The firms covered here do still value hierarchical control highly, especially concerning their most distinct O-advantages.

The explorative component of a majority of the alliances is also clear from the interviews. Nonetheless, it makes sense to distinguish between vertical and horizontal alliances in a more detailed analysis of the nature of explorative activities that the firms engage through alliances. Vertical alliances cover collaboration between upstream suppliers of raw-materials, services, or components and downstream customers along a relatively clearly defined value chain. The general impression is that firms involved in these types of alliances are more prone to truly share their O-advantages for the development of new technologies or innovations and thus engage in exploration proper. Typically these vertical alliances are organised as joint development agreements or research joint ventures. They appear to be relatively more common between firms in engineering and the traditional industries. Concrete examples include alliances between pulp & paper conglomerates and papermaking machinery providers, or between ICT process software providers and manufacturing firms.

> "...in the case of the commercialisation of specific technologies, we have many examples of cases in which we collaborate with equipment suppliers on a regular basis...they are based on common goals in R&D projects..." (Firm A)

> "...very close collaboration with key customers related to specific deliveries, but also to R&D...especially in areas where there are only a few customers..."(Firm A)

> "...we call them 'solution-partnerships'. They cover system integration services, state-of-the art technologies, and very demanding applications. This type of activity is very knowledge-intensive" (Firm B)

> "...vertical alliances increase in importance over time...i.e. collaboration with firms, customers, suppliers, raw-material providers, machinery producers etc... they typically have joint projects..." (Firm C)

Horizontal alliances cover collaboration that span different value chains and hence often comprise of competing firms. In horizontal alliances the explorative element comes through the creative combination of existing technologies, or O-advantages, rather than the joint development of new ones. These creative combinations are sometimes a necessity, especially in the ICT and related industries where the interoperability of components, products and systems is important. They often involve cross-licensing agreements between firms, whereby firms exchange the rights to use each others technologies in the definition and development of common interfaces between products. Horizontal alliances of this kind are thereby also often related to standardisation, which is a primary feature of the ICT industry. Sometimes these types of alliances might amount to quite complex constellations, or pacts, of inter-firm collaboration which become institutionalised into dedicated forums. One example of such a forum is the 3GPP, which is set up to facilitate the development of third generation wireless telecommunications standards. Nonetheless, cross-licensing and standard setting is also relatively common in other types of industries, for example in cases where firms have to comply with various construction or environmental norms and regulations.

> "...we certainly do not make everything ourselves. With competitors...we have out-licensed [technologies] to competitors in cases were we have deemed it viable and outside Europe we have done it quite often...we have also engaged in pre-competitive R&D with competitors e.g. related to performance measurements of various competing material..." (Firm D)

> "...[the alliance] typically have a duration of 2–3 years, indeed through these cross-licensing agreements we operate in quite large alliance networks in which it is also possible to do things together in a deeper sense when viable..." (Firm D)

> "...we perceive an alliance as an arrangement which truly contributes to the development of new technologies on a longer term basis, an arrangement that has significant goals. What we have might rather be described as collaborative consortia which finance R&D in certain fields. Sometimes these consortia might lead to an alliance with the aim of commercializing a breakthrough technology". (Firm A)

> "...standards imply that we collaborate with competitors throughout alliances...these are long-term issues. Yes, we are involved in many such alliances. Then, in cases when we develop new products, these are other types of arrangements. In these cases there are alternatives, sometimes we give the suppliers greater degrees of freedom..." (Firm E)

The data is not conclusive on whether vertical or horizontal alliances account for the largest increase in the number of alliances of the firms included in the analysis. Nonetheless, given the large share of newly found alliances by firms in the ICT industry an insightful estimate is that horizontal alliances have become the dominating type in recent years. This is a direct consequence of the rapid development and growth of Nokia since the mid 1990s, and the specialisation of Finland in ICT-related technologies. The dominance of explorative alliances also suggest that large Finnish firms foremost participate in alliance capitalism as technology suppliers rather than technology users, or exploiters, and that this trend is strengthening over time. Having said this, it should also be noted that many alliances comprise of various elements related not only to explorative R&D, but also to production and marketing. These variegated features of alliances are difficult to identify especially in the statistical analysis.

4.3. MOTIVES IN ALLIANCE FORMATION

The motives in alliance formation that the interviewees raised are in line with those identified in table 2.1 in the conceptual discussion. The interviews thereby essentially confirm insights from previous research, as well as the related theoretical frameworks available for interpreting the reasons for why firms engaged in alliances. Nonetheless, the interviews also show that there typically are multiple motives behind the formation of alliances, and that the motives might vary quite a lot depending on the strategic orientation and industry of the firm in question. We can therefore not pinpoint any particular motives as more important than others. But on a general level we can identify a certain hierarchical ordering in their relevance as firms contemplate on their R&D and internationalisation strategies.

Following up on this hierarchical ordering, we noticed that all interviewees highlighted strategic alliances as a means to reduce or *share risks* in one way or the other. This is compatible with insights into the fundamental drivers of "alliance capitalism", the intertwined consequences of globalisation and rapid technological change. Alliances offer a flexible means for firms to enter new technologies and markets without excessive unilateral liabilities that arise e.g. through FDI. This appears to be especially pronounced in explorative alliances in which firms engage in R&D activities where the outcomes are highly uncertain (see also Palmberg and Pajarinen (2005)). Some interviewees also suggested that alliances reduce the risks of organic growth of the firm since they facilitate partial diversification into new technology and business fields.

> "...the world is moving in a direction…whereby all significant technological developments are so risky and expensive that the trend is towards...the sharing of risks...i.e. firms engage in alliances and develop these things together" (Firm F)

> "...these [alliances] contribute to the organic growth of the firm, the equipment and tools for growth. Growth in collaboration with our customers..." (Firm B)

> "...R&D is risky business, it's a risky investment to acquire a firm…ownership is not the most important thing, but rather to get things under way...we can source technologies and other things also through alliances..." (Firm G)

Apart from risk sharing as a general motive, various combinations of lower-level motives were highlighted. *Cost reduction* motives often go hand in hand with the aspiration of firms to *shorten innovation and/or entry times* to new markets in a competitive environment. In increasingly competitive and fast-paced markets the speed at which firms develop and commercialize technologies becomes an important prerequisite for success (Palmberg, 2006). If the firms manage to speed up the development times of new technologies and innovations they also often have better possibilities to reduce the costs of R&D. Foreign alliance partners can provide easer access to new markets, e.g. by sharing a brand name known to local markets or by providing access to an estabtablished retail network, and thereby make excessive FDI unnecessary.

> ”...it is a big conglomerate, and naturally our competitors, but as I suggested...if we want to be on the Japanese markets we also have to collaborate with this firm... (Firm G)

> “...[through the alliance] the technology was transferred to our firm…otherwise the development of such technology, and the first customer reference, would have taken from 4 to 5 years and would have cost us tens of millions of Euros...it was a clear strategic move...” (Firm G)

> “...it is in the interest of both firms to be able to apply both of our results quickly, to get the quickly to the market...” (Firm I)

As suggested earlier, cost reduction can also imply that the partners to an alliance agree on a certain division of labour along their areas of specialisation to avoid duplication of R&D, production and marketing. This brings us to the issue of *complementary assets* needed during innovation that many of the interviewees regarded as an important motive. Again it makes sense to distinguish between vertical and horizontal alliances in a more detailed analysis of the role played by complementary assets. Further, their role varies by characteristics of the broader technological and industrial contexts (see also Teece (1986)).

In vertical alliances, which often are associated with a stronger element of exploration proper, complementary assets arise due to the different positioning of firms in the same value chains. In these cases the firms typically appear to form alliances to access the R&D, production or marketing assets that they do not possess. Alliances thereby enable the firms to extend their activities across various parts of the value chain on an international basis without the liabilities associated with FDI. Some of the interviewees acknowledged that lack of knowledge of foreign markets or a strong global brand is a typical problem for Finnish firms, especially in consumer markets, even though they might be strong in technology-related O-advantages. This observation supports further the impression that Finnish firms participate in “alliance capitalism” mainly as explorers rather than exploiters of technologies.

> “...these [alliances] explicitly cater to our marketing and branding needs, because from here there are no possibilities to enter European markets. There is not enough money, there are no possibilities...” (Firm H)

> "...it [alliance activity] is increasing in the sense that we do more and more collaboration with firms which already have control over the markets in Europe...through this they understand the functionality of our technologies at an earlier stage, and can commercialise them more rapidly." (Firm J)

> "...we of course have very close collaboration with a few selected raw-material suppliers...might they be defined as alliances...but anyway our R&D requires deep collaboration in that direction" (Firm D)

> "...it's a kind of a concept, we have developed the equipment, but there is also a related service concept...they operate the services and bill their customers, and deliver the personalized service through our equipment..." (Firm K)

In contrast, in horizontal alliances complementary assets arise through the different technological specialisation of the partner firms. They typically relate to the cross-licensing of technologies which are necessary for firms to gain access to for the sake of interoperability of products. Complementary assets enable firms to creatively combine existing technologies throughout alliances, and this appears to be an especially important motive for firms in the ICT and related industries. In these industries firms have better possibilities to protect their technologies through patents, and these patents themselves often constitute the complementary assets that firms trade amongst each other through cross-licensing.

> "...we offer many such solutions...in which the technologies of a foreign firm are embedded. It's very common. If the customer wants 'turn-key deliveries', then there usually is foreign hardware and platforms included..." (Firm B)

> "...the core technology comes from us...and firm X, in turn, supplies a lot of knowledge related to production, and there is also specific technologies that they of tradition are particularly good at..." (Firm L)

> "...both have their own technologies...or lets say that we might have a core component and they might have some other technological competence, and then we take a look at how they might be combined...in these cases we take advantage of the R&D of both firms and respective countries as well..." (Firm H)

> "...this issue of interoperability raises it's head all the time. It drives us into these alliances." (Firm E)

With the risk of over-generalizing it seems that the interviewees at least not explicitly recognised *influencing market structures and competition* as an important motive behind alliance formation in specific cases. However, there were discussions on the disadvantages of alliances from this perspective. Some firms expressed their concern that long-term alliances with a few customers might distort competition and limit their opportunities to enter new markets. Further, some recognised a trend towards competition between larger constellations of alliances, whereby the O-advantages of specific firms will matter less in the future. In this sense one might raise concern that "alliance capitalism" is having adverse effects on market competition. This has indeed been an issues much discussed and analysed especially in the industrial organization literature. However, with the exception of ICT firms, it seems that the Finnish firms that we have covered here do not perceive themselves as having a major influence on market structure and competitive constellations through their alliance activity.

4.4 CHALLENGES RELATED TO ALLIANCES

The principal component analysis of the internationalisation profiles of the firms revealed that alliances indeed constitute an important dimension of all three profiles that we identified. From previous research, and the recent rapid growth in their numbers over time, we also know that alliances represent a new dimension of internationalisation from a Finnish viewpoint (Palmberg and Pajarinen, 2005). The interviews with the R&D managers of firms clearly acknowledged these observations and could indeed identify a range of new challenges that emerge in this context. The most general of these challenges related to the *management of alliance portfolios* once firms start to accumulate multiple alliances with various firms in the same or different industries.

> "...just the other day I sketched an alliance network map to actually find out with whom we work together...I have this feeling that a lot of time goes into merely managing these networks, and there are very may firms and research organisations involved..." (Firm K)

> "...two completely different worlds collide [throughout our alliance networks], i.e. our traditional customers and new competencies which are new to the industry, and there is the probability that new alliances emerge which are a threat in the sense that a new player might enter this business..." (Firm L)

> "...participation in alliance networks require more effort on managerial issues…its important to be aware of why this [a particular alliance] is necessary, what we can get out of it, and whether the interests of both partners truly converge..." (Firm D)

> "We have one person in charge of each alliance. But our corporate management team is also quite aware of the alliances that we take part in and might intervene in the details if necessary. We have special meetings to deal with these issues" (Firm E)

> "...management is sometimes very tricky...in one alliance we are head to head competitors, while in another we collaborate full-out...it is a very complex and dispersed activity..." (Firm F)

As has been suggested "alliance capitalism" implies that hierarchical control over value-added activities is yielding to network-based collegial entrepreneurship that can give rise to quite complex and multidimensional constellations of inter-firm collaborative agreements across value chains and national borders. It is quite understandable that firms face various challenges in coordinating their multiple collaborative activities in alignment with their individualistic strategic and business goals. The interviewees highlighted the importance of keeping track of all collaborative obligations and opportunities, a task that might be especially challenging in rapidly changing industries. This monitoring is important in order to mitigate unintended knowledge spillovers to third parties as well as to avoid hostile entry into their own markets through back doors. Alliance portfolio management practices also differ quite significantly across the sample depending on the extent of their involvement in alliances. Some firms have centralised their management on an ongoing basis. Others bring up the issue sporadically, especially if they are involved in a fewer number of longer-term alliances.

The choice of alliance partner is also a tricky task. On the one hand firms must signal their complementary assets in order to attract the most viable partners. On the other hand, they must avoid to become engaged in an alliance that is characterised by strong asymmetries with respect to the market power, IPR claims or strategic positioning of the foreign partner which often is the bigger one. This implies that the viability of each alliance agreement has to be carefully analysed in terms of the positioning in value chains and networks, a consideration that is challenging especially in the field of ICT where technologies and markets are converging. Trust is often a key issue in decision making, and quite often alliances are formed based on close personal ties between firms. Many interviewees mentioned cultural barriers as the main reason for the failure of alliances.

> "You cannot enter technology alliances if you do not have some specific assets and competencies, you have to be an attractive partner, if you do not know anything you will not gain anything..." (Firm F)

> "The motivations [behind the alliances] are very diverse, somebody offers you something that is already developed...other sketch their ideas in the corner of a tablecloth... here I give you a good idea. Sometimes they do not even reveal their idea...the diversity is huge." (Firm K)

> "Everybody engages with everybody...it's a wild situation" (Firm F)

> "Personal ties, they are very important. Trust, that is very important in international activities in general, the world is huge... you have to know the right people." (Firm E)

> "It would be very hard to imagine an [alliance] agreement…at least in the longer term...with a firm within which we do not have a trustful relationship" (Firm D)

> "Well...cultural issues and personal issues are often the trickiest, not the technology itself...we know how to deal with the technology-side of things in both firms...in the end it failed because of these cultural barriers" (Firm L)

The most concrete issue that the interviewees highlighted was the challenges related to sharing intellectual property rights (IPRs) and they were of the opinion that these challenges are increasing over time. Almost everyone suggested that IPR issues over technologies were the most demanding ones during alliance negotiations, and that these issues tended to dominate in vertical explorative alliances where two or more firms have to settle how the commercial rights to a jointly developed technology should be divided. The problems are compounded in situations where the foreign partner firm is the dominating one in terms of market power, which give leverage to its negotiation position as the alliance is formed. Such positional asymmetries imply that the Finnish firms that we covered presently are putting a lot of effort into strengthening their IPR and management capabilities.

> "Yes, and they [IPR issues] are, in fact, the most difficult part of the negotiations, that is how the results of the alliance are to be appropriated...those IPR issues as a general trend are increasing in importance all the time." (Firm D)

> "When innovating together, then we come to questions about who own what…IPR issues are important and their importance are, in a way, increasing quite significantly over time. In discussions with our legal department...they clearly indicate that these things are becoming even more demanding as time goes by." (Firm M)

> " The situation is relatively straightforward if the partner firm is from another industry, whereby they normally do not have anything against selling or buying IPRs through licensing." (Firm D)

> "[These positional asymmetries imply that] the best possible partner is number 2 or 3 in the field, not the most dominating one..." (Firm H)

> "Yes, IPR issue always arise. In the case of larger competitors we rely on cross-licensing. We do not have to deal too much with IPR issues in those cases. But in certain other technological choices IPR issues become very significant, easy cases are those where firms from the same industry collaborate." (Firm E)

In horizontal alliances IPR issues are also important but offer less challenges, and they tend to be settled through relatively clear-cut cross-licensing agreements. These agreements concern the exchange of already enforced IPR on a mutually beneficial basis. Again a typical example is the ICT industry in which firms often trade patents in order to promote the development of a standard and secure interoperability between products.

5 A SUMMARISING DISCUSSION

5.1 ALLIANCES INCREASINGLY IMPORTANT FOR INTERNATIONALISATION

This paper applies international business theories of the firm to give new insights into the role that alliances play in the overall internationalisation of the in-house technologies of major Finnish firms, and the main motives and challenges that firms see in this context. We use a new database on strategic alliances and apply multivariate and descriptive statistics to trace the broader developments and nature of international alliances, complemented with in-depth interviews of R&D managers. The paper thereby relies on methodologies common to a multi-method research approach, and seeks validation from ex-post researcher triangulation and functional complementarities between different methodologies.

International business theory, developed especially by Dunning (1981), suggests that the documented surge in international alliances mounts to a new mode of "alliance capitalism" that is replacing traditional modes of capitalism in which firms mainly strive to retain hierarchical control over their cross-border activities through internalization. This paper shows that also Finnish firms to an increasing extent engage in international alliances, especially since the late 1990s. Nonetheless, alliances merely offer one complementary route towards internationalisation along many others. The role of alliances appear to be especially pronounced in the 'high-tech' ICT and chemicals industries, while being lesser in the more traditional metals & engineering and forest-based industries. Hence, the entry of Finland into "alliance capitalism" is primarily explainable by the increasing alliance intensity of major ICT firms in Finland, amongst which Nokia stands out with the largest number of international alliances by far.

We make a distinction between explorative alliances with an R&D component, and exploitative alliances which comprise of production and marketing elements. The underlying assumption is that all of these types relate to the in-house technologies of firms (their O-advantages to refer to the OLI theory) albeit in different ways. By this distinction it is clear that firms increasingly seem to favour explorative over exploitative alliances as time goes by, especially due to the strategies of ICT firms. A major share of these alliances cover R&D activities, and they range from R&D joint ventures and joint development agreements to cross-licensing schemes. The share of exploitative alliances is relatively much higher in the more traditional industries, and these alliances are equally distributed across production and marketing activities. More generally, these trends and other results also suggest that Finland participates in "alliance capitalism" mainly as an explorer rather than exploiter of technologies.

The quantitative data on alliances is also analysed in terms of the geographical distribution of the foreign partners to the alliance. North American partners appear as the most frequent ones, seconded by European and Asian partners. Over time we can see increase in the importance of Nordic and other European partners while the share of North American firms as partners remains stable. When these results are compared to the geographical distribution of exports and FDI, the importance of Asia is noteworthy. This holds true especially in exploitative alliances where there is an increase in the share of Asian partners, set against a corresponding decline in the share of partners from other regions of the world. These results suggest that in so far as locational (L) advantages of the origin of partners of alliances matter in alliance formation, these appear to be of different in nature when compared especially with FDI. Further, the significance of Asian partners underlines identified trends of globalisation from a Finnish viewpoint (see e.g. Valtioneuvosto, (2004)).

5.2 MOTIVES AND CHALLENGES DEPEND ON THE NATURE OF ALLIANCES

The qualitative interviews deepen our insights into trends, motives and challenges of international alliance activity from the viewpoint of Finnish firms. By and larger the interviewees confirm the surge in the number and importance of alliances. Alliances have indeed become an integral part of the international R&D and business strategies also of the Finnish firms covered here, although they still value hierarchical control highly. An additional insight revealed by the interviews was that the distinction between vertical and horizontal alliances largely appears to explain how they perceive the motives and challenges.

A characteristic of vertical alliances is that firms are more prone to truly share their technology-related O-advantages for the development of new innovations and thus engage in exploration proper. They are typically formed based on the identification of complementary assets that arise from the different positioning of firms in the same value chains. Apart from complementary technology assets, firms often also seek to access e.g. large-scale production expertise, knowledge of foreign markets, or strong global brands that they might lack despite strengths on the technology side. In contrast, horizontal alliances typically concern the creative combination of existing technologies (O-advantages). These creative combinations frequently relate to interoperability demands and standardisation, especially in ICT. Therefore cross-licensing agreements are quite common, and the partners primarily identify complementary assets in each others unique technology specialisation profile.

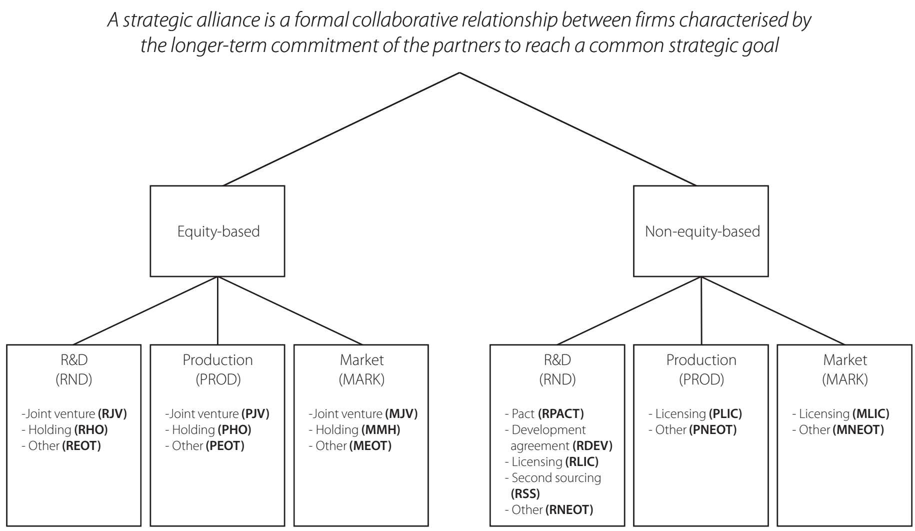
The sharing of complementary assets is often considered a prime explanation for alliance formation in managerial theories of the firm (see especially Teece (1986)). When extending the viewpoint to mainstream economics risk sharing and cost reduction, shortening innovation/entry times, and influencing market structure and competition also emerge as important issues. Our interviews also highlight these motives. Risk sharing emerges as an overreaching motive for most alliances. This motive is especially pronounced in explorative alliances that cover uncertain R&D activities. Cost reduction and the shortening of innovation entry times often go hand in hand in this context. Influencing market structure and competition was not explicitly mentioned by the interviewees, although there is a general acknowledgement of the fact that competition partly is shifting from the firm level to the level of competition between complex constellations of alliance networks. However, the general impression is that many of these motives interact and jointly determine the motives behind specific alliances.

The main challenges relate to overall alliance management issues. There was a clear acknowledgement that alliances present new challenges as the alliances portfolio grows in size. Further, the choice of partners is of crucial importance for the success of an alliance. This choice requires that firms find a balance between attracting the best partners through signalling their competencies and complementary assets, while avoiding asymmetric relationships in which the foreign partner firm has a dominating market power or IPR position. The sharing of IPRs is a big challenge in such asymmetric relationships, especially in the case of vertical alliances in which firms tend to engage in exploration proper. In horizontal alliances IPR issue arise more seldom as these mainly cover the combination of already enforced IPRs e.g. in the case of the cross-licensing of patents.

APPENDIX 1: THE SAFIF DATABASE

The SAFIF database (Strategic Alliances of Finnish Firms) consists of 36 firms that were selected on the basis of their size, innovative activity and industry affiliation. Through this selection of firms the database gives reasonable coverage of the ICT, chemical, forest-related, metals and engineering industries in terms of R&D, turnover and share of employment in Finland. The identification and data collection of alliances relies on the relatively common literature-based alliance accounting methodology originally developed by John Hagedoorn and his colleagues at MERIT research institute at the University of Maastricht in Holland (see Hagedoorn and Schakenraad (1989); Hagedoorn et al. (2000)). A strategic alliance was defined as *"a formal collaborative relationship between firms characterised by the longer-term commitment of the partners to reach a common strategic goal".* Adhering to this definition the alliances of the selected firm during the period January 1995 to April 2004 were identified through company press and stock exchange releases and Kauppalehti-online news archive. From these sources information concerning the nature, technology field (when applicable), and general description of the alliances was gathered. Complementary information on each firm was also collected from Hoovers Online firm database, Talouselämä 600 dataset and patent information from the Delphion online patent service.

Figure A1 The SAFIF typology



Based on this public information each alliance has been classified in terms of whether they involve equity-investments or are of the non-equity type. Further, they have been distinguished into R&D, production or marketing alliances (Figure A1). This classification has been flexible by allowing for on alliance to cover many of these types if multiple components of the nature of the alliance could be identified.

These data sources cover all feasible information that is publicly available. The primary limitation relates to the fact firms have different communication policies in terms of the degree to which they report publicly on their alliance activities. Further, the application of the definition of a strategic alliance proved practically tricky in some borderline cases. These are common limitations of the literature-based alliance accounting methodology. As for now the database consists of 778 alliances and 739 individual firms that were related to the alliances.

APPENDIX 2: LIST OF INTERVIEWEES

Matti Kleimola, Wärtsilä, 12/5 2004
Ilkka Kaartovaara, Stora Enso, 24/5 2004
Juha Jakkula and Ilpo Pesola, Fortum, 25/5 2004
Petri Rolig, Huhtamäki, 31/5 2004
Heikki Leppänen, Kone, 1/6 2004
Matti Lehti, Tietoenator, 2/6 2004
Yrjö Neuvo, Nokia, 21/6 2004
Eero Punkka, Suunto, 22/6 2004
Christer Pihl, Ahlström, 11/11 2004
Eero Haarla and Heikki Peltola, UPM-Kymmene, 8/12 2004
Pekka Rauhala, TeliaSonera, 21/12 2004
Annika Mäyrä-Mäkinen, Raisio, 7/12 2004
Jyrki Huovila, Metso Paper, 4/1 2004
Juhani Pylkkänen, Valtra, 4/1 2004
Jussi Mykkänen, Vaisala, 31/3 2005

FOOTNOTE

1 Principle component analysis is a multivariate method for reducing cross-correlations in a dataset (see Hair et al., (1992) for more). It divides the dataset into so-called principal components, each of which summarizes the correlations between variables as their linear combination. The variables receive a loading under each principle component to indicate their relevance under the component. As a rule of thumb, loading over 0.3 are considered as noteworthy. An important feature of the principle components is that they are orthogonal, or uncorrelated, with each other.

REFERENCES

Ali-Yrkkö, Jyrki, Lovio, Raimo & Ylä-Anttila, Pekka (eds.). 2004. *Multinational enterprises in the Finnish innovation system*. Helsinki: Taloustieto Oy.

Archibugi, Daniel & Iammarino, Siomna. 2002. The globalization of technological innovation: definition and evidence. *Review of International Political Economy* 9:1, 98–122.

Bank of Finland. 2003. Suorat sijoitukset Suomen maksutaseessa. *Statistical Bulletin 9.11. 2004*.

Caloghirou, Yannis, Ioannides, Stavros & Vonortas, Nicholas. 2003. Research Joint Ventures. *Journal of Economic Surveys* vol.17, no.4. 541–570

Casciaro, Tiziana. 2003. Determinants of governance structure in alliances: the role of strategic, task and partner uncertainties. *Industrial and Corporate Change*, vol. 12, no.6, 1223–1251.

Dunning, John. 1981. International production and the multinational enterprise. London: George Allen & Unwin.

Dunning, John. 1997. Alliance capitalism in international business and the world economy. London: Routledge.

Dunning, John. 2003. Relational assets, networks and international business activity. In Dunning, John and Boyd, Gavin (eds.), *Alliance capitalism and corporate management*. Cheltenham: Edward Elgar.

Dunning, John & Boyd, Gavin (eds.). 2003. *Alliance capitalism and corporate management*. Cheltenham: Edward Elgar.

Edquist, Charles (ed.). 1997. Systems of innovation – technologies, institutions and organisations. London: Pinter Publishers.

Gerlach, Michael. 1992. Alliance capitalism: the social organization of Japanese business. Oxford: Oxford University Press.

Giuri, Paolo, Hagedoorn, John & Myriam, Mariani. 2003. Technological diversification and strategic alliances. *LEM Working Paper Series* 2002/04.

Glaister, Keith & Buckley, Peter. 1996. Strategic motives for international alliance formation. *Journal of Management Studies*, 33(3), 301–332.

Hagedoorn, John. 2002. Inter-firm R&D partnerships: an overview of major trends and patterns since 1960. *Research Policy* 31, 477-491.

Hagedoorn, John, Link, Albert & Vonortas, Nicholas. 2000. Research partnerships. *Research Policy* 29, 567–586.

Hagedoorn, John & Schakenraad, Jos. 1989. Some remarks on the cooperative agreements and technology indicators (CATI) information system. *MERIT Research Memorandum* 89–010.

Halme, Kimmo, Kanninen, Sami, Lemola, Tarmo, Autio, Erkko, Arnold, Erik & Deuten, Jesper. 2004. Competitiveness through internationalisation. *Tekes Technology Programme Report 10/2004*.

Hair, Joseph, Tatham, Ronald & Black, William. 1992. *Multivariate data analysis*. New Jersey: Prentice Hill.

Hatzichronoglou, Thomas. 1997. Revision of the high-technology sector and product classification. *OECD Working Papers 1997/2*.

Lindström, Maarit. 2003. *Locational sources of competitiveness: Finnish companies' international business operations in the Baltic Sea region*. ETLA Series A:37. Helsinki: Taloustieto Oy.

Narula, Rajneesh & Zanfei, Antonelli. 2005. Globalization of innovation: the role of multinational enterprises. In Fagerberg, Jan, Mowery, David and Nelson, Richard (eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Palmberg, Christopher & Martikainen, Olli. Forthcoming in 2006. Pooling knowledge: trends and characteristics of R&D alliances in the ICT sector. In Zysman, John and Newman, Abraham (eds.), *How revolutionary was the revolution?* Stanford: Stanford Business Books.

Palmberg, Christopher & Pajarinen, Mika. 2004. The global dispersion of innovative activities – the case of Finnish multinationals. *ETLA Discussion papers* No. 916.

Palmberg, C. & Pajarinen, M. 2005. Internationalistaion through strategic alliances – Determinants of Non-equity alliances of Finnish firms. Liiketaloudellinen Aikakausikirja (The Finnish Journal of Business Economics), 4/05, 489–509.

Penrose, Edith. 1959. *The theory of the growth of firms*. Oxford: Oxford University Press.

Reinganum, Jennifer. 1989. The timing of innovation: research, development and diffusion. In Schmalensee, R and Willig, R (eds.) *Handbook of industrial organisation*. Amsterdam: North-Holland.

Suhdanne. 2005. Suhdannekatsaus. *Suhdanne nro 2/2005*.

Tashakkori, Abbas & Teddlie, Charles. 1998. *Mixed methodology – combining qualitative and quantitative approaches*. Thousand Oaks: SAGE Publications.

Teece, David. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy* 15, 285–305.

Teece, David. 1992. Competition, cooperation, and innovation – organizational arrangements for regimes of rapid technological progress. *Journal of Economic Behaviour and Organization* 18, 1–25.

Valtioneuvosto. 2004. *Osaava, avautuva ja uudistuva Suomi – Suomi maailmantaloudessa selvityksen loppuraportti*. Helsinki: Valtioneuvoston kanslia 19/2004.

Williamson, Oliver. 1985. *The economic institutions of capitalism*. New York/London: Free Press.

Williamson, Oliver. 1999. Strategy Research: Governance and Competence Perspectives. *Strategic Management Journal* 20, 1087–1108.

INTERNATIONALISATION THROUGH STRATEGIC ALLIANCES – Determinants on non-equity alliances of Finnish firms[1]

Palmberg, Christopher and **Pajarinen**, Mika. **INTERNATIONALISATION THROUGH STRATEGIC ALLIANCES – DETERMINANTS ON NON-EQUITY ALLIANCES OF FINNISH FIRMS**
ABSTRACT: The internationalisation of firms is a salient feature of ongoing globalisation. Internationalisation has traditionally occurred through the extensions of the in-house activities of firms through foreign direct investments or other equity-based arrangements. However, the recent rapid growth of cross-border strategic alliances indicates that such international alliances increasingly complement in-house activities. Nowadays international alliances are typically based on looser non-equity agreements between firms in activities ranging from joint R&D, production, or various market-related activities. In this study we draw on new data to identify the determinants non-equity international alliance formation of large Finnish firms and thereby contribute with new insights into the reasons behind the recent internationalisation of these firms through strategic alliances. The econometric analysis is framed in terms of organisational theories of the firm, which emphasise the relationships between uncertainties embedded in the activities undertaken within alliances and their organisation. The results suggest that the involvement of firms in uncertain R&D- or market-related activities, and ICT technologies, determine the preference for non-equity alliances over equity-based ones in their internationalisation effort. In contrast, production-related activities are associated with tighter equity-based alliance organisations. Non-equity strategic alliances have thereby contributed less to the internationalisation of production-related activities when compared with R&D and market-related activities.

KEYWORDS: internationalisation, large Finnish firms, uncertainty, strategic alliances

Palmberg, Christopher ja **Pajarinen**, Mika. **KANSAINVÄLISTYMINEN STRATEGISTEN ALLIANSSIEN KAUTTA – SUOMALAISYRITYSTEN ALLIANSSITOIMINNAN SELITTÄJÄT**
TIIVISTELMÄ: Yritysten kansainvälistyminen on oleellinen osa menneillään olevaa globalisaatiokehitystä. Yritykset ovat perinteisesti kansainvälistyneet suorien sijoitusten kautta. Kansainvälisten strategisten allianssien lukumäärän voimakas kasvu viime vuosina indikoi kuitenkin, että allianssit ovat lisäämässä merkitystään yritysten kansainvälistymisponnisteluissa. Alliansseja muodostetaan liittyen niin t&k , tuotanto kuin markkinointitoimintoihinkin. Nykyisin yhä suurempi osa alliansseista perustuu järjestelyihin, joihin ei liity suoria pääomasijoituksia. Tässä tutkimuksessa pyritään selittämään tämäntyyppisen kansainvälisten ei-pääomasidonnaisten allianssien muodostamiseen vaikuttavia tekijöitä hyödyntäen tutkimusta varten luotua uutta suomalaisten suuryritysten allianssitietokantaa. Viimeaikaisessa teoreettisessa kirjallisuudessa on korostettu allianssin toimintaan liittyvien epävarmuuksien merkitystä allianssin organisaatiomuodon valinnassa; epävarmuuden lisääntyessä ei-pääomasidonnaiset allianssit ovat tyypillisempiä. Empiirisen analyysin tulokset tukevat tätä käsitystä, sillä ei-pääomasidonnaiset allianssit ovat analyysien mukaan tyypillisiä silloin, kun niiden toiminta liittyy t&k:hon, markkinointitoimintoihin tai ICT teknologiaan. Sitä vastoin vähemmän epävarmuutta sisältävissä tuotantotoimintaan liittyvissä alliansseissa pääomasidonnaiset allianssijärjestelyt ovat tyypillisempiä ja kansainvälistyminen suhteellisesti vähempää strategisten allianssien näkökulmasta.

AVAINSANAT: kansainvälistyminen, Suomi, suuryritykset, epävarmuus, strategiset allianssit

1 INTRODUCTION

The internationalisation of firms is a salient feature of ongoing globalisation. Equity-based foreign direct investment (FDI) is one example of this internationalisation. It can be understood as an internationalisation of the in-house activities of firms ranging from R&D and production to marketing or after-sales services through equity investment. But firms also internationalise through other means. One complementary mean to FDI is international strategic alliance (Narula and Zanfei, 2003; Serapio and Hayashi, 2004). An international strategic alliance is here defined as a formal cross-border agreement between firms, which is characterised by a commitment by the partners to reach a common strategic goal. Defined in this way international strategic alliances delimitate a subset of inter-firms collaboration that excludes 'ordinary' buyer-seller or subcontracting relationships, unilateral licensing, franchising, and buyback agreements where the partners often have opposing goals (see Palmberg and Martikainen (2003) for a lengthier discussion of the definition).

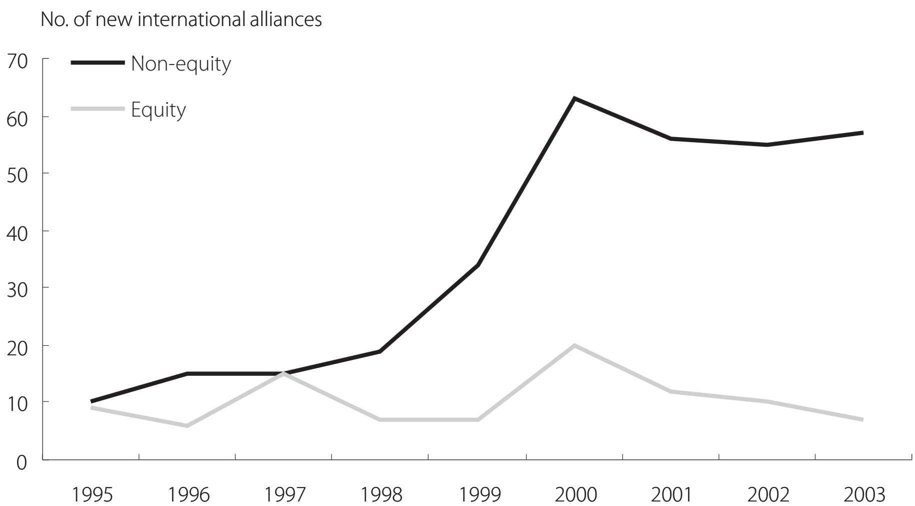
The recent increase of international strategic alliances is well documented in the business and research literature. Some even claim that this increase mounts to a new form of capitalism, namely "alliance capitalism". Alliance capitalism is characterised by collegial entrepreneurship as firms in-house activities increasingly are replaced by various multilateral and complex inter-firm network structures (Dunning, 1995; Dunning and Boyd, 2003). Traditionally this has been reflected in the increasing frequency of joint ventures between firms. An international joint-venture is essentially an extension of the in-house activities of firms, and shares certain similarities with FDI since they involve equity investments into a new entity controlled by the firm. However, the largest share of the recent increase in international strategic alliances is due to the proliferation of looser types of alliances based on non-equity agreements (Hagedoorn, 2002).

In this paper we leave the broader discussion of alliance capitalism aside and focus on the internationalisation of large Finnish firms through international strategic alliances. The internationalisation of Finnish firms has mainly been studied from the viewpoint of FDI (Pajarinen and Ylä-Anttila, 1999; Ali-Yrkkö et al., 2004). A recent study indicates that the largest Finnish firms indeed are internationalised, especially in terms of the share of turnover generated by production abroad, by the share of personnel located abroad, and by the share of R&D that they perform abroad (Lovio, 2004). Nonetheless, until now, less is known about the extent and nature of their international strategic alliances as a complementary mean of internationalisation.

This paper draws on a new database of strategic alliances involving large Finnish firms. A quick initial glance at this new data in figure 1 suggests that these firms have also internationalised through international strategic alliances at an increasing rate, especially since the late 1990s, even though there has been a levelling off in recent years. Further, the increase in international strategic alliances of Finnish firms is compatible with global trends in the sense that the largest share of this increase is due to looser types of non-equity alliances rather than equity-based joint ventures.

The aim of this paper is to identify the determinants of non-equity alliance formation of Finnish firms and thereby also contribute with new insights into the reasons behind the rapid internationalisation of these firms through strategic alliances. Extant research has typically analyzed the choice of strategic alliance organisation from the viewpoint of transaction cost economics and structural sociology (see e.g. Hagedoorn and Narula, 1996; Gulati and Singh, 1998). These theoretical frameworks emphasize issues related to uncertainties in partner selection during alliance formation. A recent paper by Casciaro (2003) convincingly downplays the importance of partner selection uncertainties in favour of uncertainties embedded in the actual tasks undertaken in alliances and their industrial contexts. In this paper we elaborate further especially on this insight. Through our focus on international strategic alliances we can also incorporate variables relating to the nationality of the foreign partner of these alliances. We also incorporate positional asymmetries between the firms which appear as especially relevant from the viewpoint of Finland as a small country. The paper thereby complements extant research, and also offers new insights into the internationalisation of Finnish firms through strategic alliances.

Figure 1.1 The growth of international strategic alliances of Finnish firms



Source: The SAFIF database.

The paper is structured as follows. Section 2 presents the analytical framework applied in the empirical analysis. Section 3 discusses the data sources and sample in greater detail, motivates and describes the variables used. Section 4 covers the descriptive and econometric analysis, while section 5 concludes the paper.

2 AN ANALYTICAL FRAMEWORK

2.1 STRATEGIC ALLIANCES AND THE INTERNATIONALISATION OF FIRMS

Barely a day goes by without press releases of the formation of an international strategic alliance between firms. From extant research we indeed do know that the growth in strategic alliances has picked up especially since the early 1980s and increasingly transcend country boundaries. Which factors have contributed to this proliferation of international strategic alliances? Why are firms increasingly opting for looser types of non-equity alliances in the internationalisation efforts? One can identify a set of factual explanations that relate to the changing nature of competition and technologies in the global economy, as well as a range of theoretical frameworks focusing on governance structures pertinent to different firm activities.

As suggested above the growth in international alliances is generally considered to be intertwined with the ongoing process of globalisation. International alliances, especially of the non-equity kind, provide a means of firms to simultaneously be present, source knowledge and compete in these multiple countries and regions without the liabilities associated with FDI or joint ventures. Nonetheless, globalisation and inter-firm collaboration as such are not very new phenomena if we apply a historical viewpoint. Instead reference is often made to the overall reduction of the costs of coordinating economic activities within and between firms and other parties that drive globalisation itself. Two reasons are usually singled out as particularly important in this context. The first is the introduction of new space-shrinking technologies due to developments in the field of information and communication technologies (ICT). The second relates to the harmonisation of regulations and barriers as a result of economic liberalisation (Narula and Zanfei, 2003).

The effects of ICT on coordination costs are quite obvious. ICT technologies have developed very rapidly especially since the 1990s, while the price of the related equipment successively has dropped. As a result computers, mobile telephone networks and various Internet-related technologies have diffused widely and dramatically lowered communication costs in all industries. Communication and transactions across geographical space is now much more convenient and supportive for the coordination of international strategic alliances than ever before. Firms do not necessarily have to be physically present in the various countries and regions to which they internationalise their activities, and might thereby also prioritize strategic alliances over FDI or joint ventures as the more traditional modes of internationalisation.

The effects of economic liberalisation are more multi-faceted with different implications for different firms, industries and regions of the world.

These have been further enhanced by the establishment of multinational organisations such as NAFTA and the EU, and multilateral international agreements such as WTO, WIPO etc. Such organisations and agreements have reduced risks and enhanced the enforceability of cross-border inter-firm agreements. From the viewpoint of Finland, the role of the Single European Market, EUREKA and the R&D framework program initiatives of the EU should be highlighted. Finland has been an active participant in these initiatives, especially after full EU-membership in 1995 (Lemola, 1994; Luukonen, 2002).

However, the reduction of coordination costs might not always be the prime motivator for international strategic alliance formation, especially since longer-term strategic goals are involved. The emergence of new technological fields and the general increase in technological complexity are important additional considerations that incentive firms to share risks and pool knowledge through alliances (Palmberg and Martikainen, 2006). Today many products and processes typically build on multiple technologies which require complementary knowledge inputs from many firms, especially in high-technology fields such as biotech, ICT or new materials. Due to national differences in regulations and norms governing new technologies cross-border collaboration is also often a requirement for market access. Meanwhile development costs are mounting. In these circumstances international strategic alliances often constitute a first-best path of internationalisation due to added flexibility, cost- and risk-sharing in the various activities of firms, especially when compared with FDI.

2.2 DETERMINANTS OF NON-EQUITY ALLIANCE FORMATION

The various theoretical frameworks that have sought to interpret the proliferation of international strategic alliances usually take their departure in transaction cost economics pioneered by Coase (1937) and developed further by Williamson (1975, 1985, 1991 and 1999), see also Lemola (1994). Transaction cost economics considers how different attributes of transactions that firms are involved in relates to the way in which firms organises, or govern, their transactional activities with other firms. These attributes are the frequency with which transactions occur, the uncertainty to which they are subject to, and the type of asset that is being transacted. Further, firms are assumed to act opportunistically.

The issue of uncertainty is especially important in transaction cost economics. Transactional uncertainty arises when the possible contingencies affecting the execution of the related agreement are complex and difficult for the partners to understand, predict or articulate. One example might be a situation where a firm considers how to organise a specific R&D project in a new and risky technology field. In such a situation transaction cost economics would suggest that a collaborative agreement, for example in the form of a non-equity R&D alliance, is unviable due to the transactional uncertainties involved. This is nonetheless at odds with the observation of the rapid growth of such alliances recently, especially in high-technology areas characterised by uncertainties and various other contingencies.

Elaborations of the transaction cost framework have sought to come up with alternative interpretations for why firms engage in strategic alliances, especially of the non-equity and cross-border type. One line of research highlights the importance of trust as a mediating factor in the trade-offs between uncertainties and the preference for such alliances. The logic here is that an alliance is an organisational device that offers some degrees of control over transactional uncertainties between firms and that trust is the social mechanism that reduces opportunistic behaviour and transaction costs in such cases (Das and Teng, 1998). Partner selection is considered as crucial since an alliance with a familiar partner mitigates uncertainties, facilitates trust, and thereby reduces transaction costs. (see e.g. Gulati and Singh (1998); Nooteboom (1999)).

In this paper we take a dissenting view along the lines suggested by Casciaro (2003). She convincingly downplays the significance of partner selection uncertainties and instead introduces the concepts of task and strategic uncertainty. Task uncertainty is defined as the extent to which it is possible to predict in advance the behaviour of the elements that compose the task to be undertaken in an alliance, and will be affected by the complexity and number of elements composing a task. Strategic uncertainty stems from the strategic positioning of the alliance within chosen markets and concerns the markets' demand, supply and valuation of the products, services or technologies developed within an alliance.

The point made is that various combinations of task and strategic uncertainties are determined by the type of activities covered by the alliance. Strategic alliances, whether of the equity or looser non-equity type, commonly comprise of R&D, production or market-related activities. According to Casciaro (2003) these different types of activities embody different combinations of task and strategic uncertainties. Differing levels of task and strategic uncertainty, in turn, are considered the determinants of choice of non-equity alliances over equity-based ones irrespective of partner selection uncertainties. Strategic uncertainty is the theoretical elaboration of particular interest especially in this paper.

The organisation of alliances will be solely driven by task uncertainties in cases when strategic uncertainty is low. However, when strategic uncertainties increase the risks of equity investments in alliance formation will also grow and make equity-based alliances increasingly unviable. Such strategic uncertainty might, for example, relate to the exploration of new technology fields or product markets which are highly dynamic and competitive and characterized by technological complementarities between firms. In such cases non-equity alliance provides firms with a flexible option to explore new technologies or markets without excessive commitments. This insight is also compatible with the discussion of complementary assets in Teece (1992). The predicted effects of task and strategic uncertainty on the organisation of alliances is summarised in figure 2.1.

The discussion of task and strategic uncertainty complements transaction cost economics with a more nuance interpretation of the trade-offs between uncertainty and the organisation of strategic alliances. Further, it refocuses the discussion on strategic alliance formation from partner selection issues to the actual tasks undertaken and their broader contexts. Nonetheless, it is clear that the asymmetric position of firms in technology fields and industries also will influence the organisation of alliances. This is the case especially in international cross-border alliances where different national cultures and other unobserved issues probably amplify firm asymmetries further.

The literature identifies different sources of positional asymmetries between firms. The effect of firm size on organizational behaviour is a common issue (see e.g. Hernan et al., (2003)). In the context of strategic alliances larger firms might have scale-economy advantages in their equity investments related to equity-based alliances. But larger firm size might also enhance the ability of firms to simultaneously manage multiple alliances and thereby affect the willingness to collaborate with other firms on a looser non-equity basis. Larger firm size typically also correlates with the technological strengths of firms, for example as measured through the size of patent portfolios. Such differences between firms are additional sources of positional asymmetries in alliance formation, for example in terms of negotiating power and IPR positions, technological strength or absorptive capabilities in general (Baughn et al., 2001). They should be taken into account in empirical analysis of the alliance activity of firms.

Figure 2.1 Effects of task and strategic uncertainty on alliance organisation

	Task uncertainty	
Strategic uncertainty	**Low** Equity-based	Non-equity
	Non-equity	Non-equity **High**

3 DATA DESCRIPTION

3.1 DATA SOURCES AND SAMPLE

The sample includes 22 Finnish firms. Inclusion of firms was based on firm size and industry affiliation. The point of departure was the most recent ranking list of the 500 largest Finnish firms produced by the business magazine Talouselämä. The forestry-related, metals/engineering, chemicals and ICT industries were selected as the most important ones to the Finnish economy. From this ranking list 4–5 of the largest firms were selected. Further, the list was complemented with three largest diversified multi-industry firms in Finland which could not easily be assigned to a particular industry.

The data on alliances was collected through systematic reviews of the press reports of these firms, complemented with a review of relevant articles in the largest Finnish business newspaper Kauppalehti. These sources were used to identify strategic alliances formed by the included Finnish firms during 1995–2004 and to collect data on the nature and content of these alliances into a database (the SAFIF database). An international strategic alliance is here defined as *a formal cross-border agreement between firms, which is characterised by a commitment by the partners to reach a common strategic goal*. Defined in this way international strategic alliances delimitate a subset of inter-firms collaboration that excludes 'ordinary' buyer-seller or subcontracting relationships, unilateral licensing, franchising, and buyback agreements where the partners often have opposing goals. The possible pitfalls of this methodology mainly relate to definitional issues and to potential under coverage since firms might have varying attitudes towards publicizing their involvement in alliances (see e.g. Palmberg and Martikainen (2003) for a further discussion).

As suggested in the discussion above, we seek explanations for the choice of non-equity alliances over equity-based ones in the tasks being undertaken within alliances, in their industrial contexts and in the characteristics of the partner firms. From a definitional viewpoint our starting point is thereby the information in the data on whether the alliances include equity-investments by the partner firms involved in the alliance. The data also contains information on the actual activities undertaken in terms of R&D, production or market-related activities. Typically the non-equity alliances in the data comprise of R&D development agreements, R&D or production second sourcing agreements, or various types of cross-licensing agreements. Non-equity market-related alliance typically cover various agreements whereby firms exchange marketing rights over specific products/components which make up a larger product system – this is quite common in ICT due to interoperability requirements.

This information on alliances was complemented with firm-level data on patenting at the US Patent Office (USPTO) to cover positional asymmetries of the partner firms, both in terms of size and technological strength. Direct firm size indicators could only be found for a limited number of firms and were hence dropped. We also collected information on other complementary internationalisation efforts of the Finnish firms, such as foreign turnover and employment, and international mergers and acquisitions to cover FDI.

In order to clarify the empirical set-up we exclude international alliances between multiple firms. The final sample covers 417 bilateral international strategic alliances. Table 3.1 provides a list of the included Finnish firms, their industrial affiliation, size by net sales, and the number of international alliances that they have been involved in according to our data.

Table 3.1 Finnish firms included in the sample

	Industry	Net sales in 2003 (mill. eur)	Total number of alliances
Nokia	ICT	29 455	179
TeliaSonera	ICT	1 939	30
Elisa	ICT	1 538	28
TietoEnator	ICT	1 374	39
Novo	ICT	370	18
Kemira	Chemical	2 738	12
Orion	Chemical	2 262	16
Uponor	Chemical	1 021	8
Dynea	Chemical	992	2
Raisio	Chemical	861	6
Stora Enso	Forestry-related	12 172	6
UPM-Kymmene	Forestry-related	9 948	9
Huhtamäki	Forestry-related	2 108	5
Ahlström	Forestry-related	1 556	6
Outokumpu	Metals/engineering	5 921	16
Kone	Metals/engineering	5 344	2
Metso	Metals/engineering	4 250	8
Wärtsilä	Metals/engineering	2 358	7
KCI Konecranes	Metals/engineering	665	3
Amer	Diversified	1 104	4
Instrumentarium	Diversified	1 036	10
Hackman	Diversified	401	3
Total		89 413	417

Sources: The SAFIF database and Talouselämä Top 500 database.

3.2 DEPENDENT AND INDEPENDENT VARIABLES

Type of international alliance

The dependent variable is constructed based on the information on whether equity investment was involved during alliance formation. It is coded as a binary variable labelled CATEGORY and takes the value 1 if the alliance is based on a non-equity agreement and the value 0 if it involves equity-investment. The dependent variable thereby captures the organisation of international alliance involving the included large Finnish firms, compatible with our aim to explain why these firms are opting for looser types of non-equity alliances in their internationalisation efforts and at an increasing rate.

Task and strategic uncertainty

Our focus on task and strategic uncertainty, rather than partner selection uncertainty, as determinants of the organisation of alliances is holistically incorporated through three dummy variables. The information collected on the alliance enabled the classification of all alliances into three main types, namely R&D, production or market-related alliances. R&D alliances are labelled as RTYPE, production alliances as PTYPE and market-related alliances as MTYPE. They take the value 0 or 1 depending on the specific type of tasks or activities involved.[2] The predictive effects of these variables on the organisation of alliances are derived from figure 2.1 and similar to the set-up in Casciaro (2003).

The variable RTYPE is assumed to be associated with high task uncertainty since R&D activities typically embody complexity, unpredictable outcomes and high risks. However, the association of R&D activities with high levels of strategic uncertainty is more noteworthy in this context. This is due to the fact that R&D activities, per definition, aim for the development of new marketable products. In these circumstances insights into the markets' demand, supply and valuation is incomplete at best. We thereby predict that R&D activities will encourage firms to choose non-equity alliances over equity based ones in their internationalisation efforts.

The variable PTYPE is assumed to be associated with moderate to high levels of task uncertainty, and low to moderate levels of strategic uncertainty. This is because production involves the exchange of relatively standardised inputs and outputs between the partners, and is subject to high levels of standardisation and coordination. Nonetheless, strategic uncertainty tends to be low since voluminous production already presupposes knowledge about the markets' demand, supply and valuations, even in cases where the technologies are new to the market. We thereby predict that production activities will encourage firms to favour equity-based alliances over non-equity ones due to advantages of tighter coordination between firms.

The variable MTYPE is assumed to be associated with highly variant levels of task uncertainty as market-related alliances might differ greatly in nature. They might be limited in scope as joint promotional efforts or the transfer of marketing rights over established products. They might also cover complex joint design, retailing or after-sales activities in new markets whereby task uncertainty might be high. As regards strategic uncertainty it can be assumed that it ranges from low to moderate since joint market-related alliance activities also presupposes knowledge about the markets' demand, supply and valuations. Still the heterogeneous nature of market-related alliances implies that any clear-cut predictions are hard to make. In line with Casciaro (2003) we also refrain from doing so.

Technology fields

As suggested above the viability of non-equity alliances will depend on the broader industrial context, especially in terms of the nature of different technology fields. There is empirical evidence to suggest that non-equity alliances are preferred in new and dynamic technology fields in which risks and costs are higher, irrespective of the level of strategic uncertainty, while equity-based alliances are preferred in more stable fields (Hagedoorn and Narula, 1996; Hagedoorn, 2002).

In order to control for this we constructed dummy variables for different technology fields based on the description of the technological content of alliances.[3] These variables capture the technological contexts on an aggregate level, differentiating between the fields of chemicals (including pharmaceuticals) labelled CHEM, ICT labelled ICT, mechanical technologies labelled MECH and various other miscellaneous technology fields labelled MISC. They take the value 0 or 1 depending on the technology fields involved.

Positional asymmetries between partners

The variables capturing positional asymmetries between the partner firms are based on the number of granted patents at the USPTO that the firms have accumulated and are thus continuous. APOS is constructed as the absolute difference in granted patents of the alliance partners. We include a logarithmic transformation of this variable, LNAPOS, to incorporate for significant variance of APOS (see Table 4.1). Further, we construct a dummy variable DAPOS to assess whether positional asymmetries in terms of the number of patents favourable to the foreign partner has any effects on the organisation of alliances from the viewpoint of the Finnish firms.[4]

As suggested above the level of patenting usually correlates positively with firm size. APOS, LNAPOS and DAPOS thereby capture the joint effects of technological strength asymmetries between the partners and firm size. From the extant literature we know that such positional asymmetries might affect alliance formation in various ways depending on the activity undertaken. We therefore also extend the analysis to include interaction variables defined as RTYPE*LNAPOS, PTYPE*LNAPOS and MTYPE*LNAPOS. These extensions seek to interrogate whether positional asymmetries between partners to the alliances have a mediating effect on the suggested relationships between task and strategic uncertainty and the organisation of alliances. Nonetheless, no clear-cut predictions are derivable from the extant literature (Baughn et al., 2001).

Country of origin

Our focus on international cross-border alliances adds a new dimension to Casciaro (2003) which is limited to an empirical analysis of strategic alliances between US firms in the ICT industry. We can include country dummies to cover unobserved effects of different national regulations, norms or cultures on the organisation of international alliances. These country dummies are constructed based on the country of origin of the foreign partner firms to the alliances.

Altogether the database covers alliances with firm partners from 45 different countries. We single out the six most important countries as dummies to cover about 70 percent of all alliances. These dummies include SWE for Sweden, USA for USA, FRG for Germany, PRC for China, JPN for Japan, and FRA for France. The variable ROW captures all remaining countries, i.e. the remaining 30 percent of the alliances. They take the value 0 or 1 depending on the country of origin involved.

Complementary internationalisation

The role of FDI in the internationalisation efforts of firms is relatively well understood, also in the case of large Finnish firms. In this paper we suggest that international strategic alliances – especially of the non-equity kind – offer complementary means of internationalisation. In the extant literature there is some evidence to suggest that such alliances are interrelated with the FDI strategies of firms (Narula and Zanfei, 2003). In order to control for these possible interrelationships we also include variables to capture the extent of FDI that the included firms have been involved in.

FDI covers equity investment into established or new entities abroad. Cross-border mergers and acquisitions (M&A) is the dominating type of FDI in the case of large Finnish firms. We constructed a continuous control variable, FORMA, to captures this. FORMA is defined as the number of cross-border acquisitions that the Finnish firms have been engaged in 1996–2003. We also constructed the control variable FOREMP defined as the average percentage share of foreign employees in 1996–2003.[5] This variable can be interpreted as a very general measure of the degree of internationalisation of the firms, even though international strategic alliances are excluded.

4 EMPIRICAL ANALYSIS

4.1 DESCRIPTIVE ANALYSIS

Table 4.1 provides descriptive statistics of the sample and variables used in the analysis. We can see that 78 percent of all alliances are non-equity ones. Categorized by the type of activity, R&D alliances have the largest share in the sample (58%) followed by market related (27%) and production alliances (15%). Categories of the technological field reveal that 2/3 of alliances are related to ICT.

Our proxy for positional asymmetries between partners, APOS, indicates that there is a huge variance in the partner firms' patent portfolios and/or size. To cope with this feature in the ensuing empirical analysis we use logarithmic transformation of the variable (ln(1+APOS)). Further, DAPOS shows that almost 1/3 of alliances involve foreign partners with a larger patent portfolio than the Finnish partner.

By countries of foreign partners, the frequency is the highest for the US firms (43%), followed by the Swedish (7%) and German (7%) ones. Our measure for the degree of internationalisation, FOREMP, shows that on average the share of foreign employees is 45 percent. The proxy for FDI, FORMA, reveals that the number of M&As of the sample firms in 1996-2003 period ranges from 0 to 36, while the average is 14 acquisitions.

Table 4.1 Descriptive statistics

	Mean	S.D.	Min	Max	N
CATEGORY	0.782	0.414	0	1	417
RTYPE	0.578	0.494	0	1	417
MTYPE	0.273	0.446	0	1	417
PTYPE	0.149	0.356	0	1	417
CHEM	0.199	0.400	0	1	417
ICT	0.664	0.473	0	1	417
MECH	0.125	0.331	0	1	417
MISC	0.007	0.085	0	1	417
APOS	2 489	3 936	0	24 818	417
LNAPOS	5.813	2.883	0	10.119	417
DAPOS	0.312	0.464	0	1	417
SWE	0.067	0.251	0	1	417
USA	0.427	0.495	0	1	417
FRG	0.065	0.246	0	1	417
PRC	0.053	0.224	0	1	417
JPN	0.043	0.203	0	1	417
FRA	0.038	0.192	0	1	417
ROW	0.307	0.462	0	1	417
FOREMP	0.454	0.218	0.045	0.917	417
FORMA	14	10	0	36	417

Table 4.2 depicts unconditional pair-wise correlations. We can see that the preference for non-equity alliances over equity based ones by the variable CATEGORY correlates positively both with RTYPE and MTYPE and negatively with PTYPE. All these correlations are also statistically significant ($p<0.01$). CATEGORY correlates positively and statistically with ICT ($p<0.01$) and negatively with CHEM ($p<0.10$) and MECH ($p<0.01$). Further, all our measures for positional asymmetries between partners (APOS, LNAPOS, DAPOS) correlate positively and statistically significantly with CATEGORY.

Table 4.2 Pairwise correlations

	CATEGORY	RTYPE	MTYPE	PTYPE	CHEM	ICT	MECH	MISC	APOS	LNAPOS	DAPOS	SWE	USA	FRG	PRC	JPN	FRA	ROW	FOREMP	FORMA
CATEGORY	1.000																			
RTYPE	0.207	1.000																		
	(0.000)																			
MTYPE	0.220	-0.718	1.000																	
	(0.000)	(0.000)																		
PTYPE	-0.563	-0.489	-0.256	1.000																
	(0.000)	(0.000)	(0.000)																	
CHEM	-0.086	-0.060	0.045	0.028	1.000															
	(0.081)	(0.218)	(0.364)	(0.568)																
ICT	0.313	0.164	0.072	-0.317	-0.701	1.000														
	(0.000)	(0.001)	(0.145)	(0.000)	(0.000)															
MECH	-0.345	-0.162	-0.150	0.414	-0.188	-0.531	1.000													
	(0.000)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)														
MISC	-0.024	-0.042	0.012	0.044	-0.042	-0.120	-0.032	1.000												
	(0.629)	(0.391)	(0.816)	(0.368)	(0.387)	(0.014)	(0.513)													
APOS	0.173	0.148	-0.062	-0.128	-0.130	0.207	-0.143	-0.038	1.000											
	(0.000)	(0.003)	(0.210)	(0.009)	(0.008)	(0.000)	(0.004)	(0.439)												
LNAPOS	0.210	0.217	-0.142	-0.124	-0.002	0.094	-0.138	-0.028	0.632	1.000										
	(0.000)	(0.000)	(0.004)	(0.011)	(0.966)	(0.056)	(0.005)	(0.566)	(0.000)											
DAPOS	0.155	-0.096	0.191	-0.107	-0.050	0.095	-0.082	0.004	0.313	0.111	1.000									
	(0.002)	(0.051)	(0.000)	(0.030)	(0.306)	(0.053)	(0.096)	(0.936)	(0.000)	(0.024)										
SWE	0.026	0.035	0.029	-0.085	-0.062	0.089	-0.043	-0.023	-0.126	-0.299	-0.057	1.000								
	(0.600)	(0.473)	(0.556)	(0.082)	(0.208)	(0.069)	(0.378)	(0.642)	(0.010)	(0.000)	(0.250)									
USA	0.221	0.060	0.145	-0.265	-0.017	0.172	-0.238	-0.016	0.223	0.260	0.278	-0.232	1.000							
	(0.000)	(0.220)	(0.003)	(0.000)	(0.724)	(0.000)	(0.000)	(0.743)	(0.000)	(0.000)	(0.000)	(0.000)								
FRG	-0.003	0.028	-0.030	0.000	0.064	-0.040	-0.040	0.093	-0.081	-0.121	-0.030	-0.071	-0.227	1.000						
	(0.959)	(0.575)	(0.539)	(0.994)	(0.192)	(0.416)	(0.412)	(0.058)	(0.100)	(0.014)	(0.544)	(0.150)	(0.000)							
PRC	-0.187	-0.102	-0.049	0.203	-0.037	0.009	0.041	-0.020	-0.049	-0.041	-0.159	-0.063	-0.204	-0.062	1.000					
	(0.000)	(0.037)	(0.323)	(0.000)	(0.451)	(0.858)	(0.406)	(0.683)	(0.315)	(0.400)	(0.001)	(0.197)	(0.000)	(0.206)						
JPN	-0.059	0.062	-0.104	0.044	-0.047	-0.049	0.134	-0.018	0.199	0.172	0.086	-0.057	-0.183	-0.056	-0.050	1.000				
	(0.228)	(0.206)	(0.034)	(0.371)	(0.341)	(0.319)	(0.006)	(0.713)	(0.000)	(0.000)	(0.078)	(0.246)	(0.000)	(0.255)	(0.307)					
FRA	-0.046	0.019	-0.011	-0.013	-0.006	-0.017	0.038	-0.017	-0.058	-0.057	-0.027	-0.054	-0.172	-0.053	-0.047	-0.042	1.000			
	(0.353)	(0.698)	(0.831)	(0.787)	(0.906)	(0.735)	(0.439)	(0.729)	(0.240)	(0.250)	(0.588)	(0.275)	(0.000)	(0.284)	(0.337)	(0.388)				
ROW	-0.114	-0.084	-0.082	0.219	0.059	-0.188	0.205	0.005	-0.168	-0.084	-0.201	-0.179	-0.574	-0.175	-0.157	-0.141	-0.133	1.000		
	(0.020)	(0.087)	(0.096)	(0.000)	(0.230)	(0.000)	(0.000)	(0.921)	(0.001)	(0.087)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.004)	(0.007)			
FOREMP	-0.168	0.173	-0.351	0.199	0.153	-0.329	0.242	0.143	-0.005	0.231	-0.258	-0.044	-0.052	-0.098	0.047	0.099	-0.053	0.121	1.000	
	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.003)	(0.912)	(0.000)	(0.000)	(0.376)	(0.290)	(0.046)	(0.337)	(0.044)	(0.281)	(0.013)		
FORMA	0.039	0.226	-0.184	-0.084	-0.130	0.190	-0.102	-0.065	-0.004	0.003	-0.102	0.219	-0.014	-0.065	-0.048	0.026	-0.088	-0.017	0.450	1.000
	(0.425)	(0.000)	(0.000)	(0.086)	(0.008)	(0.000)	(0.037)	(0.187)	(0.930)	(0.945)	(0.037)	(0.000)	(0.783)	(0.188)	(0.332)	(0.593)	(0.073)	(0.731)	(0.000)	

Notes: p-values are presented in the parentheses.

From the country controls, positive and statistically significant correlation with CATEGORY is found in the case of USA ($p<0.01$), while the correlation is negative for PRC ($p<0.01$) and ROW ($p<0.05$). Finally, FOREMP seems to correlate negatively and statistically significantly ($p<0.01$) with CATEGORY while no correlation is found in the case of FORMA.

These unconditional correlations thus preliminary suggest that firms choice of non-equity alliances over equity-based ones in their internationalisation efforts foremost are determined by the involvement of R&D or market related activities, ICT-related technologies, and situations in which there are positional asymmetries between partners during the formations of alliance.

4.2 ECONOMETRIC ANALYSIS

In order to elaborate further on the descriptive analysis we next run standard probit regressions in which the dependent variable is CATEGORY. Probit regressions use maximum likelihood methods to model the behaviour of a binary variable, such as CATEGORY, so that the results are interpreted in terms of the probability that the variable in question takes the value 1.[6] In this set-up we use three different sets of explanatory variables that are added in phases to the estimations.

The *first set* includes the variables capturing the different types of alliances based on the activities undertaken within the alliance (PTYPE is the omitted category). As suggested these are taken as indicative of various levels of task and strategic uncertainty related to alliance activity as the prime focus of the analysis. In addition, the first set includes dummy variables to capture technology fields (MECH is the omitted category).

We can see from table 4.3 that in this specification the coefficients RTYPE and MTYPE are positive and statistically significant ($p<0.01$), while the benchmark PTYPE is characterised by the opposite effect. These results confirm our descriptive analysis that R&D- and market- related alliance activities determine firms' choice of non-equity international alliances over equity based ones, while the effect of PTYPE is the opposite. Since R&D activities are taken to indicate higher levels of both task and strategic uncertainty, the effects of RTYPE and PTYPE are in line with our predictions derived from the analytical framework and the results in Casciaro (2003). In the case of MTYPE, no prediction was made and hence the result provides explorative evidence of the association between market-related activities and high strategic uncertainty. In addition, from dummy variables capturing technology fields of alliances, only the coefficient for ICT is positive and statistically significant ($p<0.01$).

In the *second set* we extend the specification to include the variables to capture positional asymmetries between partners and foreign partners' country of origin (ROW is the omitted category).

In this set RTYPE, MTYPE and ICT remain positive and statistically significant although the significance of ICT weakens somewhat ($p<0.05$). The coefficient for LNAPOS is positive and significant ($p<0.05$) which suggests that positional asymmetries between partners appear to matter and favour looser types of non-equity alliances in the internationalisation efforts of firms. In addition, the coefficient for DAPOS is positive and weakly significant ($p<0.10$). This gives some indication that from the viewpoint of the Finnish firms non-equity alliances are favoured in situations in which the foreign partner is larger in terms of technological strength/size. The coefficients for the interaction variables LNAPOS*RTYPE and LNAPOS*MTYPE are statistically insignificant. Table 4.3 also shows that the non-equity alliances tend to be disfavoured when Chinese or Japanese partners are involved as indicated by the negative and statistically significant ($p<0.05$) coefficient for PRC and negative and weakly statistically significant ($p<0.10$) coefficient for JPN.

Table 4.3 Estimation results.

	Probit estimations, dependent variable CATEGORY								
	(1)			(2)			(3)		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
RTYPE	1.592	0.217	***	1.896	0.564	***	1.892	0.569	***
MTYPE	2.031	0.267	***	2.670	0.619	***	2.667	0.625	***
CHEM	0.207	0.260		0.093	0.282		0.076	0.284	
ICT	0.695	0.228	***	0.620	0.244	**	0.567	0.276	**
MISC	0.439	0.969		0.185	0.976		0.258	0.985	
LNAPOS				0.191	0.088	**	0.200	0.089	**
DAPOS				0.357	0.211	*	0.336	0.213	
LNAPOSxRTYPE				-0.071	0.094		-0.071	0.095	
LNAPOSxMTYPE				-0.123	0.110		-0.128	0.111	
SWE				0.018	0.370		0.048	0.380	
USA				-0.184	0.226		-0.188	0.227	
FRG				0.022	0.354		0.003	0.358	
PRC				-0.805	0.361	**	-0.815	0.364	**
JPN				-0.707	0.405	*	-0.701	0.406	*
FRA				-0.510	0.405		-0.544	0.411	
FOREMP							-0.322	0.581	
FORMA							-0.001	0.011	
Observations	417			417			417		
Chi^2	126.067			151.037			151.586		
degr. of freedom	5			15			17		
significance	0.000			0.000			0.000		
Pseudo R^2	0.288			0.345			0.346		
Log likelihood	-155.747			-143.262			-142.987		

Notes: CATEGORY takes value 1 if the alliance is a non-equity one and 0 if it involves equity investment. S.E.= standard error. The asterisks indicates statistical significance of coefficients: (***) denotes significance at 1 percent level, (**) at 5 percent level and (*) at 10 percent level.

In the *third set* we add the variables to capture complementary internationalisation efforts, FOREMP and FORMA. In this final set all previously noted results remain valid with the exception that DAPOS is now insignificant. However neither FOREMP nor FORMA turn up as significant, although the sign of their coefficients are both negative.[7] Thus, by and large there does not seem to be a noteworthy relationship between FDI or more traditional modes of internationalisation and international non-equity alliances in this data.

4.3 ROBUSTNESS ANALYSIS

In the following we summarize the results of some additional analysis to study the robustness of our probit model estimation findings. Taking each robustness test in turn:

Robustness test 1

In order to show that our results are not biased by the estimation model used, we rerun estimations by using alternative estimation models. Specifically, we rerun the estimations by using 1) logit instead of probit model and 2) standard OLS with robust standard errors. In these estimations the coefficients for RTYPE, MTYPE and ICT maintain their signs and remain statistically significant (for RTYPE and MTYPE $p<0.01$ and for ICT $p<0.05$) in all three variable specification sets and hence appear robust. Also the sign and significance level of LNAPOS remain unchanged in the logit and OLS estimations while DAPOS is insignificant in these estimations. The coefficients for PRC and JPN remain negative and maintain their significant levels ($p<0.05$ and $p<0.10$, respectively) in sets 2 and 3 in which they are included. We can conclude that the main results appear as robust according to this first robustness test.

Robustness test 2

The largest Finnish firm, Nokia, also has the largest number of international alliances in the sample. To analyse whether our findings are driven by this single firm we excluded it from the sample and rerun the probit estimations. In these estimations MTYPE, RTYPE and ICT remain positive and maintain their significance levels. However, the significance of the other coefficients weakens even though their signs remain the same. In the specification 3, for instance, only RTYPE, MTYPE and ICT are statistically significant. From the other variables LNAPOS is the closest to acceptable significance levels, in specification 2 the p-value is 0.090 and in specification 3 the p-value is 0.105. We can conclude that the effects of other than the three above mentioned variables are dependent on the inclusion of Nokia in the sample, even though the main variables which we are focusing in this paper remain robust also according to this second robustness test.

5 A CONCLUDING DISCUSSION

The point of departure of this paper is in the recent rapid growth of non-equity alliances globally and from the viewpoint of large Finnish firms. We suggest that such alliances offer a complementary means of internationalisation when compared with FDI and other equity-based investments, such as joint ventures. Using new data we focus on the formation of international strategic alliances of these large Finnish firms with the aim of identifying the determinants of the choice of non-equity alliances over equity-based ones, and thereby also contribute with new insights into the reasons behind the rapid internationalisation of these firms through such strategic alliances.

In general the recent rapid growth of non-equity international alliances foremost relates to the introduction of space-shrinking ICT-related technologies, the harmonisation of regulations and barriers governing cross-border transaction, and to increasing complexities, risks and costs associated with new technologies. In the traditional theoretical literature strategic alliance formation and organisation is typically interpreted in terms of transaction costs and uncertainties related to partner selection during alliance formation. Instead, in this paper we followed a recent paper by Casciaro (2003) and framed the empirical analysis from the viewpoint of trade-offs between a combination of so-called task and strategic uncertainties, deduced from the type of alliance activity involved. Further, we included variables to control for different technology fields, to capture positional asymmetries between the partners, countries of origin, and complementary internationalisation efforts.

The descriptive and econometric analysis suggests that firms' choice of looser types of non-equity alliances over equity based ones in their internationalisation efforts are determined by their involvement in R&D and market-related activities, such as joint promotional efforts or design, transfer of marketing rights, retailing or after sales services. This result was interpreted in terms of high strategic uncertainty, or the high risks and costs involved in the development and commercialisation of new technologies, products or processes. In such situations large Finnish firms are increasingly prone to engage in non-equity alliances as a part of their internationalisation efforts. This result is in line with extant research and the observation of rising R&D intensities in Finnish industries since the early 1990s. It is also compatible with the increasing involvement of these firms in international markets as captured by various other indicators (Lovio, 2004). In contrast, production-related activities are associated with tighter equity-based alliance organisations such as joint ventures. We thus also conclude that non-equity strategic alliances have contributed less to the internationalisation of production-related activities of these firms when compared with R&D and market-related activities.

These conclusions receive further confirmation based on the association between alliances in ICT-related technology fields with a preference for non-equity alliances since ICT is a prime example of a new and rapidly developing technology field characterised by high market uncertainty at present. We also know from extant research that non-equity alliances are particularly prominent in ICT-related fields due to prevalence of complementary technologies, systemic innovation, standardisation and network externalities (Palmberg and Martikainen, 2006).

Regarding positional asymmetries between firms the results indicate a positive association between non-equity international alliances and positional asymmetries – measured by the size differences of patent portfolios of partner firms – although the result suffers from non-robustness when Nokia is excluded from the estimations. Nonetheless, we take these results as a weak indication that positional asymmetries matter in alliance formation, as also suggested in extant research. Such positional asymmetries foremost concern issues related to bargaining power and IPRs, or the differing capability of firms to manage non-equity alliances which have not been captured in our analysis in a satisfactory way (Baughn et al., 2001). The specificities of the results regarding Nokia probably reflect the variance in the size of patent portfolios of Nokias partners, the superior internationalisation pattern of this firm when compared to most other firms in the sample, and specificities of the ICT industry.

In terms of country of origin of the foreign partners to the alliances, the only noteworthy result is that large Finnish firms forming alliances with Asian (Chinese and Japanese) partners appear to favour equity-based alliances rather than non-equity ones. However, a discussion on the specificities of these Asian countries' regulations, norms or business cultures governing alliances is beyond the scope of this paper and would warrant further in-depth research. Finally, we can conclude that the international alliance activities of large Finnish firms appear to be unrelated to their FDI activities. This conclusion is based on the insignificant effects of M&As intensity and the average share of foreign employees on the dependent variable. It suggests that the recent rapid growth of international strategic alliances presents new challenges for Finnish firms in the globalising economy.

Further research areas in the domain pursued here could concern the indications that positional asymmetries between firms matter in alliance formation. It would be important to develop better indicators to capture such asymmetries in greater detail, as well as to investigate qualitatively how various types of asymmetries between firms affect their position in alliances and the outcomes that alliances have on the performance and positioning of firms in the markets. These are especially important questions from the viewpoint of Finnish firms, which might be classified as large in a Finnish context but nonetheless constitute small players in global competition.

FOOTNOTES

[1] This paper has previously been published in the The Finnish Journal of Business Economics 4/05. We wish to kindly thank the publisher for the permission to reprint the paper in this book.

[2] Some alliances cover a combination of these activities. The variables are however constructed to describe the principal function of alliance and thus each alliance can belong to only one of the activity categories.

[3] The technology fields are defined based on the nomenclature used by the US Patent Office as done by Jaffe and Trajtenberg (2002).

[4] We calculated the total stock of US patents granted April 2004.

[5] Due to data constraints the length of time period for the two measures of complementary means of internationalisation is somewhat shorter than in the case of alliance data.

[6] See, for example, Greene (2003) for more detailed description of probit model.

[7] We ran estimations also with logarithmic transformations of FOREMP and FORMA. This modification had no effect on the results.

REFERENCES

Ali-Yrkkö, J., Lovio, R. & Ylä-Anttila, P. (eds.). 2004. *Multinational Enterprises in the Finnish Innovation System.* The Research Institute of the Finnish Economy (ETLA) B:208.

Baughn, C., Denekamp, J., Stevens, J. & Osborn, R. 2001. Protecting intellectual capital in international alliances. *Journal of World Business*. 32(2), 103-117.

Caloghirou, Y., Ioannides, S. & Vonortas, N. 2003. *Journal of Economic Surveys*, vol. 17, no.4.
Casciaro, Tiziana. 2003. Determinants of governance structure in alliances: the role of strategic, task and partner uncertainties. *Industrial and Corporate Change*, vol.12, no. 6, 1223-1251.

Coase, R. 1937. The Nature of the Firm. *Economica* no.5, 4. 386-405.

Das, T. & Teng, B. 1998. Between trust and control: developing confidence in partner cooperation in alliances. *Academy of Management Review*, 23, 49-521.

Dunning, J. 1995. Reapprasing the eclectic paradigm in an age of alliance capitalism. *Journal of International Business Studies*, Third Quarter, 461-491.

Dunning, J. & Boyd, G. (eds.). 2003. *Alliance capitalism and corporate management – Entrepreneurial cooperation in knowledge-based economies.* Cheltenham: Edward Elgar.

Greene, W. 2003. *Econometric analysis*. Fifth Edition. New Jersey: Prentice-Hall, Inc.

Gulati, R. & Singh, H. 1998. The architecture of cooperation: managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly*, 43, 781-814.

Hagedoorn, J., Link, A. & Vonortas, N. 2000. *Research partnership*s. Research Policy 29, 567-586.

Hagedoorn, J, 2002. Inter-firm partnerships: an overview of major trends and patterns since 1960. *Research Policy* 31, 477-492.

Hagedoorn, J. & Narula, R. 1996. Choosing organizational modes of strategic technology partnering: international and sectoral differences. *Journal of International Business Studies*, Second Quarter 1996, 265-284.

Hernan, R., Marin, P. & Siotis, G. 2003. An empirical evaluation of the determinants of research joint venture formation, *The Journal of Industrial Economics*, vol. LI, 75-89.

Jaffe, A. & Trajtenberg, M. 2002. *Patents, citations & innovations – A window on the knowledge economy*. Cambridge MA: The MIT Press.

Lovio, R. 2004. Internationalization of R&D activities of Finnish corporations – recent facts, management and policy issues. In Ali-Yrkkö, J., Lovio, R. and Ylä-Anttila, P (eds.) *Multinational Enterprises in the Finnish Innovation System.* The Research Institute of the Finnish Economy (ETLA) B:208.

Lemola, T. 1994. *Yritysten välisen teknologiayhteistyön tausta ja muutoksen suuntaviivat*. VTT tiedotteita 1540.

Luukonen, T. 2002. Technology and market orientation in company participation in the EU framework programme. *Research Policy* 31, 437-455.

Narula, R. & Zanfei, A. 2003. The international dimension of innovation. *MERIT-Infonomics Research Memorandum Series* 2003-009.

Nooteboom, B. 1999. *Inter-firm alliances – Analysis and design*. London: Routledge.

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

Palmberg, C. & Martikainen, O. 2003. The economics of strategic R&D alliances – A review with focus on the ICT sector. *ETLA Discussion papers*, No. 881.

Palmberg, C. & Martikainen, O. 2006. Pooling knowledge – Trends and characteristics of R&D alliances in the ICT sector. Forthcoming in Zysman, J. & Newman, A. (eds.) *How revolutionary was the revolution? National responses, market transitions, and global technology in the digital era*. Stanford University Press.

Serapio, M. & Hayashi, T. 2004. *Internationalization of research and development and the emergence of global R&D networks.* Amsterdam: Elsevier, Research in International Business vol.8.

Teece, D. 1992. Competition, cooperation, and innovation. Organizational arrangements for regimes of rapid technological progress. *Journal of Economic Behavior and Organization* 18, 1-25..

Williamson, O. 1975. *Markets and Hierarchies: analysis and antitrust implications*. Free Press, New York.

Williamson, O. 1985. *The economic institutions of capitalism*. Free Press, New York/London.

Williamson, O. 1991. Comparative economic organization: the analysis of discrete sructural alternatives. *Administrative Science Quarterly*, 36, 269-296.

Williamson, O. 1999. Strategy research: governance and competence perspectives. *Strategic Management Journal* 20, 1087-1108.

INDIGENOUS CAPABILITIES VERSUS R&D ALLIANCES OF THE FINNISH TELECOM INDUSTRY[1]

Palmberg, Christopher and **Martikainen**, Olli. **INDIGENOUS CAPABILITIES VERSUS R&D ALLIANCES OF THE FINNISH TELECOM INDUSTRY**
ABSTRACT: After the success related to the GSM standard, the Finnish telecommunications industry has come to the crossroads and now phases various possible paths to follow and challenges to master. At present there is technological and market competition both within and between different next generation telecom standards, while the ICT industry as a whole is undergoing a potentially disruptive phase of development due to the convergence between information and telecommunications technologies and the rapid diffusion of Internet-related applications. Against this background we analyse recent patterns of internal and external diversification of prominent Finnish telecommunication firms using data on patents and strategic R&D alliances. Our results indicate that the Finnish telecommunication industry has diversified its technological base in recent years. The industry appears internally/indigenously weak in Internet-related 'new' telecommunications technologies and related applications. However, telecommunications firms have also extensively engaged themselves in complementary R&D alliances in these fields. We assess the limitations, present and possible future implications of these findings.

KEYWORDS: ICT convergence, Finnish firms, diversification, R&D alliances

Palmberg, Christopher ja **Martikainen**, Olli. **SUOMEN TELEALAN OSAAMISALUEET JA T&K ALLIANSSIT**
TIIVISTELMÄ: GSM-standardin luoman menestyksen jälkeen suomalainen tietoliikenneala on uusien valintojen ja haasteiden edessä. Tällä hetkellä on käynnissä kilpailu useiden seuraavan sukupolven teknologiastandardien välillä, sekä siitä mihin standardeihin nykyiset markkinat siirtyvät. Tätä taustaa vasten analysoimme merkittävimpien suomalaisten tietoliikennealan yritysten sisäistä ja ulkoista diversifikaatiota lähihistoriassa käyttäen tietoja patenteista ja strategisista T&K alliansseista. Tutkimuksen perusteella suomalainen teleala on hajauttanut teknologiapohjaansa viime vuosien aikana. Vaikuttaa myös siltä, että sisäiset teknologiapanostukset uusiin Internet-pohjaisiin tietoliikenneratkaisuihin ja sovelluksiin ovat olleet vähäisempiä kuin traditionaalisille alueille. Näille uusille alueille on kuitenkin käynnistetty runsaasti komplementaarisia T&K-allIansseja. Arvioimme näiden havaintojen tämänhetkistä ja tulevaa merkitystä sekä niiden mahdollisesti aiheuttamia rajoitteita.

AVAINSANAT: ICT konvergenssi, suomalaiset yritykset, diversifikaatio, T&K allianssit

1 INTRODUCTION

1.1 BACKGROUND

The Finnish telecom industry has come to the crossroads and now faces various possible paths to follow and challenges to master. The 1990s witnessed the emergence, internationalisation and rapid growth of Nokia, which, today, has a very strong position globally (and indeed in the Finnish economy as a whole). Nokia has also contributed to an outgrowth of a broader ICT cluster of related and supporting industries especially in the field of embedded software, mobile network equipment and operation, multimedia and components. A pivotal event in this context was the early focus given to the GSM standard in the late 1980s in Finland and the capabilities which were developed to overcome the related technological and market discontinuities (Palmberg and Martikainen, 2005).

After the successful global inauguration of the GSM service, the Finnish telecom industry has set out on a development path towards the commercialisation of technologies related to third generation (3G) wireless standards, and especially the UMTS (the UMTS is a European incarnation of the W-CDMA standard). This is a logical path, given that the UMTS standard often is considered as a linear European outgrowth of the GSM standard. Nonetheless, the transition from the GSM to such next generation standards is made complex by the more fundamental trend of convergence between information (mainly computers) and telecommunications technologies that is changing the landscape of the whole ICT industry. This convergence is characterised by the digitalization of electronic transmissions, as well as by the emergence of Internet-related technologies that provide yet greater compatibility between information and telecommunication networks. The Internet is hence providing a range of additions to next generation standards, such as the UMTS, and might even mount to a disruptive technology with widespread implications for competitiveness of firms and countries with significant stakes in the ICT industry.

The Finnish ICT cluster and telecom industry have broadened significantly both technology- and product- wise in response to these new technological developments. However, one might suspect that a degree of path-dependency is observable in so far as the UMTS standard is a logical extension of the GSM standard, so successfully mastered in the past. Further, Nokia is now a global firm with lesser domestic ties. A key question is therefore if, and to what degree, the Finnish telecom industry indeed is overly focused within GSM based telecom technologies, especially at the expense of Internet-related 'new' technologies that hold disruptive potential.

1.2 AIM AND STRUCTURE OF PAPER

In this paper we provide an assessment of the position of the Finnish telecommunications industry with respect to the above mentioned broader technological trends, while leaving the debate on the competition between different 3G and 4G standards aside. We do not intend to provide a definitive viewpoint of whether the Finnish telecom industry has greater possibilities to succeed in one or the other of these two generations of standards. Rather, we wish to highlight and discuss the breadth and depth of recent patterns of technological diversification of the cluster from the perspective of technology fields related to traditional GSM- and new Internet- related telecom fields. As such, this paper is 'insightfully speculative' in so far as past developments are reliable indicators of the future.

More precisely, we provide empirical insights and, at least partial, answers to the following three questions that we tackle in this paper:

1. Are patterns of internal/indigenous diversification of the Finnish telecommunications industry in line in line with recent trends in ICT convergence and the emergence of Internet-related telecommunications?
2. How does the pattern of external diversification of the Finnish telecommunications industry differ from that of internal/indigenous diversification in terms of technological breadth and depth? Which are the implications in terms of the indigenous strengths and weaknesses of the Finnish telecommunications industry?
3. Which have been the characteristics of external diversification through R&D alliances in terms of their nature?

Taken together these questions hence go some way towards assessing the characteristic of Finland's entry into Internet-related telecommunications, although a full-fledged analysis of the organisational, institutional and competitive restructuring of the broader Finnish ICT cluster is outside the scope of this paper.

The point of departure is in the discussion on technological diversification and convergence at the industry and firm level. The theoretical literature is discussed in section 2 of this paper, along with a brief discussion of convergence in the ICT industry. The empirical part of the paper uses a combination of patent data to measure internal/indigenous diversification and a database of R&D alliances of prominent Finnish telecom firms to measure external diversification. Data limitations and the methodology is discussed in the third section, followed by a presentation of the results of the statistical analysis. Section 4 contains a synthesising analysis of the main findings, while section 5 concludes the paper.

2 A CONCEPTUAL FRAMEWORK

2.1 TECHNOLOGICAL DIVERSIFICATION AND STRATEGIC R&D ALLIANCES

The diversification of industries is facilitated through two main processes. Industries might diversify through the entry of new firms or through the diversification of existing firms. For practical reasons, this paper mainly focuses on the latter processes as viewed through the diversification of the firms included in the sample.

In the literature, a seminal contribution is Penrose (1959). She focused on product and market diversification of firms as an intrinsic outcome of firm growth. In various elaborations firms are understood as organizations engaged in continuous learning processes through experimental adaptation and creation of technologies and competencies. Two important insights emerge from this so-called resource-based view of the firm. First, given the centrality and locally constrained nature of learning processes, diversification exhibit strong path-dependency phenomena. Firms tend learn close to zones of their existing activities and competencies. Second, and partly as a consequence, related diversification tends to be more economically successful than unrelated diversification since the latter is managerially much more demanding (see Foss (1997) for a reader).

More recently increasing attention has been given to technological rather than product and market diversification both at the firm and industry level (see special issue in Research Policy from 1998). This is due to pioneering research drawing on patent databases. Among others Kodama (1986), Pavitt (1989), Patel and Pavitt (1994), and Cantwell and Piscitello (2000) show that the technological profiles of large multinational firms show diversifying patterns over times, even though the same firms typically have remained relatively coherent on the product side. This also appears to hold at the industry level as shown, among others, by Fai and Tunzelman (1999). Various explanations have been put forth to explain this path-dependent and diversifying patterns of technological diversification at the firm and industry levels (Granstrand et al., 1997). Some of these explanations seem to be particularly relevant in the context of the telecom industry.

There is agreement that products are becoming increasingly complex and multi-technology due to rapid scientific and technological advances, especially during the last decades. Indeed, this tendency is very clear in the telecom industry, characterised by strong technological complementarities, systematic innovations and network externalities. For example, switching technologies fused with digital technologies in the 1970s, and further with radio transmission technologies in the 1980s. Present wireless telecom standards cover a very broad and complex set of technologies, whereby firms also have to become multi-tech even though they might focus on the commercialisation of niche products (Granstrand et al., 1997).

2.2 ICT CONVERGENCE AND EXTERNAL DIVERSIFICATION

With ICT convergence we refer to the ongoing merging of information technology and telecommunications technologies which previously, until around the 1980s, rightfully could be characterised as two separate fields. In practical terms this convergence implies that both voice and data communication increasingly also occurs over data networks relayed by computers. As a consequence a range of new products, services, applications, markets, policy and regulatory domains are also merging. This, in turn, enables new business models that are changing the organisation of the ICT industry at large in a fundamental way.

For the sake of this paper it is important to notice that ICT convergence essentially has come about through two parallel technological developments. The first development relates to the digitalization of telecommunications networks starting from the 1970s that enabled data transmissions in binary digital form. The ISDN standard issued by the CCITT in 1984 is a milestone in this context, enabling digital switching and further digitalization also of the air interfaces in mobile telecommunication systems. The second development is the Internet. It is based on the so-called TCP/IP protocol that standardizes the rules of packaging, transmitting and receiving data over the Internet. The TCP/IP protocol thereby provides more flexibility and further fit between information and telecommunication technologies compared to 'traditional' ISDN-based telecommunications, and it is really the technology that drives ICT convergence since the 1990s. The key point is that ISDN-related traditional telecommunications technologies are based on circuit-switching while Internet-related 'new' telecommunications technologies are based on packet-switching (Bohlin et al., 2000).

The Internet has many important implications for telecommunications firms as the focus of this paper. The increasing popularity of the Internet means that mobile telecommunications applications and services increasingly also have to become TCP/IP-compatible (reference is often made to 'all-IP applications' in this context). This is also evident in a range of standardization efforts around the fringes of the core next generation standards (e.g. the UMTS), examples of which include the WAP forum, GPRS and EDGE standards, Bluetooth or the Symbian alliance for the development of an operating system for smart phones. In terms of firms in the industry the implication is that Internet-related technologies increasingly are becoming core fields to master. This is all the more true if these technologies hold disruptive potential in the sense that the Internet replaces telecommunications networks as the medium of transferring digital voice and data communications, a scenario that seems unlikely albeit not impossible (Kogut, 2003; Tan et al., 2004).

The received literature has foremost focused on the internal diversification of firms as measured by the distribution of patents across technological fields. But internal diversification based on in-house R&D is not the only means that firms can use to diversify their technological base. In the ICT industry, and especially in telecommunications, the number and importance of strategic R&D alliances have been growing significantly since the mid 1980s, not least due to the active stance that firms have taken vis-à-vis standardisation and Internet-related technologies that are penetrating their traditional knowledge bases (Palmberg and Martikainen, 2006). Nonetheless, hence far R&D alliances have been considered most beneficial in unrelated diversification towards complementary, non-core, fields in order to exploit economies of scale and scope in R&D and to share risks (Teece, 1986; Hagedoorn, 1993).

3 INTERNAL VERSUS EXTERNAL DIVERSIFICATION OF THE FINNISH TELECOM INDUSTRY

3.1 A NOTE ON THE DATA USED

In the selection of firms to include in our analysis we sought to narrow down the list to those firms which have actively patented in core telecom technology fields. These core fields were identified through a combination of expert opinion and the patenting profiles of firms which we know are prominent in the Finnish telecom industry. The result was the list of 15 firms in table 3.1, all of which hold a minimum of at least ten patents.

As expected, the list includes prominent firms in the telecom industry in terms of size and/or importance. Hence, the major telecom equipment (terminals and network systems) providers are included, along with the two biggest operators, and key component suppliers. These firms also constitute the core of the broader Finnish ICT cluster (Rouvinen and Ylä-Anttila, 2003).

One problem in this context is the fact that software is not easily patentable in Europe, as compared e.g. to the US. This is because a patentable invention must have a technical character in the sense that it has industrial application. Hence, the patent system in Europe (including Finland) mainly tends to cover embedded software that is linked to hardware, for example to a switching system or mobile terminal. There is indication that embedded software indeed is increasingly being patented, especially in the core telecom

Table 3.1 Description of firm sample

Name	Employees in 2002	Description
Nokia	52 700	Telecom equipment producer
Tecnomen	249	Telecom equipment producer
Benefon	129	Telecom equipment producer
TeliaSonera (Sonera)	8 170	Operator (used to be PTT)
Elisa	8 120	Operator
Aspocomp	3 080	Circuitry and mechanics supplier
Perlos	3 640	Precision component supplier
Eimo	1 940	Plastic component supplier
Elektrobit	1 400	R&D and automation supplier
Okmetic	515	Circuitry and component supplier
Micro Analog Systems	167	Circuitry and component supplier
Scanfil	362	Electromechanical component supplier
SSH Communications Security	127	Security solutions supplier
First Hop	67	Mobile middleware supplier
Netseal	50	Embedded software supplier

technology fields (McQueen and Olsson, 2003). The poor patentability of software implies that pure software firms or inventions might not be included in our analysis, even though firms developing embedded software are included. This should be kept in mind when interpreting the results, given that Internet-related technologies are software-intensive.

The logic behind defining the firm sample through patenting was to secure the inclusion of the most innovative and R&D-intensive firms of the Finnish telecom industry. Further, it could be expected that these firms have been the most active ones in terms of strategic R&D alliances. The next step was to identify the R&D alliances of the firms. Whereas the patent data extends back to 1990s, we only have reliable data on their R&D alliances since 1995. We defined a R&D alliance as *a formal/contractual collaborative relationship between firms characterised by the longer-term commitment of the partners to reach a common strategic goal in R&D*. This definition was then used to identify R&D alliances that the firms had been involved in through reviews of their annual reports and articles in the most important business newspaper in Finland – this so-called literature-based alliance counting methodology is commonly used in research on alliances (see de la Mothe and Link (2002), Palmberg and Pajarinen (2005)).

As suggested in the introduction we use the patent data to capture internal, or indigenous, technological diversification, while the data on R&D alliances captures the external technological diversification of the firms. In addition to the poor coverage of software, patent data also has other well-know limitations. They might disguise both inter-industry and inter-firm differences in the propensity to patent, as well as differing levels of significance of individual patents in relation to technological advances (Griliches, 1990). Here a specific issue is the degree to which one can delineate the relative cognitive closeness of different patentable technology fields. In other words, relatively arbitrary assumptions have to be made with respect to which technology field (or IPC class to relate to the patent classification nomenclature employed by the European patent offices) are sufficiently different than others to count as diversification proper as this is discussed in the theoretical literature. In this paper we stick to relatively detailed 3-digit technology classes as defined by the International Patent Convention.

With regard to the data on R&D alliances, these have also been classified to the 3-digit technology classes using the same IPC nomenclature. This classification thereby enables the comparisons of patterns of diversification across patents and R&D alliances by their content. There are two limitations to this exercise that should be mentioned. First, data collection is of necessity only limited to publicized R&D alliances through the firms own reporting or through reporting by the chosen business journal – this under-coverage is a common problem of literature-based alliance counting methodologies. Second, an R&D alliance might often be somewhat broader in scope than patents as described at a 3-digit technology class level. We have attempted to minimize this limitation through careful consideration of the technical content of the included R&D alliances by an expert in the field.[2]

The final step in our methodology was to produce a concordance table linking the 3-digit technology classes to broader technology categories which are more informative in terms of recent developments in the telecom industry. In table 3.2 we hence distinguish between traditional telecommunications technologies, 'new' Internet-related telecommunications technologies and various application areas of relevance to next generation standards and networks. It should be stressed that the resulting concordance table is based on a subjective inspection of all patents and R&D alliances included, and might hence not be relevant to other firms or countries.

In the table the traditional telecommunications categories include transmission technologies, which specify the physical layer of electrical and radio interfaces, and link layer protocols in telecom systems. Switching includes technologies and algorithms for naming users and services, addressing them with numbering and algorithms and technologies for connecting users and services by using names and addresses in the switching layers. The common denominator for these technologies is their backward compatibility with the ISDN standard and circuit switching, and they hence have different ancestors when compared with Internet-related telecommunications technologies. Hence, these technologies also, to a significant extent, underlie the core net-

Table 3.2 Concordance table between 3-digit technology classes and broader categories

Technology categories	IPC-classes
Traditional telecom	
Transmission	H04B, H01Q, H01P, H04J, G01R
Switching	H04Q, H01H
Voice applications and equipment	H04M, H04R, G10L
Internet-related telecom	
Data and internet applications	G06F, H04L, G06N
Encrypting and security	H04K
User authentication and access control	G09F
Applications	
Pictoral communication	H04N
Positioning	G01S
Games	A63F
Electronic payment	G07G
Mechanical technologies	B23K, B29C, G06N, H05K, H01B, H01R, H02B, H02G
Codecs and algorithms	H03M, H03L
Machine to machine	G08C
Photography	G03B
Others	Remaining ICT-relevant classes

work solutions of the GSM and UMTS standards. We have also included voice related algorithms such as speech analysis and synthesis, voice reproduction and voice terminal equipment such as mobile phones in the voice applications category.

Internet-related technology categories include data and internet applications for digital data communications. Specific areas such as encrypting and security and user authentication and access control are important in data, since they must be built as separate functionalities or applications. In traditional telecommunications, switching authentication, access control and security are based on fixed switched connections and they are inherent in the system architecture as covered by the category 'Switching'. In the case of Internet-related technologies the common denominator is thus the TCP/IP protocol as well a packet-switching compatibility.

Application categories include pictoral, video and voice applications and corresponding codecs and algorithms, photography, games, positioning and payment technologies. Electronic payment and machine to machine applications are also included. All of these categories are of primary importance to next generation smart phones and thus relate to both traditional and Internet-related telecommunications. Mechanical technologies relevant to manufacturing of telecom equipment and terminals are complementary areas also included in application categories.

3.2 TRENDS AND STRUCTURE OF PATENTING AND R&D ALLIANCE ACTIVITY

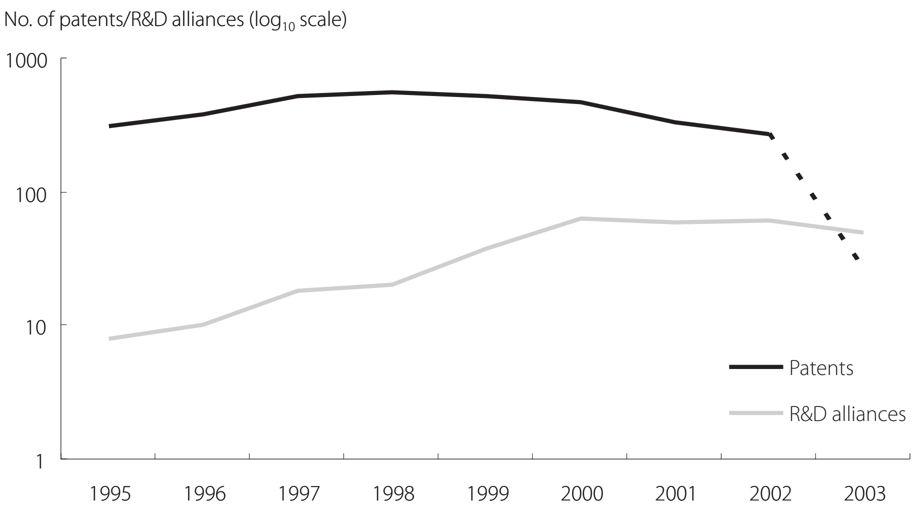
The indigenous nature of technological diversification as viewed through patenting might also be judged by the country, or patent office, where the patent was applied for (this application is also called the priority application). Inventions are typically patented in those countries where firms intend to commercialize and compete with their inventions. However, the R&D activities of firms are also often highly international, whereby a significant share of inventions might originate at their foreign affiliates through expatriate R&D (Palmberg and Pajarinen, 2004). In this paper we have chosen to limit the analysis of internal diversification to patents applied for at the Finnish Patent Office in order the underline our interest in the indigenous nature of internal technological diversification. Further, through this chose we secure the broadest possible coverage of patent applications, also of the smaller firms included in the sample.

As we limit the analysis to patents applied for at the Finnish Patent Office, our treatment will undoubtedly be somewhat biased against firms heavily engaged in expatriate R&D and operating on global markets. This is especially true in the case of Nokia as a global firm with extensive R&D activities abroad. We should therefore stress that our analysis only covers Nokia partially since a growing share of the patents are applied for at foreign patent offices (most notably the European and US patent offices). Although other firms included in our sample also patent abroad, the Finnish context is relatively much more important to these firms when compared with Nokia.

The dominant position of Nokia in Finland also strikes through the data on trends in patenting, as illustrated on a $\log_{10}$ scale in figure 3.1. Patenting picked up in the early 1990s and continued at an increasing rate throughout the mid 1990s, after which there has been a relative decline and rapid drop since 2002. This trend reflects, above all, the GSM breakthrough and subsequent internationalization of Nokia as the focus on patenting shifted toward US and European markets (Palmberg and Martikainen, 2004).[3] The rapid drop since 2002 is a statistical artifact due to an approximate 1.5 year time lag in publicizing patent applications at the Finnish Patent Office (the dotted part of the line relating to patents in the figure). According to the logarithmic scale, the R&D alliance activity picks up later than patenting, but shows relatively faster growth than patenting towards the late 1990s.

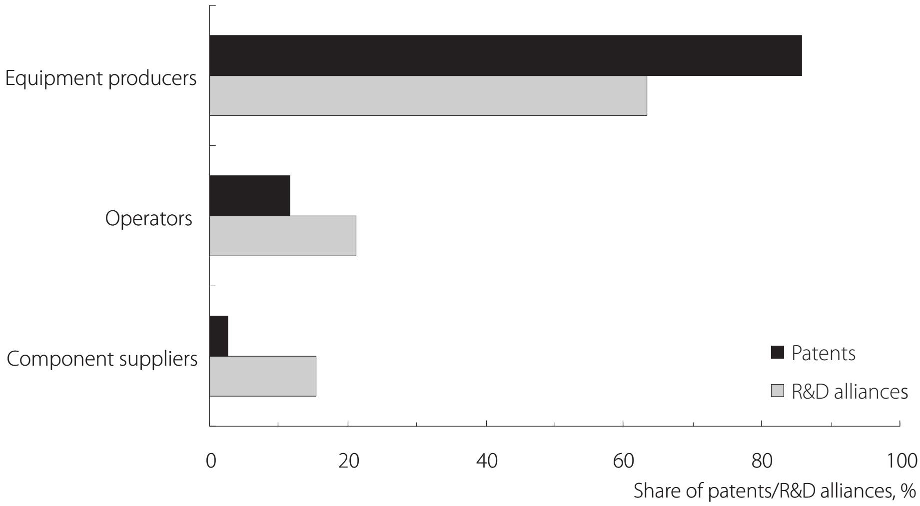
On closer inspection of the distribution of patenting and R&D alliances across the firm sample, the dominance of Nokia in patenting is especially clear. Altogether the sample includes 4 439 patent applications at the Finnish Patent Office. Equipment producers account for 85 percent of these (3 810 applications), with Nokia alone contributing to this share with 86 percent, as illustrated in figure 3.2. Nonetheless, the two main Finnish operators do also account for a significant 12 percent share of the applications (516 applica-

Figure 3.1 Trends in patenting and R&D alliance activity of firm sample



Note: A lag in the publication of patents as indicated by the dotted part of the line.

Figure 3.2 Distribution of patents and R&D alliances across firm sample



tions). The remaining 3 percent share (113 applications) is accounted for by the component suppliers, and these applications are relatively evenly spread out across the firms included in the sample.

Our literature-based alliance counting methodology identified 364 R&D alliances involving firms in the sample. Of these the equipment producers accounted for 63 percent (231 R&D alliances), while operators accounted for 21 percent (77 R&D alliances) and component suppliers accounted for 15 percent (55 R&D alliances). Even though the share of Nokia of all alliances involving the equipment producers is 96 percent, it seems that the dominance of Nokia is lesser when compared to patenting. Especially component suppliers appear to have a higher R&D alliance intensity than their share of patenting would predict. This is also true for the operators, and especially well-documented in the case of Sonera due to aggressive internationalization in the late 1990s (Annual Reports 2000–2002). In this context it should be noted that only 8 percent of all these 364 R&D alliance are between the firms included in the sample (informal R&D collaboration, not captured by our definition of R&D alliances, is probably much more widespread).

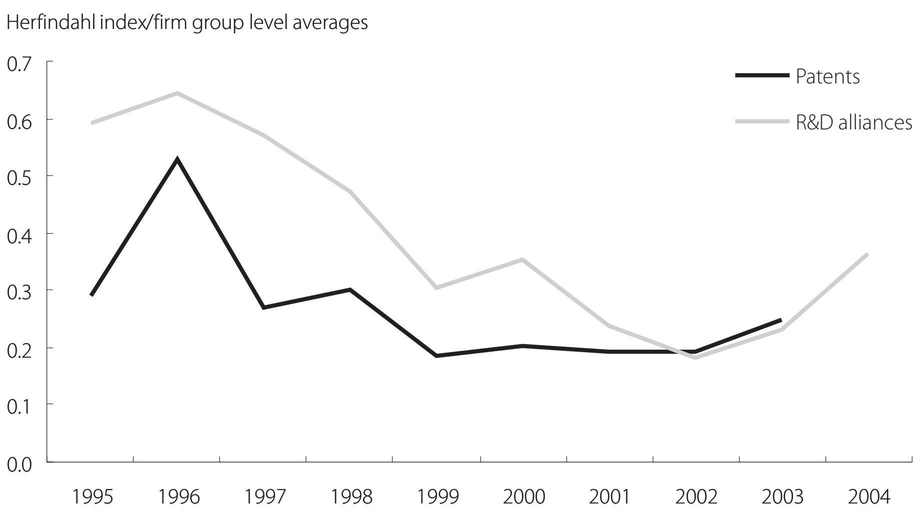
3.3 BREADTH OF TECHNOLOGICAL DIVERSIFICATION

We approach the issue at hand through indicators of the breadth and depth of internal and external technological diversification of our prominent Finnish telecom firms. Of indicators capturing the breadth of diversification, the Herfindahl index is a commonly used one (see e.g. Giuri et al., (2002)). The Herfindahl index is conventionally used to approximate industry concentration. In this paper we use it to derive a measure of the dispersion of patents and R&D alliance across the 3-digit IPC technology classes of the sample firms. Accordingly, a high value of the Herfindahl index indicates that the firms have concentrated their patenting to a few classes, and hence that their degree of internal/external technological diversification is low. A low value of the index indicates that the firms have spread out their patenting across a wider range of technology classes, and hence that they have a greater breadth in their internal/external technological diversification.

Broader patterns of diversification across all groups of firms in the sample are illustrated in figure 3.3. It is clear that internal diversification, as measured through patenting, is broader in scope than external diversification as measured by R&D alliances (although the indexes are converging during recent years). This is compatible with theoretical insights and empirical research discussed above, in so far as R&D alliances might be considered to better cover R&D of the more market-oriented and applied type when compared with patents (Giuri et al., 2002). Thus, these Finnish firms at the core of the ICT cluster appear to be multi-technology especially in their internal activities, while a greater degree of concentration within specific technology fields is evident in their external diversification patterns.

When looking at the overall trend over time, there appears to be an increase in the breadth of external diversification over time, especially when discounting observations from 2004 as an ongoing year. This result is probably explainable by the heightened uncertainty surrounding the future choice of standards in the telecommunications industry, as suggested above. It might

Figure 3.3 Degree of internal/external diversification by Herfindahl: all firms in sample



also reflect the search for 'killer applications' in future next generation markets. In these circumstances, R&D alliances might be a viable option to diversify into uncertain non-core technologies, exploit economics of scale and scope in R&D, and share risks (compare with the discussion in Teece (1986)).

In order to cater for differences across the equipment producers (mainly Nokia), operators and component suppliers, Herfindahl indexes were also calculated at the firm group level although these are not reported here. From this viewpoint it is clear that especially the equipment producers account for the higher average degree of internal diversification of the firm sample, when compared with external diversification. This is intuitive since especially Nokia is a large multinational firm with extensive R&D resources. However, the diversification of the operators is characterised by the opposite pattern. They appear as more diversified externally when compared to their internal diversification.

Finally, a distinct pattern emerges in the case of the component suppliers. These firms are characterised by lesser breadth both in their internal and external diversification patter. This is also intuitive, since these firms are significantly smaller and more specialised than the equipment suppliers and operators – they are suppliers of specific network equipment, mobile phone components or embedded software. When the Herfindahl is calculated as an average across all firms in this group rather than as averages at the firm level, we notice that these firms are focusing on different technology fields. Hence, the component suppliers are technologically diversified as a group, even though they are highly focused at the firm level.

3.4 DEPTH OF TECHNOLOGICAL DIVERSIFICATION

Turning to the depth of internal and external technological diversification, this can be approximated by ranking the distribution of patent applications and R&D alliances of the firms across the broader technology categories presented in table 3.2. This will suggest whether patterns of internal diversification are similar or different to patterns of external diversification also in terms of content. In other words, we can assess whether Finnish telecom firms have diversified towards similar or different technology fields through collaborative R&D alliances when compared with their indigenous diversification in core fields. We thereby also divided the data into the two time periods. The ranked distribution of patents by technology fields is illustrated in figure 3.4.

With reference to the concordance table between IPC classes and broader technology categories, the following observations are immediately clear from the figure.[4]

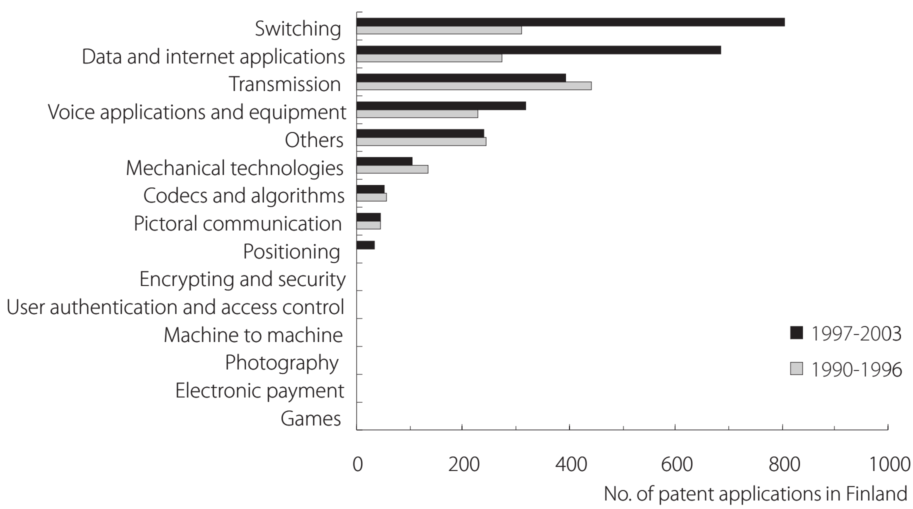
First, the traditional telecom field of 'Switching' has grown relatively most, followed by 'Data and internet applications' representing internet-related telecom. These two fields are also the most important ones in the internal diversification patterns of the firms, especially in recent years. The other fields show lesser changes in importance over time. We register a slight decrease in patenting in the field of ‘Transmission’, and an increase in the field of ‘Voice applications and equipment’. Both of these fields might also be classified to the traditional telecom category as the majority of these patents relate to both fixed and mobile telephony.

A second observation is the very low number of patent applications in the various applicaton fields of relevance to smart phones in both traditional and Internet-related telecommunications. Patenting in ‘Pictoral communications’ has remained at low levels throughout, while an entry into the field of ‘Positioning’ is evident during recent years. Nonetheless, the application fields ‘Electronic payment’, ‘Games’ and ‘Photography’ are not covered by patent applications at the Finnish Patent Office.

These two observations hold true across both the equipment producers and the operators, for which the top of the ranking list is dominated by traditional telecom fields. However, the component suppliers are characterised by a slightly different pattern since ‘Data and internet applications’ clearly tops the ranking list. As a group, it thus seems that the smaller and more focused component suppliers have been earlier entrants to Internet-related telecom fields.

The ranked distribution of R&D alliances across technology fields, in figure 3.5, is very different. R&D alliances categorized to the traditional telecom fields of ‘Switching’, ‘Transmission’ and ‘Voice applications and equipment’

Figure 3.4 Ranked distribution of patents by technology fields

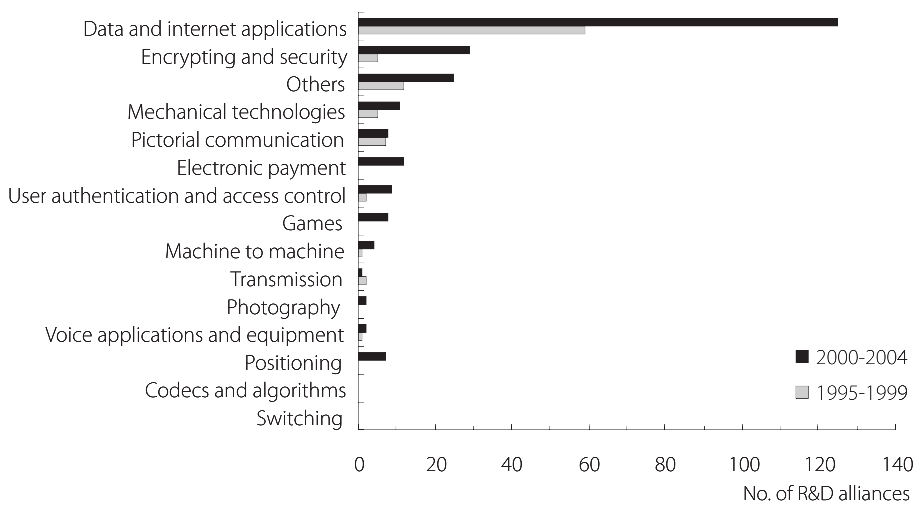


are particularly non-existent, especially in recent years. Instead a large majority of all R&D alliances fall within the field of 'Data and internet applications', followed by 'Encrypting and security' and the various application fields. Moreover, the number of alliances in these categories have increased manifold in recent years – this is especially evident in the case of 'Encrypting and security', 'Electronic payment' and 'Games' as important application fields in 3G or 4G.

By and large these observations again hold true across all three firm groups, although the share of R&D alliances in the various application fields is relatively higher for the equipment producers (especially Nokia) when compared with the operators and component suppliers. This is intuitive, since the equipment producers are 'systems integrators' of operator services and telecom components, which serve end-users of telecom equipment, and hence also need to be more involved in developing and supporting various application functionalities that add value to their hardware.

Thus, based on these ranked distribution measuring the depth of technological diversification, the general impression is that the Finnish telecom industry has pursued a dual path in technological diversification towards next generation standards. Internal, indigenous, capabilities have diversified in the traditional telecom fields in parallel with partial entry to Internet-related technology fields. Nonetheless, the relatively larger increase in patenting in the traditional telecommunications technologies suggests that indigenous capabilities of the telecom industry to a relatively larger extent is focused on traditional telecommunications technologies with strong ties to

Figure 3.5 Ranked distribution of R&D alliances by technology fields



the GSM-UMTS continuity. Further, the very low number of patent applications in the various application fields of relevance to smart phones in next generation network environments suggests that the Finnish telecom industry is indigenously weak in application fields.

Judged by the content of external diversification, the R&D alliances that the firms have been engaged in appear as highly complementary due to the dominance of Internet-related technologies and also due to the rapid growth of alliances in the various application fields. On the one hand, this overall pattern in the diversification of the core Finnish ICT cluster appears quite viable as judged by the theoretical literature. Specifically, complementary Internet-related technologies have been accessed through collaborative R&D alliances, where the uncertainties, risks but also liabilities are shared amongst the partners (compare with the discussion in Palmberg and Martikainen (2006)). This might also be a viable way forward given the present uncertainties surrounding both the competition between standards and the disruptiveness of the Internet. On the other hand, the seemingly over-reliance on external diversification through R&D alliances in these fields might also constitute a threat to the Finnish ICT cluster, especially if further developments in Internet-related fields mounts to a disruption of the whole ICT industry.

3.5 THE NATURE OF EXTERNAL DIVERSIFICATION

A complementary viewpoint is to analyse, in greater detail, the nature of the external diversification. The data on R&D alliances contains information on the collaborative partners involved. We propose two additional dimensions to our analysis, namely the regional distribution of R&D alliance partners and the ranking list of the actual partner firms. These dimensions provide possible further indications of the position of the Finnish telecom industry with respect to Internet-related technologies The strong European backing of W-CDMA that underlines the UMTS standard would suggest that European firms are the most viable partners in the traditional telecommunications. In contrast, Internet-related technologies are strongly US-backed and hence also better approached through R&D alliances with US partners (see e.g. Kogut (2003); Henten and Saugstrup (2004)).

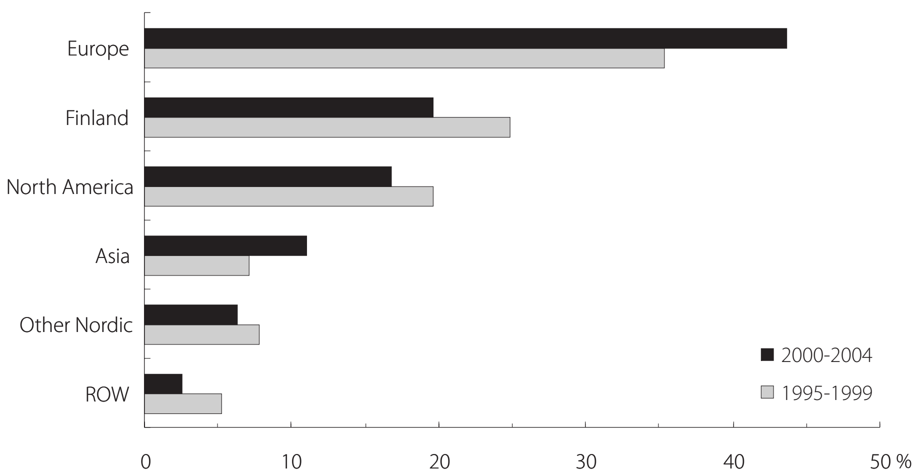
The regional distribution of R&D alliances by the country of origin of firms, displayed in figure 3.6, has undergone relatively significant changes during the time period studied. The most indicative change is the relative decline in the share of domestic R&D alliances in recent years when compared with developments in the late 1990s. This relative decline is reflected in a corresponding increase in the share of Asian and especially European R&D alliance partners, which presently accounts for the majority of all partners. Meanwhile the relative share of Nordic R&D alliances and those including US (North American) firms has declined slightly.

These regional shifts are to be interpreted from various viewpoints. What appears clear is that the decreasing relative importance of Finnish partners points towards an increasing internationalisation of the R&D of these firms. Cross-border R&D alliances is one mechanism, alongside FDI, mergers and acquisitions, through which firms might become engaged in expatriate R&D (Serapio and Hayashi, 2004). This interpretation is also in line with what we know about the trends in internationalisation of R&D of Finnish firms in general and multinational firms in particular (Ali-Yrkkö et al., 2004; Palmberg and Pajarinen, 2005).

On closer inspection of the data, at the firm group level, some interesting differences nonetheless emerge. Most noteworthy of these is the increase, rather than decrease, in the share of domestic partners to R&D alliances involving the operators. It thus seems that the Finnish context is becoming increasingly important in the external technological diversification patterns of the Finnish operators, at least from the viewpoint of formal collaboration through publicized R&D alliances. This is an interesting observation worthy of further investigation in terms of the exact content of these alliances.

The regional shifts in the nature of alliances can also be taken as further confirmation of the relative specialisation of the Finnish telecom industry within 3G technologies and related standards. As suggested, the strong European backing especially of the UMTS standard would imply that firms which pursue this path would be inclined to collaborate with other European firms possessing the necessary capabilities. The increasing share of European partners to the R&D alliances suggests that this indeed is the path being pursued. In part, these R&D alliances cover collaboration within well-known Euro-

Figure 3.6 Regional distribution of R&D alliance partners



pean 3G forums and standardization bodies, such as the 3GPP forum, the WAP forum and Symbian developing operating software for smart phones. However, especially Nokia is also involved in a range of other global forums and standardization bodies, such as the IEEE that are more focused on Internet-related technologies.

Our final viewpoint is the ranking of the actual partner firms to the R&D alliances in table 3.3. This table partly confirms the discussion above in the sense that the most frequent partner has been the Swedish firm Ericsson (including the recent joint venture Sony-Ericsson). Ericsson has been an outspoken supporter of W-CDMA technologies in the context of the UMTS standard, especially in the 3GPP forum (Leiponen, 2006).

The German telecom giant Siemens is also high on the list. US data communications firms such as IBM and Hewlett-Packard, as well as the telecom equipment and component firm Motorola and the security software producer Check Point Software are also well represented. Nonetheless, these firms are second-tier incumbents in the field of Internet-related telecom when compared to such new entrants originating in the 1990s from Silicon Valley in the US such as Cisco, Sun Microsystems, Oracle, as well as Lucent, 3 Com and the US media giant AOL Time Warner Networks (Kenney, 2003). These firms do also appear as R&D alliances partners, but much less sporadically. Hence, at least in terms of publicized formal collaboration, ties to first-tier Internet-related telecommunications carriers appear as relatively weak.

Table 3.3 Top 25 ranking list of partners to R&D alliances

	1995–1999	2000–2004	Total
Ericsson	8	7	15
IBM	5	9	14
Motorola	4	9	13
Hewlett-Packard	3	9	12
Siemens	0	8	8
Texas Instruments	2	6	8
Intel	4	2	6
Check Point Software	1	4	5
Osuuspankki	2	3	5
Sony Ericsson	0	5	5
Samsung	0	4	4
Accenture	0	3	3
Alcatel	2	1	3
AT&T	1	2	3
Cap Gemini	0	3	3
Fujitsu	0	3	3
Internet Security Systems	0	3	3
NTT Docomo	1	2	3
Philips	1	2	3
Sun Microsystems	0	3	3

4 A SUMMARISING DISCUSSION

In this paper we have taken as point of departure the ongoing convergence between information and telecommunications technologies, and present uncertainties characterising the ICT industry as a whole due to competition between next generation network standards. Our basic aim was then to analyse recent patterns of internal and external technological diversification of the Finnish telecom industry vis-à-vis these three scenarios in order to provide some insights into possible future developments. The frame of reference was the literature on technological diversification and strategic R&D alliances, and its emphasis on path-dependency phenomena, multi-technology firms, and complementary assets during innovation, all issue of which are relevant to analysis of diversification in the ICT industry and telecommunications in particular.

Our data is limited to patentable technologies, whereby especially software-related Internet technologies might be underrepresented. The focus on patent applications at the Finnish patent office is motivated by our interest in the diversification of indigenous technological capabilities, but does bias against the larger firms (especially Nokia) in the sample which are heavily engaged in expatriate R&D and operating on global markets. Our literature-based alliance-counting methodology might also be subject to under-coverage of R&D alliances depending on the publication policies of the firms included. With these limitations in mind, the following conclusions nonetheless emerge from our empirical analysis.

First, the emergence of the Finnish telecom industry and the, breakthrough of Nokia following the inauguration of the GSM service globally, is apparent both in the growth of patent applications and R&D alliances. The dominating position of Nokia is especially clear in patenting. The internationalisation of Nokia also implies that the focus of patenting has shifted towards European and especially US markets starting from the late 1990s, the patents of which fall outside the scope of our analysis. However, in R&D alliances Nokia's domination is lesser and especially the operators appear as relatively much more active than their patenting would suggest – this is largely due to the aggressive internationalization of Sonera as the major operator in Finland. The R&D alliance activities of the firms included in the sample has also increased at a faster rate than their patenting. These patterns are compatible with previous empirical research of other firms and countries, and also fit the broader picture of trends in the R&D alliance activities of firms globally in the ICT industry (Palmberg and Martikainen, 2006).

Second, a more substantial conclusion concerns the breadth and depth of technological diversification. The Herfindahl indexes that we employed to measure the breadth of diversification suggests that the degree of diversification of the Finnish telecom industry has increased over time, even though this diversification is lesser in terms of external diversification through R&D alliances when compared to internal/indigenous diversification as captured by patenting. This diversification was interpreted as a natural consequence of ongoing convergence between the telecommunications and data communications industry, the emergence of, and competition between, multiple standards after the GSM era, as well as by the search for 'killer applications' in next generation network markets. However, it probably also reflects the emergence and broadening of the ICT cluster in Finland, even though Nokia still is the dominating firm.

In the literature, special emphasis is given to the pervasiveness of path-dependency during technological diversification at the firm and industry level due to the localised nature of learning processes (Foss, 1997). Our results concerning the depth of diversification also highlights path dependency, especially in the case of the internal/indigenous diversification patterns of the firms included. The strong early focus given to the GSM standard, so successfully mastered by Finnish firms in the past, seems to prevail due to the significant, and growing, number of patent applications in traditional telecommunications technologies such as ISDN-based circuit-switching and transmission that constitute the core of the UMTS standard.

But these traditional telecom fields are also increasingly complemented with new Internet-related technologies internally, but especially in external diversification through R&D alliances. The received literature suggests that R&D alliances are especially viable in diversification towards complementary technologies where the uncertainties, but also risks and liabilities, are shared (see especially Giuri et al. (2002)). Thus, in so far as Internet-related technologies merely will provide a range of additions in the application layers of next generation networks, this mode of diversifications appears fruitful. However, if Internet-related technologies replaces telecommunications networks as the medium of transferring digital voice and data communications, and disrupts the ICT industry as a whole, our analysis provides indication that this over-reliance on external diversification might constitute a threat to the Finnish telecom industry. However, most commentators, including ourselves, deem such a scenario as unlikely.

A related *third* conclusion is the indigenously weak position of the Finnish telecom industry within various application fields of relevance in 3G and 4G network environments that our results suggest, even though these fields increasingly have been covered by R&D alliances. This might be a reflection of the ongoing uncertainty and search for 'killer applications' in the telecom industry through collaborative diversification. Many of these applications might emerge within firms and industries not directly covered in our analysis, such as media, banking and health-care. A bigger question, beyond the scope of this paper, is to what degree such industries in Finland manage to become integrated with the ICT cluster as a whole. This is relevant in all possible next generation network scenarios, where Internet-related 'all-IP' applications most probably will dominate in any case. Hence, interactions between the telecom core of the ICT cluster, and advances users within these industries, are of crucial importance to the future of the broader Finnish ICT cluster, especially if we discount Nokia as a global firm with lesser ties to Finland than previously.

Fourth, our analysis also provides observations on the nature of external diversification through data on the actual collaborative partners within the R&D alliances. Judged by the decreasing share of domestic partners to R&D alliances, the internationalisation of R&D of the Finnish telecom industry is evident and in line with what is known about the internationalisation patterns of Finnish firms more generally (Ali-Yrkkö et al., 2004). International R&D alliances provide a complementary path of internationalisation of R&D along with FDI, mergers and acquisitions, and these types of alliances become increasingly important in developing globally applicable Internet-related applications. However, more to the point, the large and increasing share of European partners strengthens further the impression that a path-dependency along the GSM-UMTS continuum. R&D alliance ties to US firms, and especially those prominent in Internet-related technologies, are more sporadic and hence appear much weaker.

Finally, we wish to point out once more that this paper does not adequately capture Nokia's diversification due to the various data limitations discussed above, and should therefore primarily be read as an analysis of the domestically-based Finnish telecom industry. Nokia is now a global firm with extensive R&D activities abroad and engaged in a broad range of R&D alliances covering most aspects of next generation networks and the Internet that we identified in this paper. Further, the patenting of this firm is increasingly internationalized to foreign patent offices not covered here, most notably the US patent office.

APPENDIX

INTERNAL AND EXTERNAL DIVERSIFICATION BY FIRM GROUPS

Figure A1 Degree of internal diversification by Herfindahl: patents

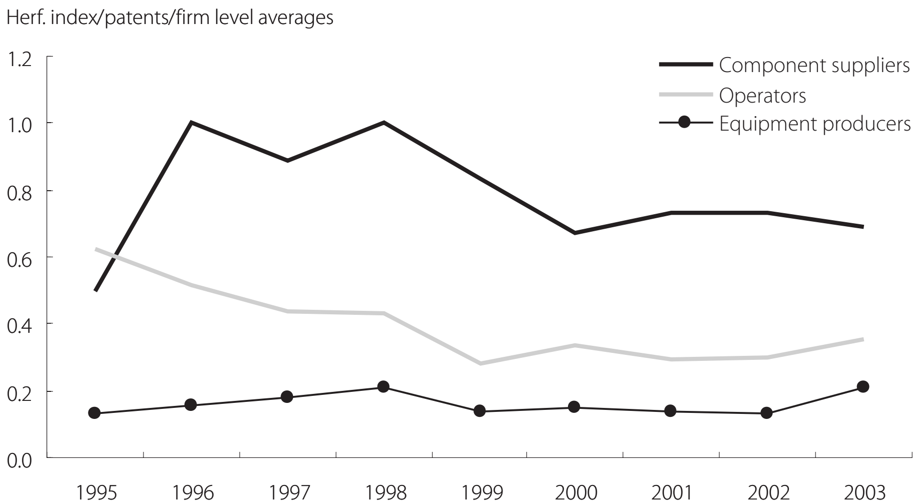
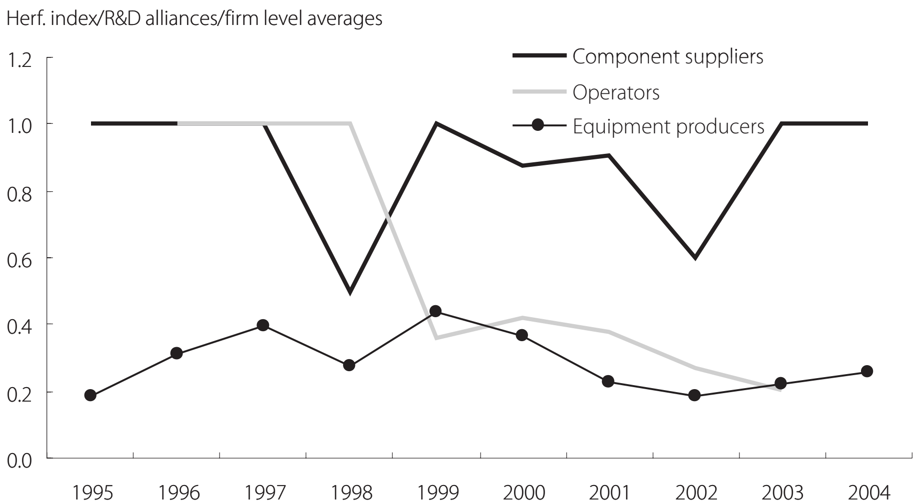


Figure A2 Degree of external diversification by Herfindahl: R&D alliances



FOOTNOTES

[1] The copyright of this paper is held by Emerald Group Publishing and it will be published in INFO: The Journal of policy, regulation and strategy, Vol. 8, No. 4. We wish to kindly thank the publisher for the permission to reprint the paper in this book. This research has also been financially supported by the joint Wireless Communication Program of the Berkeley Roundtable of the International economy (BRIE) and the Research Institute of the Finnish Economy (ETLA) (www.brie-etla.org). We wish to thank Tuomo Nikulainen for help with data collection.

[2] The R&D alliances were classified to the most important primary IPC class to define their primary content and to secondary classes in cases where an alliance clearly covered diverse contents.

[3] We also analyzed patent data drawn from the European Patent Office (EPO) and could essentially confirm that the decline in Nokia's patenting at the Finnish Patent Office is compensated by a significant increase in patenting at the EPO, especially since 1999. However, we have not had the possibility to compare with patenting at the US patent office.

[4] We also analyzed patent data drawn from the EPO and could essentially confirm that the ranked distribution of patenting is similar, by and large, when compared with figure 3.4. Even though there has been accelerating growth in patent applications of the firm sample at EPO, the ranking in recent years is topped by the category 'Switching' followed by 'Data and internet applications', 'Voice applications and equipment' and 'Transmission'. However, again we have not had the possibility to compare with patenting at the US patent office.

REFERENCES

Ali-Yrkkö, J., Lovio, R. & Ylä-Anttila, P. (eds.). 2004. *Multinational enterprises in the Finnish innovation system*. Helsinki: Taloustieto Oy.

Bohlin, E. et al. 2000. *Convergence in communications and beyond*. Amsterdam: North Holland.

Caloghirou, Y., Ioannides, S. & Vonortas, N. 2003. Research joint ventures. *Journal of Economic Surveys* vol. 17, no.4, 541-570.

Cantwell, J. & Pisicitello, L. 2000. Accumulating technological competence: its changing impact on corporate diversification and internationalisation. *Industrial and Corporate Change*., vol.9, no.1.

Foss, N. 1997. Resources, firms and strategies – A reader in the resource-based perspective. Oxford: Oxford University Press.

Fai, F. & von Tunzelman, N. 1999. Industry-specific competencies and converging technological systems: evidence from patents. *Structural Change and economic Dynamics* 12, 141-170.

Giuri, P., Hagedoorn, J. & Myriam, M. 2002. Technological diversification and strategic alliances. *LEM Working Paper Series* 2002/04.

Granstrand, O., Patel, P. & Pavitt, K. 1997. Multi-technology corporations: why they have "distributed" rather than "distinctive core" competencies. *California Management Review*, vol. 39, no. 4.

Griliches, Z. 1990. Patent statistics as economic indicators: a survey. *Journal of Economic Literature* 28, 1661-1707.

Hagedoorn, J. 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and industryal differences. *Strategic Management Journal*, vol. 14, 371-385.

Henten, A. & Saugstrup, D. 2004.3G standard: the battle between WCDMA and cdma2000. Paper presented at the *Nordic ICT Workshop* 'Past developments and future challenges of the Nordic ICT industrys', 19-20 August, Helsinki.

Kodama, F. 1986. Technological diversification of Japanese industry. Science, 233, 291.296.

Kenney, M. 2003. The growth and development of the Internet in the United States. In Kogut, B (ed.) *The global Internet economy*. Cambridge MA: The MIT Press.

Kogut, B. (ed.). 2003. *The global Internet economy*. Cambridge MA: The MIT Press.

Leiponen, A. 2006. National styles in the setting of global standards: the relationship between firms' standardization strategies and national origin. Forthcoming in Zysman, J. & Newman, A. (eds.) *How revolutionary was the revolution? National responses, market transitions, and global technology in the digital era*. Stanford: Stanford University Press.

McQueen, D. & Olsson, H. 2003. Growth of embedded software related patents. *Technovation* 23, 533-544.

de la Mothe, J. & link, A. (eds.). 2002. *Networks, alliances and partnerships in the innovation processs*. Boston: Kluwer Academic Publishers.

Palmberg, C. & Martikainen, O. 2005. The GSM standard and Nokia as an incubating entrant. *Innovation: Management, Policy & Practice*, volume 7, no. 1.

Palmberg, C. & Martikainen, O. 2006. Pooling knowledge: trends and characteristics of R&D alliances in the ICT sector. Forthcoming in Zysman, J. & Newman, A. (eds.) *How revolutionary was the revolution? National responses, market transitions, and global technology in the digital era.* Stanford: Stanford University Press.

Palmberg, C. & Pajarinen, M. 2004. The global dispersion of innovative activities – the case of Finnish multinationals. *ETLA Discussion paper* No. 916.

Palmberg, C. & Pajarinen, M. 2005. Alliance capitalism and the internationalisation of Finnish firms. *ETLA Discussion paper* No. 991.

Patel, P. and Pavitt, K. 1997. The technological competencies of the world's largest firms: complex and path-dependent, but not much variety. *Research Policy*, 26. 141-156.

Pavitt, K. 1998. Technologies, products and organization in the innovating firm: what Adam Smith tells us and Joseph Schumpeter doesn't. *Industrial and Corporate Change*, vol.7, no.3.

Penrose, E. 1959. *The theory of the growth of the firm*. Oxford: Oxford University Press. Research Policy. 1998. Special Issue: Technology and the Firm. *Research Policy* 27, no.5.

Rouvinen, P. & Ylä-Anttila, P. 2003. Case study: little Finland's transformation to a wireless giant. In Dutta, S., Lanvin, B. & Paua, F. (eds.) The Global Information Technology Report 2003-2004. New York: Oxford University Press.

Serapio, M. & Hayashi, T. (eds.). 2004. Internationalization of Research and Development and the Emergence of Global Networks. Amsterdam: Elsevier JAI.

Tan, S-E., Saugstrup, D. & Olesen, H. 2004. WLAN vs. UMTS – the European Scene. *Paper presented at the World Wireless Congress*, May 2004, San Francisco, California.

Teece, D. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy* 15, 285-305.

IV

The Rise of Asia –
New Challenges and Opportunities

OFFSHORING SOFTWARE DEVELOPMENT –
The case of Indian firms in Finland

ALI-YRKKÖ, Jyrki and **JAIN**, Monika**. OFFSHORING SOFTWARE DEVELOPMENT – THE CASE OF INDIAN FIRMS IN FINLAND**
ABSTRACT: This exploratory study examines outsourcing and offshoring of software development by analysing Indian companies in Finland. Based on qualitative data our results support the view that offshore outsourcing decisions are usually cost-driven. Another important motive has been the availability of software skills. To speed up the product development, some firms have outsourced maintenance and sustenance of existing products, which, in turn, has enabled the company to focus its in-house R&D resources on the development of next generation products and technology. In the future, offshoring software development will probably increase not only through outsourcing, but also through in-house operations. In addition to India, other potential locations include Russia and Eastern Europe.

KEY WORDS: Software, R&D, research and development, offshoring, outsourcing

ALI-YRKKÖ, Jyrki ja **JAIN**, Monika**. OHJELMISTOKEHITYKSEN KANSAINVÄLISTYMINEN – INTIALAISET YRITYKSET SUOMESSA**
TIIVISTELMÄ: Tässä tutkimuksessa tarkastellaan ohjelmistokehityksen kansainvälistymistä ja ulkoistamista analysoimalla Suomessa toimivia intialaisia yrityksiä. Haastatteluihin pohjautuvan aineiston mukaan ulkomaille ulkoistamiset ovat pääsääntöisesti olleet kustannusvetoisia. Toinen tärkeä motiivi on ollut ohjelmisto-osaamisen hankkiminen. Tavoitteena on ollut nopeuttaa tuotekehitysprosessia. Ulkoistamalla nykyisten tuotteiden ylläpidon yritykset ovat pystyneet keskittämään konsernin sisäisen t&k-toiminnan uusien tuotteiden ja teknologioiden kehittämiseen. On todennäköistä, että ohjelmistokehitys tulee kansainvälistymään myös jatkossa sekä ulkoistusten että konsernin sisäisten muutosten kautta. Intian lisäksi mahdollisia kohdemaita ovat esimerkiksi Venäjä ja Itäinen Eurooppa.

AVAINSANAT: ohjelmisto, t&k, tutkimus ja tuotekehitys, ulkoistaminen, kansainvälistyminen

1 INTRODUCTION

Asia has attracted a significant amount of foreign direct investment (FDI). Although the majority of FDIs have focused on manufacturing operations, current offshore activities are not limited to production activities alone. During the past few years, companies have also offshored business services ranging from routine call centre activities to higher-value software development. The digitalisation and developed information and communication technology (ICT) has enabled relocation in sectors that traditionally were described as "nontradable" (see Brainard & Litan 2003).

India has risen to be a major location of offshore software development. A number of North American and European companies have relocated part of their software development to India. While some companies have established their own units in India, others have outsourced software development work to firms with offshore capacity in India.

Although outsourcing and offshoring are often used interchangeably, these terms represent two different dimensions. By outsourcing we mean that other firms take over operations that were previously conducted within the firm. It is important to note that relocation is not a requirement for outsourcing. Offshoring, in turn, is understood to mean relocating activities from one country to another but not necessarily from one firm to another. Possible combinations are summarised in the following figure (1.1).

In this exploratory study, we examine Indian software firms operating in Finland[1]. We focus on the operations, establishment motives and experiences of these companies. Furthermore, the division of tasks between India and Finland is also considered. Our qualitative data is based on interviews with Indian companies and their Finnish customers.

Figure 1.1 Combinations of outsourcing and offshoring

		Outsourcing	
		No	Yes
Offshoring	No	**I** No changes	**II** Moving activities to other companies without relocation
	Yes	**III** Relocation of activities to other countries within the same corporate	**IV** Relocation of activities to other companies in other countries

The paper proceeds as follows. In the next section, we briefly describe the current development of the Indian information technology (IT) sector by focusing on its globalisation. In section 3 we present the results of our qualitative analysis of Indian firms in Finland. Section 4 contains a brief summary and discussion.

2 THE SOFTWARE INDUSTRY IN INDIA

2.1 THE DEVELOPMENT OF THE INDIAN IT INDUSTRY

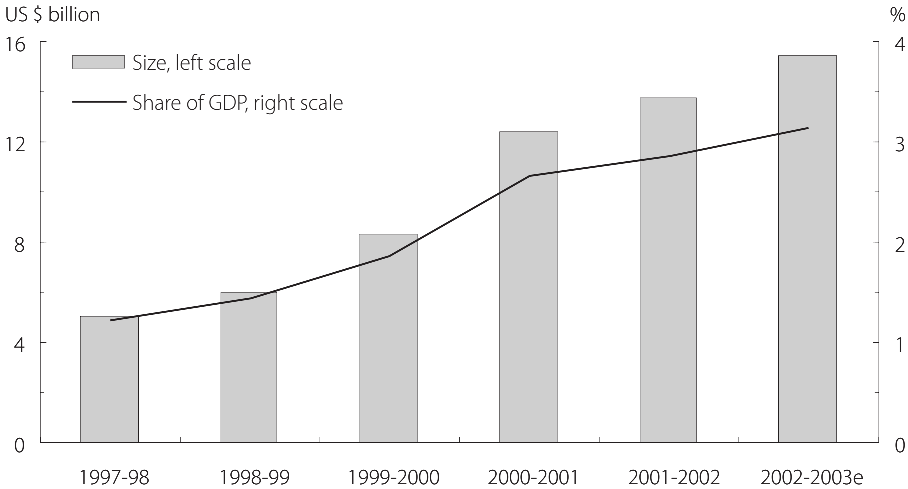
The IT industry plays a significant role in the Indian economy (Figure 2.1). During the past few years, the IT sector has been one of the fastest growing industries in India. While in 1997 the IT industry accounted for 1.2 percent of GDP, in 2003 the corresponding share exceeded 3 percent.

The Indian IT sector proved to be the country's fastest growing segment even in the troubled times in 2001–03. India has continued to be a compelling investment destination, as leading multinational companies either use Indian subcontractors or establish their own units in India. Outsourcing of IT requirements by leading global companies to Indian vendors picked up pace during 2002–03, in line with worldwide trends. The Indian software industry is, however, heavily fragmented with the top 10 players accounting for less than 20 percent of the total industry.

The IT industry plays a significant role in the Indian economy (Figure 2.1). During the past few years, the IT sector has been one of the fastest growing industries in India. While in 1997 the IT industry accounted for 1.2 percent of GDP, in 2003 the corresponding share exceeded 3 percent.

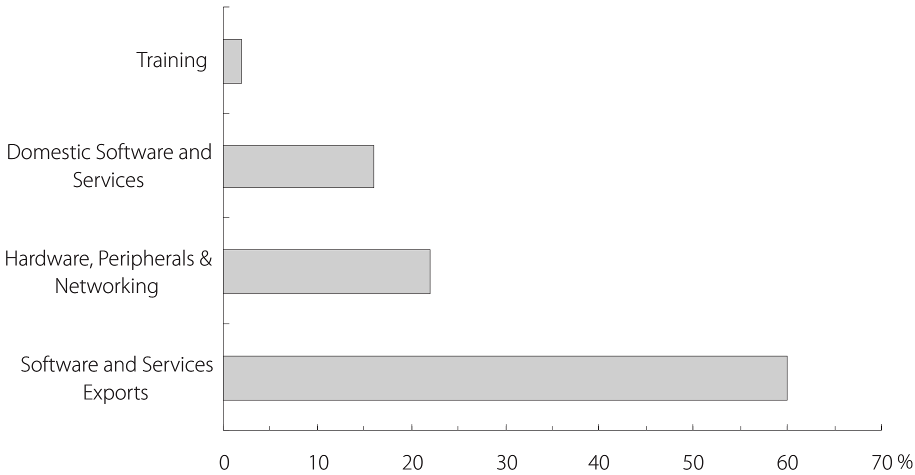
The Indian IT sector is heavily export-driven accounting for around 60 percent of the total revenue of the IT industry (Figure 2.2). The major trade partner of the Indian software and services industry has been North America

Figure 2.1 Indian IT market



Source: NASSCOM.

Figure 2.2 Composition of IT Market in India

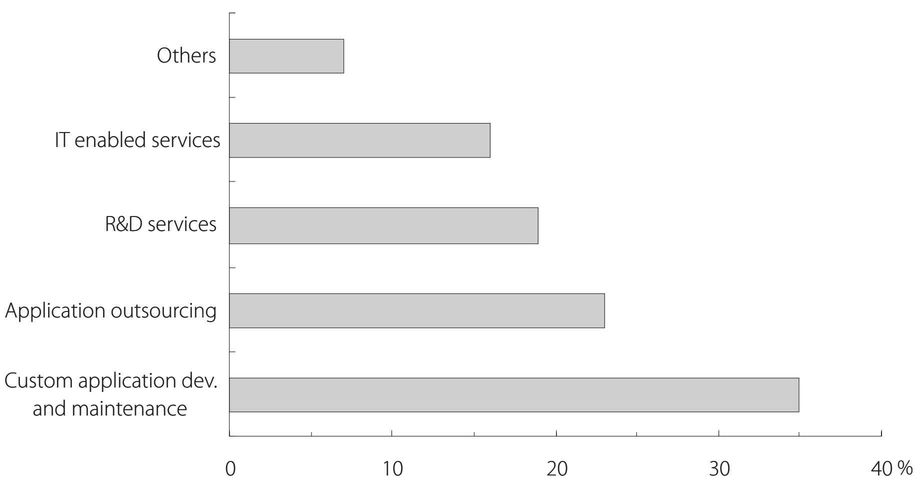


Source: NASSCOM.

but Europe and Asia Pacific have also been important regions for the industry. The UK, Germany and France together account for over 75 percent of Indian exports to Europe. Within the Asia Pacific region, Japan continued to be the largest market for Indian software and services companies followed by China, Hong Kong, Taiwan and South Korea.

In terms of industries, the Indian software export companies have focused on the financial services sector. Approximately 40 percent of the total revenue comes from this sector.

Figure 2.3 Indian Software, R&D Services and Other Services Exports (2001–02)



Source: NASSCOM.

Currently India has a high penetration in two IT services markets, namely custom application development and application outsourcing. In 2001–02, the revenues of the Indian software industry from custom applications development and application outsourcing were around US$ 4.4 billion (roughly 60 percent of total IT exports). The share of R&D services, such as product development and embedded software, is still rather low indicating that MNCs have not outsourced a significant amount of R&D to Indian firms (Figure 2.3).

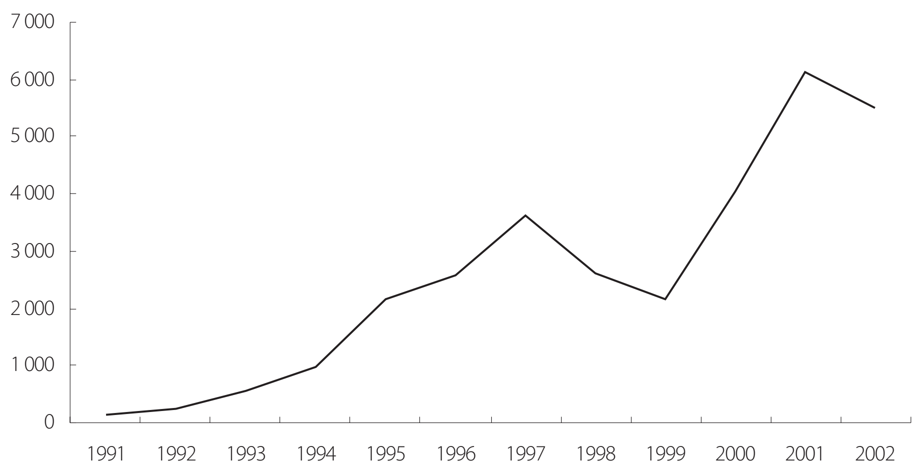
2.2 FOREIGN FIRMS IN INDIA

In spite of the growing interest in India as a host country for FDIs, the absolute level of inward FDI to India is rather modest. In 2002 FDI inflows to India were US$ 5.5 billion representing only 3.5 percent of the total FDI inflows to developing countries.

According to recent survey data (Bhaumik, Beena & Bhandari & Gokarn 2003), most of the foreign firms in India are from the U.S, Germany and the UK. The U.S and Western Europe together account for approximately 80 percent of the firms in the sample. However, the focus of North American and European companies' investment varies. A significant amount of European investment has focused on intermediate goods and machinery and equipment sectors while North American firms, in turn, have invested in the IT and financial services sectors.

Even though the survey indicate that foreign firms in India have small R&D budgets, the anecdotal evidence shows that a number of large multinational companies, such as IBM, Texas Instruments, Sony, Intel, Oracle, Huyndai and Nokia, have established R&D units in India.

Figure 2.4 Inward FDI to India, million US$



Source: UNCTAD (1996–2003).

3 INDIAN SOFTWARE FIRMS IN FINLAND

Currently, there are roughly half a dozen Indian IT companies in Finland. Starting in the late 1990s, Indian software companies have been interested in investing in Finland. Typically, however, they do not have a legal entity in the country. Even though currently only a few Indian companies operate in Finland, an increasing number of Indian firms have considered Finland as a potential location.

3.1 MOTIVES FOR INVESTING IN FINLAND

Our interviews suggest that there have been two major factors affecting the initial decision of Indian companies to establish units in Finland. First, the Finnish market with a number of companies operating internationally has been seen as a potential customer base. While some of the Indian vendors are mostly interested in large manufacturing, banking and insurance companies, some others focus more on medium-sized companies. However, practically all the companies have seen Nokia as the most important and attractive customer in Finland.

> "Why we came here [Finland] initially was because of Nokia." (Indian vendor)

The second establishment motive has been the reputation of Finland as a country with leading-edge technology. As one of the interviewees said:

> "The Finnish market is important from the technology perspective." (Indian vendor)

Hence, Finland is not only seen as a promising market, but also to as a potential location to increase the knowledge level in at least two ways. First, the presence in the Finnish market helps vendors to monitor new technological developments in selected fields. Second, learning-by-doing and learning through experience add the skill base of vendors.

3.2 THE BENEFITS AND RISKS OF OFFSHORE OUTSOURCING

The previous literature suggests that a key motive for outsourcing is simply cost reduction (see e.g. Girma & Görg 2002). Companies try to cut costs by contracting out activities that were previously performed in-house. One interviewee presented it as follows:

> "The main thing really is to cut the costs as of now." (Customer)

While the wage level of a software developer may be 5–10 times higher in Finland than in India, the difference is remarkably small when communication and management overheads are included.

> "When you are outsourcing, you have a distance management overhead. You have to manage that outsourcing. It's not so that you outsource and then forget it, and some day you'll get fine delivery." (Indian vendor)

The role of management and governance was emphasised in our interviews. In many cases, outsourcing does not diminish the need for management, but in fact it may require more management and management skills to monitor and control off-site vendors. By taking additional costs, such as management, communication, travel and cooperation costs, into account, our interviews suggest the cost savings from outsourcing offshore become clearly smaller than the labour cost difference, but they still are substantial. However, increases in software specialists' wages in India (which over the past few years have been increasing at an annual rate of somewhere between 15–25 percent, according to one of the vendors) may change the current difference substantially. One interviewee highlighted this issue as follows:

> "If the cost level [in India] will really increase by 10 percent a year, it might be a bigger disadvantage than many people think. Software competencies exist in many places in the world." (Customer)

Thus, though the potential cost savings are substantial, it is not easy to calculate them accurately because usually there is no such thing as a fixed-price contract. All outsourcing contracts contain baselines and assumptions. If the actual work varies from the estimates, the client will pay the difference. In most projects costs change by 10 to 15 percent during the development cycle.

In addition to cost savings, there are other motives for outsourcing. In some cases, outsourcing decisions are driven by the lack of in-house resources. In principle the company could undertake some activities in-house, but the lack of qualitative or quantitative resources push companies to utilise external capabilities. Hence, in that context the nature of the relationship between vendor and customer can be described more as partnering than as pure outsourcing. By using the talent pool of vendor firms, companies are potentially able not only to augment their internal capabilities, but also speed up their technology or product development processes. The following quotations illustrate this view.

> "The main driver for collaboration with the Indian companies is the availability of software skills, and also in terms of processes maturity levels. Our own software processes level is not so high. Costs certainly are another factor." (Customer)

> "We have heavily invested in R&D and we came up with certain building blocks of software... The same software development block, which we sell to one company, we can also sell to another company and build on top of it. Rather than start from scratch every day reinventing the wheel, we have these building blocks. So we offer to our customers something which is going to reduce time to market much more." (Indian vendor)

From the viewpoint of the customer, another route to accelerate product development is to outsource the sustaining and maintaining of existing products. Then, the firm is able to concentrate its in-house R&D on the development of new technology and the next generation product development. In these cases, outsourcing also serves as a means to reallocate in-house resources.

Even though outsourcing offers a potential route to speed up development, targets are not always achieved as the following quote shows:

> "Time to market was a consideration, but with initial tests we are actually losing time, maybe we have not been able to define the interfaces well." (Customer)

In addition to benefits, collaboration in development operations also includes risks and disadvantages. A major risk concerns potential information leakage and data security, which distinguishes R&D outsourcing from production outsourcing (see. e.g. Lai & Riezman 2004). Hence, even though R&D could be cheaper from external sources, R&D outsourcing is only undertaken if it does not threaten the competitive advantage of the firm.

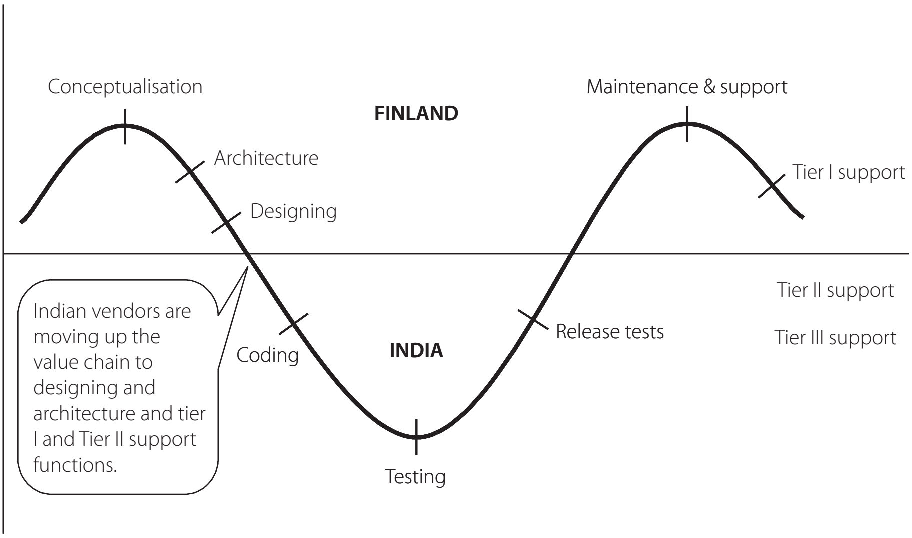
Another risk in outsourcing concerns the turnover of key personnel. Rapid growth among outsourcing vendors has created a dynamic labour market, especially in areas such as Bangalore, Gurgaon, Hyderabad and Pune. Key personnel are usually in demand for new, high profile projects, or even at risk of being recruited by other offshore vendors. While offshore vendors will often quote overall turnover statistics that appear relatively low, the more important statistic to manage is the turnover of key personnel on an account. Common turnover levels are in the 15 to 20 percent range, and creating contractual terms around those levels is a reasonable request. Indeed, the impact of high turnover has an indirect cost on the IT organisation, which must increase the time spent on knowledge transfer and training new individuals.

3.3 DIVISION OF WORK BETWEEN INDIA AND FINLAND

Our interviews suggest that typically in software outsourcing projects with Indian companies part of the work is done in Finland (on-site) and part in India (offshore). The following quote describes the role of on-site activities:

> "First, the most of the people we have in Finland are here because of a lack of skills within this country. And second, we have a coordination team here managing the Indian team. ...so that the customer can see us as one organisation. So we have one

Figure 3.1 Division of work between Finland and India in outsourcing software development



team here, which interacts, with our teams in various places in the world. This is our global delivery model." (Indian vendor)

Still the division of work between India and Finland varies by projects, and the following figure presents stylised features of the division (Figure 3.1).

In a typical case, the original ideas and conceptualisation of software is done in Finland by the customer. In most of the cases, the customer also defines the software architecture. The vendor participates in the designing phase but the coding is mainly done in India. The following quotes describe the volume and the nature of the on-site and offshore work of vendors.

> "The aim is to have a minimum number of people in Finland." (Indian vendor)

> "Today, we have about 75–80 people in Finland, and a very large team in India where maybe close to 400 people are working for Finland." (Indian vendor)

> "Exact specifications are given, only the coding is done [by Indian vendor] and then we check the quality, if it is according to the specs it is accepted." (Customer)

According to our interviews one of the key elements of outsourcing projects concerns the interfaces between outsourced and in-house elements. Without clearly defined specifications the delivery needs reworking and the cost savings are not achieved.

4 FUTURE PERSPECTIVES AND CONCLUDING REMARKS

In this exploratory study we have examined Indian software companies operating in Finland. While in 2004 only half a dozen Indian software firms are operating in Finland, other Indian companies are considering Finland as a potential location.

Typically, Indian software firms use a combination of on-site and offshore work with their customers. According to our interviews, in 2004 Indian software companies employed approximately 200 employees in Finland. However, the total number of employees working in projects with Finnish companies exceeds this figure substantially. In India, roughly 1,000 employees of these vendors work on 'Finnish' projects.

The initial motives of these companies to come to Finland include seeking customers and augmenting knowledge. Practically all the companies interviewed have seen Nokia as the most important and attractive customer in Finland.

From the viewpoint of the customers, our results support the view that the most important motive for offshore outsourcing is lower costs. However, the additional costs, such as management and communication costs, make the cost difference clearly smaller than the wage difference between Finland and India. But not all outsourcing decisions are based on costs. Companies have speeded up their product developing process by using external R&D sources. While in some cases, the lack of in-house resources has pushed companies to use vendors, another reason is the use of external resources in maintaining and sustaining of existing products which, in turn, enables the firm to focus its in-house resources on the development of next generation products. Even though offshore outsourcing of R&D offers substantial potential benefits, it also includes risks and disadvantages. The crucial risk concerns information leakage and data security. Even if some of the R&D could be undertaken with lower costs externally, the threat of information leaks renders this option unattractive.

It seems that in the future, Indian vendors are moving up in the value chain to designing and architecture functions. This will probably mean that on-site work will increase. But offshore work will also increase through both increasing offshore outsourcing and in-house operations. However, Indian companies are not the only ones in offshore outsourcing market. For instance, Russian offshore companies are also interested in the Finnish market and they are potential competitors for Indian outsourcing companies in the future. However, it is not easy to estimate accurately how substantial this development will be and more importantly what impacts the development will have on Finland. One interviewee described the future as follows:

> "I think that we will increase our in-house R&D in India. It is not necessarily away from Finland but it is away from somewhere. Or the growth will be in India instead of the U.S. which is at least twice as costly as Finland." (Customer)

FOOTNOTE

1 From the viewpoint of Finland and Finnish companies, these activities represent quadrants II (on-site work) and IV (offshore work) in figure 1.1.

REFERENCES

Bhaumik, S., Beena, P., Bhandari, L. & Gokarn, S. 2003. *Survey of FDI in India*. DRC Working Papers No 6, Centre for New and Emerging Markets, London Business School, London, UK.

Brainard, L. & Litan, R., E. 2003. *Services Offshoring: Bane or Boon and What to Do*? *CESifo Forum,* summer 2004 vol 5, pp. 3–7.

Girma, S. & Görg, H. 2002. *Outsourcing, Foreign Ownership and Productivity*: Evidence from UK Establishment level Data. Research Papers 2002/16, The University of Nottingham.

Lai, E., Riezman, R. & Wang, P. 2004. *Outsourcing of Innovation*. Paper presented in ETSG 2004 seminar in Nottingham, 9–11 September 2004.

UNCTAD (1996–2003). World Investment Reports. Geneva: United Nations.

NAVIGATING IPR THICKETS FROM A LATECOMERS PERSPECTIVE – The case of the emerging Chinese ICT industry[1]

Long, Vicky and **Palmberg**, Christopher. **NAVIGATING IPR THICKETS FROM A LATE-COMERS PERSPECTIVE – THE CASE OF THE EMERGING CHINESE ICT INDUSTRY**
ABSTRACT: China is catching-up the developed industrialized countries as a major user, developer and producer of ICT. Nonetheless, the longer-term success of this catching-up process will also depend on how emerging Chinese firms manage to build up international intellectual property right (IPR) stakes and manage these in the thickets of overlapping patents held by the incumbents due the importance of standardization, patent pooling and cross-licensing in this industry. This paper analyses the endeavours that Chinese ICT firms face in this context, drawing on data on granted patents at the US patent office combined with interviews of the key firms. The results suggest that Chinese firms indeed are building up patent-related IPR stakes, and acknowledge their importance, although the absolute level of patenting still is very low. Further, these IPR stakes are relatively indigenous in terms of ownership and the related knowledge base. The public standardization initiatives related to the third generation TD-SCDMA standard apparently also support such indigenous developments even though re-engineering and incremental innovation still plays an important role. Chinese firms also use secrecy, and lead time advantages as means to protect their IPRs, especially in the large domestic market characterized by an underdeveloped patent system. This duality in terms of differentiated strategies abroad and on the Chinese market also provides challenges for the incumbents in the industry.

KEYWORDS: catching-up, China, ICT industry, patent thicket, IPR management

Long, Vicky ja **Palmberg**, Christopher. **IMMATERIAALISTEN OIKEUKSIEN HALLINTA KEHITTYVÄN MAAN NÄKÖKULMASTA – KIINAN ICT-ALAN NOUSU**
TIIVISTELMÄ: Kiina on kuromassa umpeen sitä etumatkaa mikä kehittyvillä mailla on ollut informaatio- ja kommunikaatioteknologian (ICT) käyttäjinä, kehittäjinä ja tuottajina. Kiinan näkökulmasta tämä kiinnikurominen riippuu kuitenkin paljon siitä miten kiinalaiset ICT-alan yritykset kykenevät kehittämään teknologian suojaamiskeinoja ja patentteja joiden avulle ne voivat osallistua standardien kehittämiseen ja etabloitujen yritysten allianssiverkostoihin. Käsillä oleva tutkimus paneutuu tarkemmin niihin haasteisiin joihin kiinalaiset ICT-alan yritykset törmäävät tässä yhteydessä. Tutkimuksessa on hyödynnetty patenttiaineistoa sekä täydentäviä haastatteluita. Tulosten mukaan kiinalaiset ICT-alan yritykset tiedostavat patentoimisen tärkeyden ja ovat myös enenevässä määrin patentoineet Yhdysvalloissa, vaikka myönnettyjen patenttien lukumäärä vielä on hyvin pieni, varsinkin suhteutettuna maan isoon kokoon. Patenttien omistuspohja ja taustaosaaminen ovat kuitenkin kiinalaisperäisiä. Kolmannen sukupolven TD-CDMA standardilla on myös ollut tärkeä merkitys kiinalaisten ICT-yritysten osaamispohjan kehittämisessä. Olemassa olevien tuotteiden uudelleentoteutusten ja näennäisinnovaatioiden merkitys korostuu kuitenkin myös. Varsinkin kotimarkkinoilla yritykset pyrkivät suojaamaan teknologiaansa myös salassapidon avulla sekä edelläkävijän eduilla. Kiinalaisyritysten moninaiset IPR-käytännöt ja -strategiat ovat myös haasteellisia etabloituneiden yritysten näkökulmasta.

AVAINSANAT: kiinnikurominen, Kiina, ICT toimiala, patentoiminen, IPR hallinta

1 INTRODUCTION

1.1 BACKGROUND

Rapidly developing countries are catching-up the industrialized countries as major users, developers and producers of Information and Communication Technologies (ICT). This paper analyses the case of China and focuses on how firms in the emerging Chinese ICT industry are building international stakes related to Intellectual Property Rights (IPR), and manage these in the broader catching-up process. The relevance of the paper stems from the significant increase in the importance of IPRs in international competition (see e.g. Special Issue in Economics of innovation and New Technology (2004)). In the ICT industry the concerns over IPRs are especially pronounced due to the strategic role that patents play in standard-setting. Firms often hold multiple overlapping patents due to technological complementarities, whereby these patent-based IPRs become 'bargaining chips' in, or 'tickets' to, standard-setting alliances between firms (Bekkers et al., 2002; Shapiro, 2003). Since especially the incumbent firms from developed countries have acquired large shares of such patent-related IPRs Chinese firms are facing a great challenge as they are endeavor to further upgrade existing knowledge bases and market position in the global ICT industry.

The literature on IPR management does not really account for the fact that countries and firms enter industries on unequal terms. The fundamental dilemma for latecomer countries stems from the inherent characteristics of knowledge in the ICT that can be characterized as both "proprietary" and "infrastructural" (Steinmueller, 1995). As a consequence the engineering community of the incumbents has strong incentives to pool knowledge and related IPRs in their upstream activities while they also might wish to create entry barrier for new entrants from latecomer countries to sustain their competitiveness in downstream activities. This creates so-called "IPR thickets", or an overlapping set of patent-based IPRs requiring those seeking to develop and commercialize new technologies or standards to obtain licenses from multiple patentees (Shapiro, 2003). As a consequence latecomer countries and firms might get caught in a vicious circle and face severe constraints even though they might be able to narrow down other knowledge-related gaps in their catching-up with their highly developed competitors (Perez and Soete, 1988).

The case of the emerging Chinese ICT industry is especially interesting from a catching-up perspective due to ongoing convergence between data communications and telecommunications, as well as the diffusion of the Internet Protocol (IP), that provides new entry opportunities (e.g. Bohlin et al., (2000)). In this context China may be particularly well-placed to take advantage of a heterogeneous and huge-sized home market as a living laboratory to advocate its own technological platforms. This is best exemplified by the development of the Chinese 3G standard TD-SCDMA[2] as well as by the 4G proposal LAS-CDMA[3]. In this sense the situation for latecomer firms engaging in catching-up is now quite different when compared to the single standard environment of the Global System for Mobile Communications (GSM).

1.2 AIM AND STRUCTURE OF THE PAPER

The point of departure of this paper is that the future rise of China to the forefront of new ICT technologies and markets largely hinges on whether the Chinese ICT firms – a majority of which currently are paying voluminous patent royalities to foreign firms – manage to navigate IPR thickets and in the process create indigenous knowledge bases and IPRs. Given the importance of patenting as a means to protect IPRs in the ICT industry, the empirical part of the paper we will focus on patent-related IPRs although other means of protecting and managing IPRs are also discussed. With reference to the discussion above, its purpose can be broken down into two following sets of research questions:

1. What is the present position of the emerging Chinese ICT industry in terms of patent-based IPRs in an international context? How has this position changed over time, and how indigenous are these IPRs and the related knowledge base?
2. Apart from patenting, which other means do Chinese ICT firms use in protecting their IPRs, and how do they manage these IPR internally and in collaboration with other firms and actors in China and abroad?

Through these research questions the paper also discusses whether there is a Chinese IPR profile contextually embedded in its cultural and managerial norms. It thereby also contributes to a better understanding of the extent to which IPR strategies and indigenous efforts affect latecomers' catching up capabilities, as well as how policy may be designed to support the catching-up process of latecomers.

The paper is structured as follows. Section 2 provides a conceptual background and a brief review of related extant research, while also attempting to contextualize the discussion of IPR management from a latecomers' perspective. Section 3 introduces the methodology used and discusses the empirical analysis that combines patent data with complementary firm-level interviews. Section 4 concludes the paper.

2 A CONCEPTUAL FRAMEWORK

2.1 CONVERGENCE, DIVERGENCE AND CATCHING-UP THROUGH ICT

The discussion on "converging and diverging" patterns of industrialization amongst developed and developing countries started at the beginning of 1990s. It argues that the growth of cross-border intra-firm trade, foreign direct investment (FDI), strategic alliances, technology transfer, and an emerging Global Production Network facilitate knowledge fluidity and increase the "footloose" character of firms (Duysters and Hagedoorn, 1995; Ernst et al., 2002). This was also evidenced by an increasing accumulation of advanced technological capabilities and strategic alliances within the Triad (USA, Japan and Europe), followed by a rapid catching-up by developing countries especially from East Asia (Freeman and Hagedoorn, 1995). Convergence and divergence theory further suggested that ICT has the capability to act as the basis for a technological revolution in the catching-up process. Freeman (1994) and Hobday (1995) find support for this proposition in the case of the first tier "Asian tigers" which show a pattern of industrial restructuring where ICT products have been the fastest growing category in the commodity composition of exports. The availability of generic ICT technologies and low sunk cost of high-tech industries suggest that ICT even has the potentials to support "leapfrogging" across industrialization phases (Steinmueller, 2001).

Apart from the general role of ICT for catching-up and leapfrogging there are many features of the present development stage of the ICT industry that suggest that China has a real window of opportunity in this context. For example, Asia is increasingly considered as a living laboratory for next generation wireless communications. This is also reflected in the fact that many firms in the telecommunications industry now are moving R&D centres to Asia. (Lu, 2003). The opportunities offered to developers of next generation wireless communications by a huge home market also elevates the Chinese potential in ICT to a new competitive level. The heterogeneity of the country with both densely populated and sparsely populated regions, and the variety embodied for example in its existing telecom infrastructure (i.e. the co-existence of three 3G standards), which require high quality seamless mobility handover functionality, combined with rising income levels and the emergence of new lifestyles, also make China an especially interesting test trial field for new technologies (Long and Laestadius, 2005).

However, the catching-up process of the Chinese ICT industry is far from easy despite many positive signs. It will largely depend on "absorptive capacity". Catching-up based on new technologies is far from the passive process that the literature on spillovers and imitation sometimes seems to suggest (Cohen and Levinthal, 1990; Freeman, 1994). While the mass of FDI has greatly contributed to a local high-level technology infrastructure, the development of absorptive capacity and downstream integration capabilities among latecomers requires continuous indigenous efforts for innovation. In another words "economies of scale" in today's catching-up context may only suggest a follower position focusing on low-end segments and cost advantages. Catching-up will also require sufficient "economies of scope" in terms of R&D and innovation in order to be sustainable in the longer term, especially in the technologically complex and dynamic ICT industry. This also introduces IPRs into the picture and thereby complicates the catching-up process further.

The emergence of the ICT industry in China has previously been studied from the perspective of regional innovation system (Enright et al, 2005; Sigurdson, 2005). Peter Nolan (2001, 2003) has conducted a thorough study on Chinese state-owned large corporations. He argues that the global consolidation has tightened incumbents' grips on the global economy, whereby latecomers like China face problems of a magnitude not experienced before by any other developing country. The evolution of China's R&D system in response to foreign R&D investment into China has also drawn research attention recently (Fischer and Zedtwitz, 2004; Walsh, 2003). Further, Bhattacharya (2004) uses the USPTO database to examine the differences between India and China in patenting in terms of their assignee and inventor structure and their active technological domains. But this is a far more general study without a focus on the ICT industry. The only studies we have found on IPR issues in the Chinese ICT industry appear overly descriptive and ignorant of the broader discussion of patent thickets and IPR management issues at the firm level (e.g. Meng and Yang (2004), Bao et al. (2004)). Hence, and to the best of our knowledge, this paper is breaking some new ground by taking an explicit focus on IPR management in the emerging Chinese ICT industry from the viewpoint stated above.

2.2 CONTEXTUALIZING IPR MANAGEMENT FROM A LATECOMERS PERSPECTIVE

Given the neglect of the extant literature, as well as the novelty of our particular focus in this paper, a brief contextualization of IPR management issues from a latecomer perspective is warranted in order to frame the subsequent empirical analysis. Following a significant increase in the importance of IPRs in the global economy there is a virtual explosion of patenting activities in the last two decades (Reitzig, 2004).

Given the focus of this paper, it makes sense to settle for a sufficiently broad 'taxonomy' to describe the means and strategies that firms use in their IPR management. For the sake of clarity, we will take the seminal categorization of various means to appropriate R&D and protect the related IPRs developed by Levin et al. (1987) as the starting point. In order to contextualize the case of China as a latecomer in this taxonomy we will refer to the concepts of appropriability and technological regime (see especially Teece (1986) and Marsili (2001)). The former concept refers to the broader economic environment in terms of how it will affect the possibilities that firms have to appropriate their IPRs. The latter refers to the nature of different industries and technology fields that also matters in an IPR management context.

The taxonomy by Levin et al. (1987) was developed based on the extant theoretical literature as well as both quantitative and qualitative research in order to frame questions in a survey. It essentially identifies patent-related and non-patent related means of protecting IPRs in terms of six different categories.

The first two categories cover patents as a conventional means to protect IPRs, especially in the industrialized countries and high-tech industries. Of these the first concerns *patenting to prevent duplication*, or imitation by competitors. It refers to the notion of "Schumpeterian profits" arising from the temporary monopoly position that an entrepreneurial innovation brings to firms (Schumpeter, 1911, 1934). The second category concerns *patents to secure royalty income.* It refers to patenting in a more strategic sense as the basic motivation is the value of the related IPR itself rather than the possible innovation based on which it is applied for. In other words, certain patents might be applied for in strategic fields in order to generate revenue streams. This type of practice is quite common in the ICT industry.

The third category concerns *secrecy* as a means to protect IPRs. Secrecy is generally considered more effective than patents in process-intensive industries. Secrecy relates to the term 'trade secret', i.e. "any valuable process, information, or idea which has been identified and kept secret from others" (Anawalt and Powers, 2000, p. 210). According to Levin et al. (1987) the effectiveness of secrecy is positively correlated with the extent to which the information disclosed in a publicly accessible patent limits effectiveness of patents as a mean of protecting IPRs.

Table 2.1 Different means of protecting IPRs

1. Patents to prevent duplication
2. Patents to secure royalty income
3. Secrecy
4. Lead time
5. Moving down the learning curve
6. Complementary sales or service efforts

Source: Levin et al. (1987).

The fourth category concerns *lead time.* This mean of protection is a direct consequence of the increasing complexity of technologies especially in high-technology industries. Increasing complexity, combined with rapidly shifting fads amongst consumers, implies that firms gain a natural lead time advantage of being first within a specific technology field or business area (von Hippel, 1988). Latecomer firms will always be one step behind the leader, which thereby also yields a natural protection over the related IPRs.

The fifth category concerns a related means, namely *moving down the learning curve.* This refers to advantages that certain firms might have over others in being quick learners of complex technologies due to various in-house capabilities that enhance their absorptive capabilities (Cohen and Levinthal, 1990). Firms with this capability can protect their IPRs simply by being faster learners than their competitors. One particular example is re-engineering as an explicit strategy for firms to accelerate movements down the learning curve (Hammer and Champy, 1994).

Finally, the sixth category concerns the development of *complementary sales or service efforts*. This refers to the fact that innovators seldom are the sole appropriators of their innovations and IPRs since the commercialisation of technology also often requires the control of complementary assets in production, marketing or distribution (Teece, 1986). Hence, even though firms might not possess patents to a particular innovation they might still be able to protect it by possessing such complementary assets that are often difficult to access or imitate.

2.2.1 THE APPROPRIABILITY REGIME IN – THE CHINESE PATENT SYSTEM

As suggested above, the concept appropriability regime has been developed to capture characteristics of the economic environment that govern the ability of firms to appropriate R&D and protect their IPRs. An important dimension of this regime is the efficiency of the legal mechanisms that govern the patent system in various industries and countries. (Teece, 1986, 2000). As the Chinese ICT industry is endeavouring to move from manufacturing-based competitiveness derived mainly from cost advantage to R&D-based competitiveness the development of such a system to strengthen the appropriability regime becomes all the more important.

Our study indicates that Chinese patent system started to develop in the mid 1980s when the open policy has attracted increasing FDI. Under the long negotiation process to enter the World Trade Organization (WTO) trade-related intellectual property issues has also been highlighted through the TRIPS agreement, and a Chinese patent policy is gradually emerging. China joined WTO in the end of 2001 and the developing patent system has to a great extent been exogenously enforced upon China due to the more open policy that the country has gradually followed. Of obvious significance in this context is also the fact that the Chinese economy was under strict socialistic/communistic rule for nearly three decades since 1949 up to the introduction of "market socialism" starting from 1978. Today the motivations for setting up a patent system are derived from "capitalistic competition". It is also intended as an incentive system to encourage indigenous innovation. This was obviously not the issue under socialist/communist rule.

Based on the history of policy introduced above it may come as no surprise that China, in general, has been considered by the outside world as having a fairly weak appropriability regime that invites much "free-riding" in business practices that escapes both international and national IPR regulations. Nonetheless, emerging Chinese IPR policies focus on developing the Chinese patent office, related policies and regulations. The State Intellectual Property Office (SIPO) was established in 1998 based on the former state patent office. The state patent office was established when the first Chinese patent law was issued in 1985. It has developed rather slowly before the establishment of SIPO, and greatly suffered from a lack of people with sufficient skills in IPR issues. Until 1998 there were just around 400 patent engineers while the corresponding number for USPTO was 6000. Despite a short history of patent law in China industries in all sectors have been encouraged to develop their own technologies over the past two decades. We also see enormous efforts at the local level to encourage firms to establish their own IPR management practices. For example, at the provincial level there are different complementary policies like tax breaks, state-controlled venture capital support to IPR management at the firm level. This has, hence far, only marginally provided incentives for firms to formally seek patent protection. According to SIPO currently only 0.03 percent of the total population of Chinese firms own patents. Conversely 99 percent of the firm have not even applied for a patent. (SIPO website, 2005).

2.2.2 THE TECHNOLOGY REGIME – THE NATURE OF ICT

The concept technological regime refers, in a broader sense, to the technological and cognitive environment in which firms conduct R&D, innovate and seek to protect their IPRs in terms of the tacit-ness, complexity and cumulativeness of the related knowledge base (Marsili, 2001). In this context it seems useful to make a distinction between "cumulative and complex" and "discrete technologies (Cohen et al., 2000; Reitzig, 2004). According to this distinction ICT can be considered to fall into the domain of complex technologies where the patentable elements are tightly connected to each other. It is very typical that an individual patent does not entirely cover a product whereby firms often have to collaborate in R&D. (Merges and Nelson, 1990).

The cumulative and complex nature of ICT technologies and prevalence of R&D collaboration also naturally leads to a patenting behaviour where the patents themselves become tradable assets and 'tickets' to standardization alliance networks through patent pooling and cross-licensing activities. In other words, the reciprocal exchange of IPRs rather than patent interference is the norm in this type of technological regime (Reitzig, 2004). It should also be noted that this type of patenting behaviour has partly been institutionalised by formal standard-setting organizations – such as the European Telecommunications Standardization Institute (ETSI) – that have set up a system of obligatory notification of patents deemed essential for the further development of a particular standard. These systems create the institutional and regulative framework for patent pooling and cross-licensing.

From the viewpoint of China, as a latecomer country, it is thus important to acknowledge that there are two types of relationships between firms. On the one hand, members of standard consortia interact intensively in R&D and patenting trough cross-licensing and patent pooling which, in turn, seems to shape the downstream market structure of the industry (see especially Bekkers et al. (2002)). On the other hand, the breadth of the aggregated patent pool and cross-licensing activities will contribute to fencing out those latecomer countries and firms that do not manage to develop indigenous and significant patent-based IPR stakes. A related aspect of this is also that incumbent countries and firms "stand on the shoulders of giants" as they accumulate knowledge of the technologies that they trade through patent pooling or cross-licensing, and thereby also create knowledge-related barriers to entry for latecomers. (Scotchmer, 1991).

3 EMERGING CHINESE IPR STAKES IN ICT

3.1 A BRIEF NOTE ON THE METHODOLOGY

The twofold aim of this paper to trace the broader position and development of Chinese patent-based IPRs as well as to understand how Chinese firms manage IPR issues in general calls for a combination of quantitative and qualitative analyses. We do this by combining broader patent analysis with qualitative interviews at the firm level in China.

The quantitative analysis focuses on Chinese patents granted in the US (the US patent office USPTO). The underlying logic here is to focus on patenting as the most significant means of protecting IPRs in the context of ICT industry, since they provide protection as well as function as tradable assets in the type of regime that prevails in this industry as we argued above. Thus, one might argue that patenting is a necessity for latecomer countries and firms, even though we also highlighted various others means of protecting IPRs that are relevant outside the core patent pooling and cross-licensing activities of firms.

The patent analysis will thereby provide insights into the IPR activities of Chinese firms at the 'tip of the iceberg'. In the qualitative part of this section we use the interviews to broaden the viewpoint beyond patenting and discuss the perceptions that Chinese firms have also on other means of protecting IPRs, as well as the underlying motives and indigenous nature of the knowledge base. This part is based on a sample of 39 Chinese firms active in the field of ICT subject to one or more of the following criteria (see the list of firms in Appendix 1):

- Good export performance in terms of export and total sales ratio based on a ranking list of 100 top firms from 2004 put together by the Ministry of Information Industry of China
- Active participants in various industry standard consortia both international and indigenous, such as the TD-SCDMA and LAS-CDMA consortium
- Patenting at the USPTO

The firms were approached in China during November 2004 to August 2005 with a semi-structured face-to-face or telephone interview (21 structured telephone interviews and 18 face-to-face interviews in China). The interviews were not taped out of respect of the interviewees but extensive written notes were made. In addition, two groups of incumbent firms in Sweden and Finland were interviewed to also incorporate their views on navigating patent-based IPR thickets.

In the subsequent sections the quantitative and the qualitative firm level analyses are used in parallel. We start of by quantitatively analyzing broader trends in patenting of Chinese firms and use the interviews to provide qualitative interpretations of these trends. Next we move on to discuss the indigenous nature of Chinese patent-based IPRs, again through a quantitative analysis complemented with qualitative interpretations to also cover other means of protection. The section ends with a broader qualitative interpretation of how Chinese firms manage their IPRs also beyond patenting, as well as which motivations are identifiable in the background.

3.2 BROADER TRENDS IN CHINESE ICT PATENTING

Definitional considerations

In analysis of patent data special attention has to be given to define the patent office of reference as well as the nationality of patents. The majority of Chinese ICT patents are filed at the SIPO, the Chinese patent office. SIPO provides an obvious home advantage although it is clear from the discussion in section 2.2.1 that the patent system in China still is in an embryonic phase. Hence the focus of this paper is on the international patents of Chinese ICT firms under the assumption that these patents have passed a much higher threshold in terms of technological and economic significance, and hence also embody more valuable IPRs. A good starting point is to look at Chinese ICT patenting within the Triad (i.e. US Patent Office (USPTO), the European Patent Office (EPO) and the Japanese Patent Office (JPO) to identify the best data sources for our more elaborate analysis of the ICT industry. This is done in Appendix 2 where we define a Chinese patent as one where the priority country is China.

From Appendix 2 it is clear that Chinese patenting at the Triad has increased significantly in recent years. The figure also suggests that the USPTO is the best international data source to analyze Chinese patent-based IPRs relating to ICT, as shown in Appendix 2 from an obvious sharpest increase in applications among Triad offices. This is also backed-up by the fact that the US still is considered as the most important market for technologically advances products, whereby the USPTO also is of strategic importance for firms that wish to protect their IPRs through patenting. Before turning to broader trends of Chinese ICT patenting at the USPTO a word of caution is in order regarding the definition of the nationality of patents. In addition to priority country, the country code of the assignee as well as the inventors serves as alternative means to define nationality. The country code of the assignee denotes the geographical location of the entity that has applied for the patent, usually the firm. In this case patents originating from the foreign affiliations of the assignee are excluded. The country code of the inventors denotes their place of residence. (Hinze and Schmoch, 2004). In order to settle for the optimal definition for the nationality of patents we also tabulate developments in total Chinese granted patents at the USPTO across these three nationality indicators.

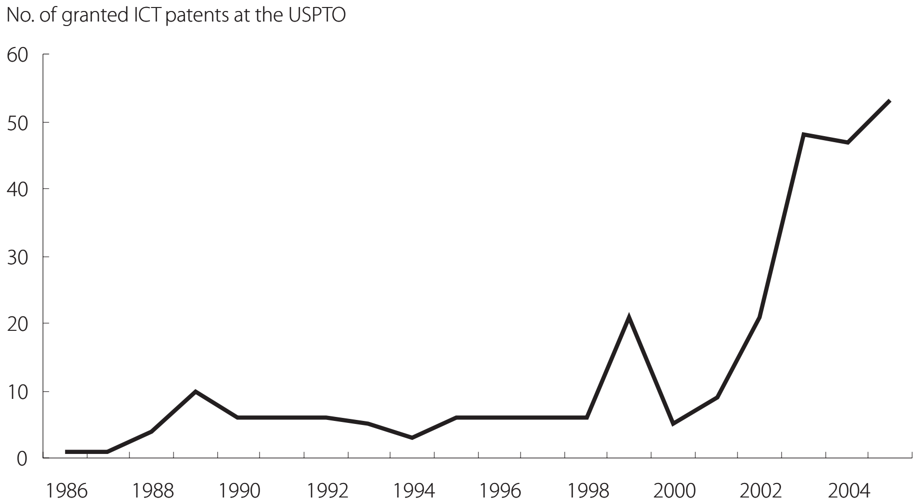
From Appendix 2 we see that developments in terms of granted patents with China as the "assignees country" and China as the "priority country" are almost identical, while granted patents with the first inventor a Chinese have grown significantly more rapidly. This is interesting since it suggests that Chinese inventors could be highly dispersed outside China, at least when looking at patenting across all technology fields. It could also suggest that Chinese inventors as individuals contribute to foreign affiliated firms inside China. Unfortunately we are not able in this paper to investigate which implications this might carry for indigenous technological developments. However, it is clear that priority and assignee country appear to be the most relevant in defining Chinese patent-based IPRs. Since patent-related IPRs also assumedly are managed by the firms themselves, the assignee is the natural choice for defining nationality in this paper. Hence we stick to this definition of Chinese patents throughout the ensuing analyses.

Our focus on the ICT industry also requires some consideration. Patents are classified by the International Patent Classification (IPC) system, whereby there will be a discrepancy between the industrial affiliation of firms and the technology fields in which they patent. In this paper we define the Chinese ICT industry through IPC classes that cover technology fields identified as belonging to ICT broadly defined. Luckily the OECD has put effort in defining ICT in terms of the IPC system and this OECD classification will also be our point of departure (see Appendix 3). When this definition of ICT is used, combined with the limitation to granted patents by Chinese assignees at the USPTO up until mid 2005, we are left with a subset of 270 granted patents that we will analyze in greater details. It should be noted that the definition excludes software as patenting in this field is scant and tricky to identify.

Quantitative analysis

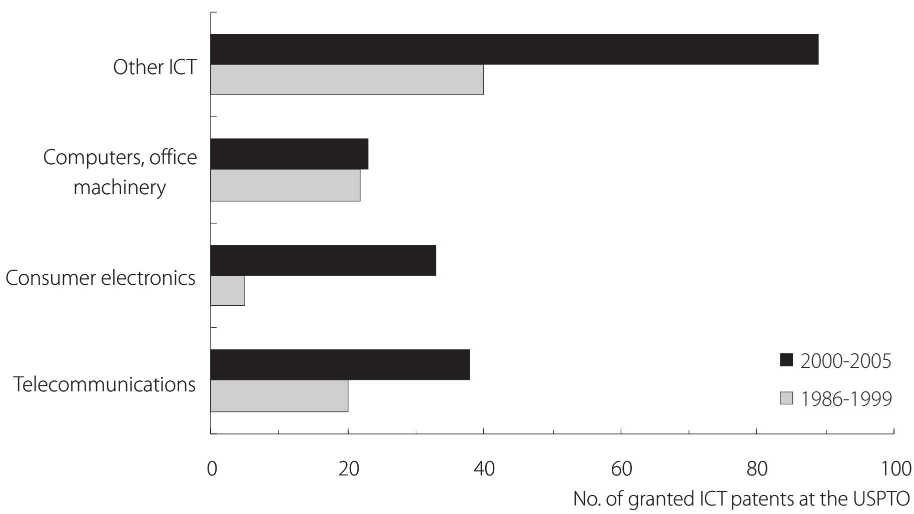
This paper focuses on the IPR-aspects of patenting and is hence limited to granted patents that appear with a lag of 2–3 years. When turning the development of Chinese ICT patenting at the USPTO the growth has been particularly rapid during the last five years with the large majority of all patents having been granted during this period. The growth of Chinese ICT patent applications (Appendix 2) is even more impressive and suggests that firms indeed are in the process of building up patent-based IPR stakes in the field and that the technological sophistication of the Chinese ICT industry is increasing over time. Nonetheless, the absolute level in the number of granted patents is still very low, especially in relation to the large size of the Chinese economy. We illustrated this further in Appendix 4 where the development of granted Chinese ICT patents at the USPTO is compared with that of Finland and Sweden as significantly smaller countries, and it also includes India with a population similar to that of China.

Figure 3.1 Chinese patenting in ICT at the USPTO



Source: Based on data from USPTO.

Figure 3.2 Chinese patenting in ICT at the USPTO by technology fields



Source: Based on data from USPTO.

The OECD classification of ICT comprises of technologies relating to telecommunications, consumer electronics, computers and office machinery, as well as various miscellaneous measuring and control instruments and electronic components. We can break down the aggregate figures from above by technology fields to look in greater detail at the structure of Chinese ICT patenting. By this breakdown we can see that the lions' share of all granted patents fall into the miscellaneous category of 'Other ICT' that mainly comprises various instruments and components. This category has also witnessed the most rapid increase in granted patents in the 2000s compared with the 1990s. Beyond that patenting is relatively evenly spread out between 'Telecommunications', 'Consumer electronics' and 'Computers, office machinery'. It thus seems that the Chinese ICT industry up to now has its strongest patent-based IPR positions in instrument and component technologies that assumedly complement the core technologies of incumbent firms from the developed countries. This result is thereby broadly in line with extant research on the emergence of the Chinese ICT industry. (Chen and Shih, 2005).

Qualitative interpretations

The interviews also confirmed that Chinese firms are in the process of building up patent-based IPRs. Our informants acknowledged the cumulative nature of ICT industry where patents build up on each other in a "cumulative and complex" technological regime as described in section 2.2.2. They also noted that it is important to have a long-term vision in building up in-house R&D capabilities and a strong patent portfolio. This can be exemplified by the development of Nokia, as an incumbent in the industry, for which it took more than a decade to build up a strong patent portfolio during the development of equipment for the GSM standard. Naturally, it may take even longer for firms from a country like China that is characterize by a weak appropriability regime, especially in terms of the patent system.

The interviews also suggest that the building up of patent-based IPR, in this catching up context, has assumed a strategic role for firms. It is not only motivated by appropriating the economic returns of R&D. Access to markets, improving the position of firms in standard setting, and attracting R&D alliance are also considered highly important. For many the motive to increase the value of their firm is surprisingly of marginal importance. Further, in cases where patent pooling and cross-licensing amongst the incumbents block technological developments for the Chinese outsiders we also see a strong endeavor to develop national standards. The prime example is the development of the Chinese 3G TD-SCDMA standard. This standard is also backed up by a huge domestic market. According to the interviews with the incumbents, a new member will not easily be let in to institutionalised patent pooling and cross-licensing activities of the incumbents without a patent-related 'ticket' in the relevant technologies. Any current member can easily veto over the attempt by another member to license technology to third parties. Our informants from incumbent firms indicated that they become more and more cautious on defining scopes of contributions in the pre-pooling stage to ensure a balance between maximum gains from membership and freedom of individual licensing.

Another commonly debated case as suggested by the interviewees also illustrates the challenges that Chinese firms face. In line with the ambition of the latecomer firms to build up an indigenous knowledge base and to avoid skyrocketing royalties to the patent-based IPR holders of the DVD Video format (the royalties reportedly are in the range of 13–20 USD per hardware video player), a Chinese development consortium – the Beijing E-World – started to develop the so-called EVD (Enhanced Versatile Disc) in 1999 which also allows the storage of HDTV resolutions. However, the American On2 Technologies that had developed the technology upon which EVD technology partly is based soon initiated a contract dispute and claimed that they did not properly receive royalties. Although the arbitrator finally dismissed all claims by On2, primarily because an insignificant number of player devices had been produced by the E-World consortium, the latecomers dilemma could clearly be observed.

3.3 THE INDIGENOUS NATURE OF CHINESE IPRS IN ICT

Quantitative analysis

Apart from the broader trends, an interesting viewpoint to take is to look at the structure of patenting across different assignee types to assess the indigenous nature of these patent-based IPRs. For this viewpoint we divided the ICT patents into seven different categories. The first category covers patents granted to Chinese firms as the clearest case from the viewpoint of this paper. The second category covers patents granted to Chinese universities, colleges or research organisations. The third category covers patents granted to a Chinese joint venture between independent firms, universities or colleges or their combination. The fourth category covers patents granted to independent Chinese inventors.

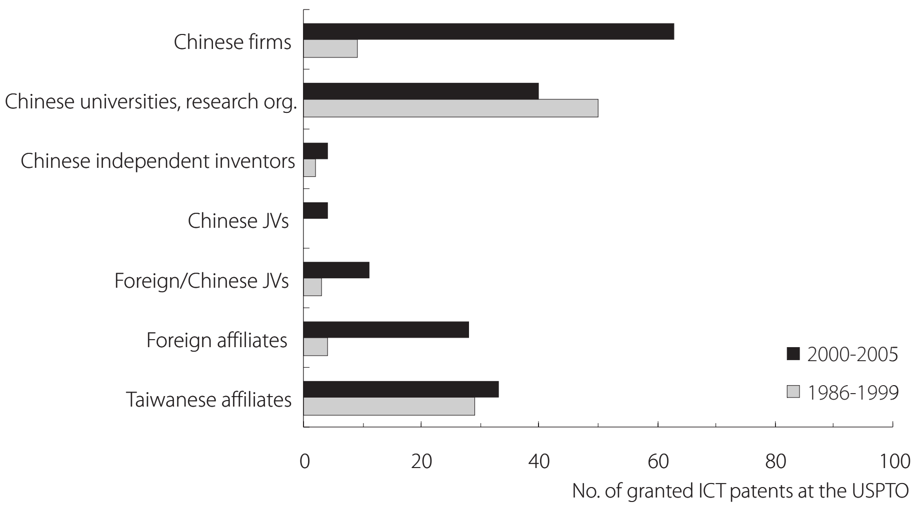
However, beyond these cases where the patent solely belongs to a Chinese entity, there are various mixed ownership modes where the stakes of foreign players might vary depending on the details of the contract. Hence the fifth category covers patents granted to joint ventures between Chinese and foreign firms and/or universities, colleges, research organisations. In these cases patent ownership is shared and it thus less-indigenous, even though joint ventures also facilitate spillovers and thus might support the indigenous development of knowledge. The sixth category covers patents granted to foreign affiliates registered in China while the seventh category covers patents granted to Taiwanese affiliates in mainland China.

As figure 3.3 shows, the majority of all patents have been granted to Chinese entities, foremost firms, universities or research organisations as the holders of the ownership to the related IPRs. Thereby it seems that the modest but rapidly increasing patent-based IPR stakes of the Chinese ICT industry indeed appear indigenous. Over time we also see that the Chinese firms contributed most to this increase, while the role of Chinese universities and research institutes is declining. This might be symptomatic of a more general shift in inventiveness from the public to the private sector in China.

In cases where the patent is spilt between Chinese and foreign firms in joint ventures (JVs) it is unclear how the IPR ownership is distributed. The large share of Taiwanese as well as other foreign affiliates is also interesting and a closer investigation of the relationships between these firms and the indigenous Chinese ICT industry would be important to explore in greater detail. The increase especially in the share of granted patents by foreign affiliates in China is also noteworthy and might generate beneficial spillovers.

As a firm's knowledge acquiring and sharing pattern underlines its patent-based IPRs, we also used the patent data to give some indication of how the Chinese firms build up their knowledge base and to what degree this process is indigenous and thereby also strengthens their IPR position. For this purpose we analysed the composition of inventor teams of the patents that contains information on the affiliation of each inventor. First we illustrate the

Figure 3.3 Chinese patenting in ICT at the USPTO by type of assignee



Source: Based on data from USPTO.

share of inventors with Chinese affiliations for the patents as a whole, and changes over time, in table 3.1. Thereafter we break down this share by the different types of assignees in table 3.2.

The observations above are also backed up table 3.1 Altogether 67 percent of all inventors of the granted Chinese ICT patents at the USPTO have a Chinese affiliation. Moreover, there is a clear indication that this share is growing over time as we move from the period 1986–1999 to the period 2000–2005.

Table 3.1 Share of inventors with Chinese affiliation

Inventors with Chinese affiliation in total data	67 %
Inventors with Chinese affiliation 1986–1999	55 %
Inventors with Chinese affiliation 2000–2005	72 %

Source: Based on data from USPTO.

Table 3.2 Share of inventors with Chinese affiliation by assignee groups

Chinese firms	79 %
Chinese universities/research org.	92 %
Chinese independent inventors	100 %
Chinese JVs	89 %
Foreign/Chinese JVs	39 %
Foreign affiliates	31 %
Taiwanese affiliates	0 %

Source: Based on data from USPTO.

In the case of Chinese firms as the assignee the share with inventors with a Chinese affiliation is 79 percent, while being even higher for Chinese universities or research organisations and Chinese joint ventures. This share of drops in the case of entities with foreign involvement as can be expected and reaches 0 percent in the case of Taiwanese affiliates. Hence, especially the Taiwanese affiliates appear, at least by the face of it, to be relatively autonomous actors in China at least in ICT industry although this naturally is pending on the perspective one the relationships between China and Taiwan.

Qualitative interpretations

From the interviews it also became clear that indigenous R&D is regarded as highly important in this context. Many firms highlighted in-house R&D as a means to be actively involved in standardization. Qualcomm's revenue model, i.e. a strategy to make revenues of royalties through licensing CDMA technologies, is frequently and explicitly quoted by many Chinese ICT firms, both in good and bad. Our informants suggested that they have learned from the case of Qualcomm that there is a positive correlation between revenue and patent-based innovation. Incumbents in the industry commonly appear to perceive that many Chinese indigenous innovations – such as those relating to the 3G TD-SCDMA standard – are mainly for gaining stronger negotiation position in licensing than otherwise while the technology merits of the standard is sometimes doubted. However, our interviews also reveal that there are ambitions and underlying motivations for creating indigenous Chinese standards as a way to break patent thickets created by the incumbents, and furthermore, as a way to also break out from a 'follower' strategy that has characterized the Chinese firms.

Apparently the Chinese firms sometimes see re-engineering as indivisible from in-house R&D. It is considered an important method to learn more about international rival technologies. Although the novelty of reverse engineering is questionable in terms of its patentability, it has undoubtedly played an important role in the learning of the Chinese firms. Therefore many firms conducting re-engineering, although innovative, have not considered applying patent-based IPRs at all. As re-engineering is generally not considered when granting a patent, this may also explain why the absolute number of USPTO patents granted to Chinese firms is still so low, although the interviews do reveal that their firms have managed to innovate incrementally through learning by doing related re-engineering. This is also publicly acknowledged and supported by policymakers in China.

Apart from in-house R&D and re-engineering, R&D alliance is ranked as highly important by the informants, and this observation appears to find backing in the growth in the number of patents assigned jointly to foreign and Chinese firms. Furthermore, collaboration between universities, research organizations and firms varies greatly among regions. Regions with a traditionally strong university base appear to show closer collaboration, although we can not evaluate how this collaboration has supported the patenting activities of firms. However, in general it seems that firms tend to partner up with each other rather than with universities or research organizations as firms find it is easier to reach agreements on priorities and time schedules for R&D projects. The interviews also reveal that SMEs cooperate more closely with universities to exploit spillovers while large firms prefer in-house R&D to a greater extent. This seems to be in line with extant research from the international literature (see e.g. Zoltan et al. (1994)).

R&D alliances and collaboration does of course not always result in joint patenting, and our interviews appear to indicate that this is especially true in the case of collaboration between Chinese ICT firms. The patent analysis indeed indicates that joint patenting among Chinese actors is low despite the importance that firms give to domestic R&D alliances and collaboration. We may speculate how far trust, or "guanxi" as the Chinese call it, extends in the increasingly competitive environment of the Chinese ICT industry and how this has affected joint patenting. The issue of trust is complicated, however, and of necessity falls outside the focus of this paper.

3.4 IPR MANAGEMENT PRACTICES IN CHINESE ICT FIRMS

As suggested earlier patenting at the USPTO might only represent the "tip of the iceberg" in the development of IPR stakes amongst Chinese ICT firms. From the previous quantitative analysis we know that the absolute numbers of granted patents at the USPTO indeed hence far is very low especially from a comparative perspective, although patenting has picked up significantly in recent years as also evidenced by the number of patent applications (see Appendix 2). In the following we provide some additional qualitative interpretations of how these firms manage patent-based IPRs before also turning to a discussion of the various other means of protecting IPRs that we encountered during the interviews.

Patent-based IPR management practices

Through the interviews, we identified some relatively big Chinese ICT firms which have set up their own IPR departments following the increasing propensity to patent, infringe and litigate in both domestic and international contexts. However, these IPR departments still appear far less comprehensive compared to their counterparts in Japanese firms as studied by Granstrand (1999). Most Chinese firms are still in an early stage in developing their IPR

Table 3.3 A taxonomy of IPR management practices of Chinese firms

Type	Firm characteristics	Drivers for patenting	Case examples
1. Market-oriented firms	Strong independent actors in the industry	International market as the target	Huawei, ZTE, Netac, Datang
2. Alliance-oriented firms	Joint ventures with foreign firms	Access to alliances to gain complementary assets	Liu He Wan Tong, Vimicro
3. Technology-based firms	Spin-offs from universities or research organistations	Branding, attract venture capitalists	Lenovo, Tsinghua Tong Fang
4. Lesson-learners	A history of IPR infringements	Build up quality and technology image among consumers	Haier, Hisense, Beijing Huaqi

departments and only employ approximately 1–5 patent engineers internally. But it seems that IPR departments gradually are becoming an essentially irreducible part of Chinese high-tech firms. Based on this we can identify four partly overlapping types of patent-based IPR management practices.

In the case of *'Market oriented firm'* the target is set on conquering international markets. These firms are already quite independent with a relatively strong indigenous knowledge base to stand on in terms of innovation and IPRs. They are also typically those firms which are most active in patenting at UPSPTO. The best example is Huawei which is one of the largest ICT firms in China presently. In the extreme case these firms might use the winning case in an IPR lawsuit as a strategy to increase international and domestic brand recognition.

For *'Alliance oriented firm'* patenting also function as a way to signal technological capability in order to attract foreign alliance partners and access new markets. This becomes more and more important in the ICT industry, as illustrated by the cases of TD-SCDMA and EVD described in previous sessions. Our informants also argue that improving positions in standard setting, and throughout alliance networks, is more important than blocking competition.

For *'Technology-oriented firms'*, who are mostly spin-offs from universities or state-owned research organizations, patenting is natural for branding purposes and a means to attract venture capitalists. For these firms, most of which are SMEs, a patent application is also a 'test' of the effectiveness of in-house R&D as well as to enter unknown markets.

Finally, for *'Lesson learner firms'* the patent system itself is a maze and requires time to learn. Firms in this category apply for patents to learn the rules of the game, and to test the level of their technology. Many of these firms have actually been in a defendant position in a patent infringement lawsuit especially when exporting goods to foreign markets.

Management of IPRs through other means

In the case of China many ICT firms are younger than 15 years and are still in the early stage of their development. Further, our interviews reveal that patenting sometimes is 'over-stressed' as it might neither be cost-efficient nor socially acceptable. Many Chinese ICT firms still generate their largest share of revenue from sales on the domestic market and patenting is considered as an atypical behavior in this context. However, connecting with international business system makes it an unavoidable issue to face. Such cultural issues also imply that other means of managing IPRs sometimes are considered more relevant especially on the domestic market where the appropriability regime is weaker.

For the sake of clarity we will discuss the relevance of these others means to manage IPRs with reference to the 'taxonomy' put forward by Levin et al. (1987) that we discussed in section 2.2. Of these *secrecy* is commonly used in manufacturing process and incremental innovation. Many examples from the South China manufacturing centers illustrate this. China may have more process-related cumulative innovations derived from learning in manufacturing than product innovations, although we have difficulties to quantitatively evaluate it. Furthermore, there has been a general desirability of maintaining secrecy especially in Chinese process technology developments such as in the silk dye industry in the Yangze River Delta region during the last 2000 years, or maybe even for a longer period. The informants stated that secrecy commonly is considered to compensate for the risks associated with disclosing information contained in the patents and secrecy is sometimes combined with patenting in different sub-products portfolios. The combination of secrecy and patenting is an attempt to identify an optimal mix of cost-saving and appropriating returns.

Contractual arrangements might also complement patenting and secrecy as a means of protecting IPRs. For example, a preferential contract with suppliers or customers is common in China due to the emphasis given to trust, or "guanxi. Nonetheless, the Chinese cultural tendency of "anti-conflict" – derived from Confucian doctrines – also plays an important role in the IPR management practices of Chinese ICT firms. This doctrine advocates neither offensive nor defensive patent lawsuits. A time-consuming and resources-demanding patent lawsuit is, in general, still not socially acceptable in China. According to this line of argumentation trust, or "guanxi", can facilitate contractual arrangements and guarantee its enforcement in certain degree. Although it is argued in that this Chinese ethic has been greatly deteriorated as a consequence of rapid economic development, the moral values and business ethics are still valid within the "guanxi" networks.

According to the interviews *lead time advantage* is also greatly favoured as a pragmatic IPR management strategy. Chinese ICT firms commonly perceive that technological developments are so fast that patenting, in fact, might become irrelevant. This is more obvious in "faddish" consumer products. The attractiveness of a new mobile handset model could die out within 3–6 months and the embedded software becomes useless when re-programming of the software is needed. In the Chinese market the interviews reveal that every year there are 600–700 new handsets models introduced to the market both by domestic and foreign firms. Hence, many latecomer firms' innovative strengths lie in developing minor market adaptations and improvements where the learning curve is shallower compared to that of the precedent innovators. Bureaucracy relating to patenting is simply considered too tedious and a resource demanding. Furthermore, as the enforcement of patent laws in

China still is very weak lead time advantages appear as more effective for firms with a domestic market focus.

As suggested above, lead time advantages amongst Chinese ICT firms appears to relate to a capability to *move down the learning curve* faster than competitors, or the possibility to 'choose' shallower learning curves compared to foreign incumbents due to the large size of the market. In this context Chinese firms tend to favor coding-like technologies. Strong in-house capabilities and absorptive capacity facilitate faster learning than competitors, derives from a "decoding" skill when learning from others and a "coding" skills when protection learning from imitators. The "code" concept is originally introduced by Lessig (1999). "Code" is software or a combination of software and hardware. It builds "bugs" into protection and codifies the rules, therefore functions as an invisible hand or a "trusted system" regulating the distribution of, and access to, material on the Internet. "It permits a much more fine-grained control and it can do so without the aid of the law" (ibid, p. 129). In the ICT industry it is more pronounced in terms of seeking self-sufficient "code"-like protection as many services (solutions) could be delivered through the net. The infringement probability is negatively correlated with easiness of "code" protection. In short, the nature of IPRs and ICTs may advocate different means on learning, imitation and innovation. Following the broadening of Chinese ICT indigenous innovation scope we expect that there are more and more conflicted interests in new technologies, combined ICT-specific new means of protecting IPRs.

Finally, complementary *sales or service effort* is considered highly important by the informants, especially when technology development is rapid and patenting is considered nearly irrelevant. In these situations aggressive sales and marketing strategies become the explicit goal and also contribute to protecting IPRs. Nonetheless, during interviews with local government officials some argue that this marketing and sales effort is over-emphasized and might even cannibalize revenues. This may also be illustrated by looking at the distribution of granted IPRs by SIPO in the year 2004. Domestic patent application only make up 24 percent of all SIPO documents while the majority of IPRs related to design and utility models.

4 A CONCLUDING DISCUSSION

This paper starts from the observation that some rapidly developing countries, such as India and China, are now catching-up the developed ones in terms of the knowledge base, production and trade patterns in high-technology areas. Nonetheless, this catching-up process might be severely hindered by the IPR thickets of overlapping patents held by the incumbents which might mount to impenetrable entry barriers for many firms from the developing countries. In this paper we focus on the degree to which firms in the emerging Chinese ICT industry are entering such patent-based IPR thickets, as well as on how they manage IPRs in the context of this industry and develop indigenous knowledge bases during that process.

The case of China is especially interesting since IPR management and patenting is pivotal due to the pervasiveness of standardization, cross-licensing and patent pooling in response to technological complementarities. However, the large Chinese market combined with indigenous efforts to promote the 3G TD-SCDMA and 4G LAS-CDMA standards implies that China is in a unique position in this context. We frame the paper in a framework that deals with catching-up and leapfrogging processes, while attempting to contextualize IPR management issues from a latecomer perspective. The empirical part of the paper combines quantitative analysis of Chinese ICT patenting at the US patent office (USPTO) with qualitative interviews. The paper yields four main results of relevance both to the further development of the Chinese ICT industry, as well as to a discussion of the changing competitive constellation of the global ICT industry.

First, it seems clear the Chinese ICT firms indeed are entering patent-based IPR thickets as witnessed by an accelerating growth in the number of granted patents at the USPTO, and this trend is underlined further by an equally accelerating growth in patent applications in the most recent years. These patents foremost relate to the more peripheral fields of ICT, namely various instruments and components, even though the core fields of 'Consumer electronics' and 'Telecommunications' also are becoming the targets of patenting. However, the absolute level of Chinese ICT patenting is still very low especially when accounting for the large size of the country. By the face of it, the emerging Chinese ICT industry thus still has a long way to go before it can penetrate patent-related IPR thickets of the incumbents from the developed countries. The qualitative interviews that we undertook also confirm that Chinese firms in the ICT industry acknowledge the strategic importance of building up patent-based IPR stakes to navigate the thickets.

Second, the patent data suggests that the emerging Chinese patent-based IPR stakes are relatively indigenous. Chinese firms as assignees account for the largest and growing share of granted Chinese ICT patents at the USPTO.

Foreign affiliates also contribute with a noteworthy share, while joint ventures with foreign partners appear as relatively insignificant. These insights were confirmed an analysis of the share of inventors with a Chinese affiliation. They were also confirmed by the interviews, although many firms highlighted the importance of re-engineering as an important source of indigenous incremental innovation. Further, the firms recognized the importance of Chinese efforts in standardization as exemplified primarily by the 3G TD-SCDMA standard. Thus, it seems that this standard not only has enhanced the negotiation position of China in standard-setting. It has also contributed to developing an indigenous knowledge base by providing a national test-trial laboratory for next generation technologies.

Third, our qualitative analysis provided insights into the motives behind the aspirations of Chinese ICT firms to develop patent-based IPR stakes, as well as develop their IPR management practices in a broader sense. We identified four partly overlapping types of firms in this context. The first type comprises of strong and independent/indigenous firms which take the international market as their target also in patenting. The second type comprises of firms that seek to enter alliances with foreign firms to gain complementary assets and thus patent in order to gain entry tickets into patent pooling and cross-licensing activities of the incumbents. The third type comprises mainly of spin-offs from universities or research organisations that use patents to signal their technological capabilities to attract venture capitalists. The fourth type comprises of firms with a history of patent infringements that put a lot of efforts to learn the 'rules of the game' in IPR management, and thereby also seek to build up a strong brand on the domestic market.

Fourth and finally, it also appears clear that Chinese ICT firms resort to other means of protecting and managing their IPRs. In particular, it seems that the rather underdeveloped patent system combined with cultural traits of the Chinese way of doing business is strongly reflected in the IPR management practices of ICT firms. Especially in the case of domestically oriented firms patenting is consider as an atypical behaviour and might not be cost-efficient neither socially acceptable. Instead secrecy appears as more viable as it compensates for unintended spillovers associated with disclosing information contained in patents. Further, Chinese ICT firms appear to value trust (or "guanxi" as it is called in China) highly and this can also facilitate various contractual arrangements between collaborators and thus mitigates the need for patenting. Lead time advantages and aspirations to rapidly move down the learning curve also appear as important, especially as Chinese ICT firms largely are engaged in incremental innovation where learning curves are shallower.

Through these results this paper highlights an interesting duality in the emergence of the Chinese ICT industry. Clearly the largest and most significant firms with the international market as the target, such as Huawei, ZTE, and firms closely involved with the indigenous Chinese 3G standard such as Datang, are in the process of entering the patent thickets due to the leverage that they have in terms of their knowledge base. Meanwhile the firms with a stronger domestic focus appear to follow quite different IPR management strategies to cope with the weaker Chinese appropriability regime that stems from the underdeveloped IPR system. Hence, it seems that incumbent firms also need to apply a dual approach towards interacting with the emerging Chinese ICT industry. The relevance of patent-pooling and cross-licensing of technology in line with international rules of the game is clear in interactions to the larger and internationalized firms, while the building-up of trust and local partnerships is pivotal in the interactions with smaller firms in the large Chinese market.

APPENDIX 1

List of firms and interviews from November 2004 to January 2006.

FACE-TO-FACE INTERVIEWS
Beijing area in China
- Vimicro, Liu He Wan Tong, Chinacomm

Xian area in China
- Xian Datang, Haitian Antenna, Jietong, Kandosoft, Xian software park, Shanxi Telecommunication bureau

Chengdu area in China
- Hua Micro, Hui Yuan, Summit, Goldtel, Megasun, Chengdu software park

Hangzhou area in China
- Alibaba, Utstarcom, Youcan

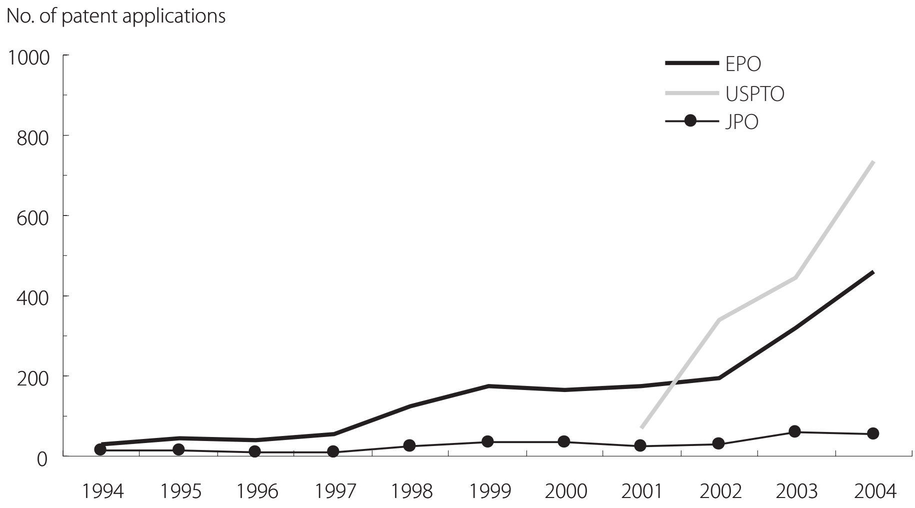
Sweden and Finland
- Ericsson (8 interviews), ZTE Kista, Nokia (1 interview), Comptel (1 interview)

TELEPHONE INTERVIEWS
- Haier, Legend, Shengan, Changhong, Huawei, Huawei (R&D unit in Stockholm), Chuangzhi, Datang mobile, Datang Telecom, Huiqun Tong Fang, Futong, Hisense, Insigma, Lenovo, Lingqing, Netac, Yangzhou Speakerfactory, Xiawen, ZTE, Sichuan Tongda, Sichuan Atenna, firm X in the field of "Computer-based Measurement & Automation" wished to remain anonymous

APPENDIX 2

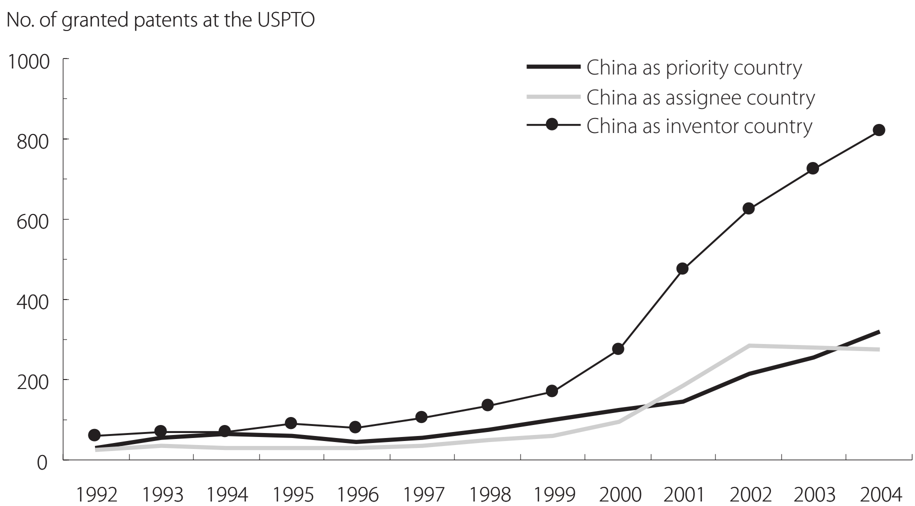
DEVELOPMENT OF CHINESE PATENT APPLICATIONS

Figure A1 Chinese patent applications at the Triad, China as priority country (USPTO applications have only been made public after 2001)



Source: Based on data from DELPHION.

Figure A2 Chinese granted patents at the USPTO by different nationality definitions



Source: Based on data from USPTO.

APPENDIX 3

OECD DEFINITION OF ICT PATENTS

"Telecommunications"

ipc=="G01S" | ipc=="G08C" | ipc=="G09C" | ipc=="H01P" | ipc=="H01Q" | ipc=="H01S" | ipc=="H03B" | ipc=="H03C" | ipc=="H03D" | ipc=="H03H" | ipc=="H03M" | ipc=="H04B" | ipc=="H04J" | ipc=="H04K" | ipc=="H04L" | ipc=="H04M" | ipc=="H04Q"

"Consumer electronics"

ipc=="G11B" | ipc=="H03F" | ipc=="H03G" | ipc=="H03J" | ipc=="H04H" | ipc=="H04N" | ipc=="H04R" | ipc=="H04S"

"Computers, office machinery"

ipc=="B07C" | ipc=="B41J" | ipc=="G02F" | ipc=="G03G" | ipc=="G05F" | ipc=="G06" | ipc=="G07" | ipc=="G09G" | ipc=="G10L" | ipc=="G11C" | ipc=="H03K" | ipc=="H03L"

"Other ICT"

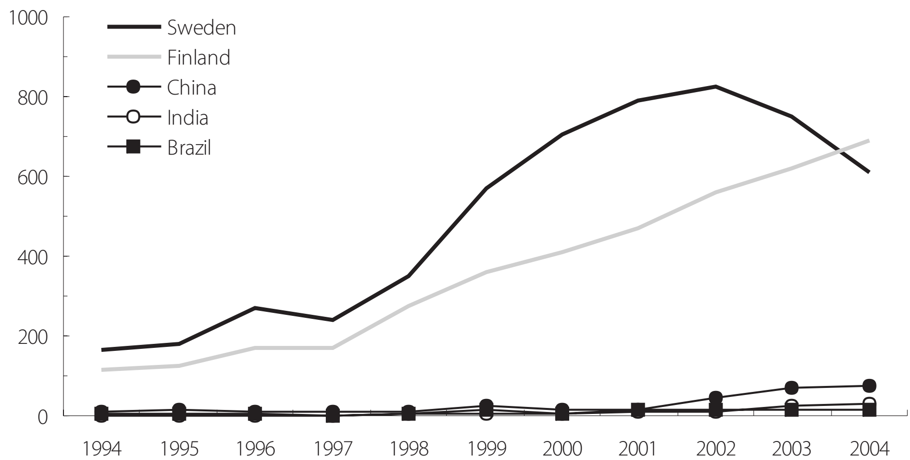
ipc=="G01B" | ipc=="G01C" | ipc=="G01D" | ipc=="G01F" | ipc=="G01G" | ipc=="G01H" | ipc=="G01J" | ipc=="G01K" | ipc=="G01L" | ipc=="G01M" | ipc=="G01N" | ipc=="G01P" |ipc=="G01R" | ipc=="G01V" | ipc=="G01W" | ipc=="G02B" | ipc=="G05B" | ipc=="G08G" | ipc=="G09B" | ipc=="H01B11" | ipc=="H01J" | ipc=="H01L"

Source: Schmoch (2004).

APPENDIX 4

GRANTED FINNISH, SWEDISH, INDIAN AND CHINESE ICT PATENTS AT THE USPTO

Figure A3 Granted Finnish, Swedish, Indian and Chinese ICT patents at USPTO 1994–2003



Source: Based on data from USPTO, ICT as defined by the OECD (see Schmoch (2004)).

FOOTNOTES

1 This research has also been financially supported by the joint Wireless Communication Research Program of the Berkeley Roundtable on the International Economy (BRIE) and the Research Institute of the Finnish Economy (ETLA) (www.brie-etla.org). We wish to thank Mika Pajarinen for data assistance and Per Högselius for comments, with the usual disclaimers. We also wish to thank for Bengt Domej, Cali Nuur, Staffan Laestadius and Ed Steinmueller for their comments on earlier versions.

2 TD-SCDMA or Time Division Synchronous Code Division Multiple Access.

3 LAS-CDMA or Large Area Synchronous Code-Division Multiple Access.

REFERENCES

Anawalt, H. & Powers, E. (eds,). 2000. IP Strategy-Complete Intellectual Property Planning, Access and Protection, West Group.

Arora, A. & Ceccagnoli, M. 2004. Patent protection, complementary assets, and firms' incentives for technology licensing, unpublished paper.

Arora, A. & Gambardella, A. 2005. *From underdogs to tigers: the Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel*, Oxford Press.

Bao, H., Ye, J. & Xu, M. 2004. A research on the patent pools in intro-industry technology transfer, paper presented in Globalics Conference, Beijing, October 2004.

Bekkers, R., Duysters, G. & Verspagen, B. 2002. Intellectual Property Right, Strategic Technology Agreement and Market Structure-the Case of GSM, *Research Policy 31*, 1141-1161.

Bhattacharya, S. 2004. Mapping inventive activity and technological change through patent analysis: a case study of India and China, *Scientometrics*, Vol. 61, No. 3 (2004) 361-381.

Bohlin, E., Brodin, K., Lundgren, A. & Thorngren, B. 2000. *Convergence in communications and beyond*. North-Holland.

Chen, C. & Shih, H. 2005. *High-tech industries in China*, Cheltenham: Edward Elgar.

Cohen, W. & Levinthal, D. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, Vol. 35, No. 1 Special Issues: Technology, Organizations, and Innovation, Mar, 128-152.

Cohen W., Nelson, R. & Walsh, J. 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent. *NBER Working Paper* No. 7552.

Delphion. 2005. http://www.delphion.com

Duysters, G. & Hagedoorn, J. 1995. Convergence and Divergence in the International Information Technology Industry, paper collected in *Technical Change and the World Economy – Convergence and Divergence in Technology Strategies*, Edited by John Hagedoorn, Cheltenham: Edward Elgar.

Enright, M., Scott, E. & Chang, K. 2005. *Regional Power House: The Greater Pearl River Delta and the Rise of China*, Published by John Wiley & Sons (Asia) Pte Ltd.

Ernst, D., Fagerberg, J. & Hildrum, J. 2002. Do global production networks and digital information systems make knowledge spatially fluid? *Working paper No 13* at Centre for Technology, Innovation and Culture, University of Oslo.

Fischer, W. & Zedtwitz, M. 2004. Chinese R&D: naissance, renaissance, or mirage, *R&D Management* Volume 34 Number 4, Sep, 2004, edited by Alan Pearson & Jeff Butler.

Freeman, C. 1994. Technological Revolutions and Catching-Up: ICT and the NICs, Page 198-221, *The Dynamics of Technology, Trade and Growth*, 1994, edited by Fagerberg & Verspagen & Tunzelmann, Cheltenham: Edward Elgar.

Freeman, C. & Hagedoorn, J. 1995. Convergence and Divergence in the Internationalization of Technology, in Hagedoorn, J (ed,) *Technical Change and the World Economy-Convergence and Divergence in Technology Strategies,* edited by John Hagedoorn (1995), Cheltenham: Edward Elgar.

Granstrand, O. 1999. *The Economics and Management of Intellectual Property – toward Intellectual Capitalism*, Cheltenham: Edward Elgar.

Hinze, S. & Schmoch, U. 2004. Opening The Black Box – analytical approaches and their impact on the outcome of statistical patent analyses, Mimeo.

von Hippel, E. 1988. *The sources of innovation*, Oxford: Oxford University Press.

Hobday, M. 1995. *Innovation in East Asia: The Challenge to Japan*. Cheltenham: Edward Elgar.

Jaffe, A. & Tarjtenberg, M. 2002. *Patents, Citations & Innovations*, The MIT Press.

Lessig, L. 1999. *Code and other laws of cyberspace*, published by Basic Books, a member of the Perseus Books Group.

Levin, R., Klevorich, A., Nelson, R., Winter, S., Richard, G. & Griliches, Z. 1987. Appropriating the Returns from Industrial Research and Development, Brookings Papers on Economic Activity, Vol 1987, No. 3, *Special Issue on Microeconomics*, 783-831.

Long, V. & Laestadius, S. 2005. Globalization of Knowledge Formation – The Role of China in Today's R&D Relocation, paper to be included in 6CP *Internationalization of R&D* book, forthcoming.

Lu, W. 2003. 4G mobile research in Asia, *IEEE Communication* Magazine.

Marsili, O. 2001. *The Anatomy and evolution of Industries – Technological Change and Industrial Dynamics*. Cheltenham: Edward Elgar.

Meng, Q. & Yang, D. 2004. An analysis of the function of enterprise allies and government in the high-tech industries standard war: a case study of the competition between Wi-Fi and WAPI, paper presented in Globalics Conference, Beijing, October 2004.

Merges, R.P. & Nelson, R.R. 1990. On the Complex Economics of Patent Scope, *Columbia Law Review,* 90, 839-916.

Nolan, P. 2001. *China and the Global Economy*, Basingstoke, UK, Palgrave.

Nolan, P. & Zhang, J. 2003. Globalization Challenge for Large Firms from Developing Countries: China´s Oil and Aerospace Industries, *European Management Journal*, Vol. 21, No. 3, 285-289.

Perez, C. & Soete, L. 1988. Catching up in technology: entry barriers and windows of opportunity, in Dosi, Giovanni et al, (2004): *Technical Change and Economic Theory*, London & N.Y., Pinter Publ.

Reitzig, M. 2004. Strategic Management of Intellectual Property. Spring 2004 *MIT Sloan Management Review*.

Reitzig, M. 2004. The Private Values of "Thickets" and "Fences": Toward an Updated Picture of the Use of Patents Across Industries, Economics of *Innovation and New Technology*, 2004 Vol 13(5) July, 457-476.

Schumpeter, J. 1911/68. *The Theory of Economic Development*, Cambridge, Mass., Harvard U.Pr.

Schumpeter, J. 1934. *Capitalism, Socialism and Democracy*.

Sigurdson, J. 2005. *Technological Superpower China*, Cheltenham: Edward Elgar.

Schmoch, U. 2004. Definition of Patent Search Strategies for Selected Technological Areas. Fraunhofer ISI Kalrsruhe, Germany.

Scotchmer, S. 1991. Standing on the Shoulders of Gaints: Cumulative Research and the Patent Law, *The Journal of Economic Perspective*, Volume 5, Number 1-Winter 1991.

Shapiro, C. 2003. Navigating the patent ticket: cross licenses, patent pools, and standard-setting. In Jaffe, A.,Lerner, J. & Stern, S. (eds.) *Innovation Policy and the economy*, Vol. 1. Boston: MIT Press.

SIPO. 2005. http://www.sipo.gov.cn/sipo/ywdt/jdlt/t20060116_64126.htm

Steinmueller, E. 1995. "Technology Infrastructure in Information Technology industries", paper for *Technological Infrastructure Policy (TIP) – an International Perspective*, edited by Teubal, M., Foray, D., Justman, M. & Zuscovitch, E. Kluwer Press.

Steinmueller, E. 2001. ICTs and the possibilities for leapfrogging by developing countries, *International Labour Review* Vol. 140, No.2.

Teece, D. 1986. Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. *Research Policy* 15, 285-305.

Teece, D. 2000. Managing Intellectual Capital. Oxford University Press.

USPTO. 2005. http://www.uspto.com

Walsh, K. 2003. Foreign High-tech R&D in China: Risks, Rewards, and Implications for US-China Relations. Working paper in Henry L. Stimson Center, Washington DC.

Zoltan, J., Audretsch, D. & Feldman, M. 1994. R&D Spillovers and Recipient Firm Size, /The Review of Economics and Statistics/, Vol 76, No 2, 336-340.