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Software Innovation in Finland

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Foreword

This report examines Finnish software innovations, and is based on a study carried out within the project "Finnish innovations", undertaken in VTT Group for Technology Studies. While establishing the Sfinno innovation database, which currently contains information on about 1600 Finnish innovations, we were struck by the high number of software innovations introduced to the market between 1985 and 1998. Having reported on the methodological and theoretical framework and the first results of the project in two working papers, we decided to take the opportunity to study patterns of Finnish innovation in more detail. This study is the first of the in-depth studies following the two earlier research reports. Although there are other in-depth studies currently being carried out, this report is the only one, originating from the project, which concentrates on just one homogenous product group, namely software innovations. Given the social, political, economic and technological importance assigned to information technologies, of which software makes up a large share, it was rather natural to choose software innovations for examination in more depth.

The project "Finnish innovations" was originally launched at the VTT Group for Technology Studies in 1992. However, five years later, the study was re-launched to be carried forward in a more systematic manner, and from 1998 onwards the National Technology Agency of Finland (Tekes) has provided the project with financial resources. Since 1998, three to six researchers have been fully engaged in the establishment of the Sfinno innovation database, other data collection, the mail survey directed at innovators, and writing. The project has been carried out at VTT Group for Technology Studies, although some studies are currently being made at Statistics Finland, too.

The report has benefited from the co-operation of several persons. The author would like to thank the other members of Sfinno project, Christopher Palmberg, Tanja Wahlberg, Petri Niininen, Jukka Hyvönen and Jani Saarinen, all of whom have commented on drafts of this report. The author also wishes to acknowledge the co-operation and assistance of the 11 interviewees, who generously devoted time to the subject. I am also indebted to the editor of the Working Paper series, Soile Kuitunen, whose comments have benefited the report. All errors and omissions are entirely my own.

Otaniemi, August 2000

Hannes Toivanen

Executive summary

This study addresses software innovation in Finland. The pattern of software innovation is examined in comparison to innovations in other product groups at the level and with regard to innovation process and market aspects. Special attention is paid to public policy aspects, in particular public funding, public technology programmes, and collaboration. The study has been carried out as part of a larger project, “Finnish Innovations”, which has produced an extensive innovation database consisting of about 1600 Finnish innovations from the 1980s to 1990s. In addition, interviews and an extensive mail survey targeted at innovators have been undertaken. Additional data on firms has been obtained from Statistics Finland and from the Finnish Patent and Trade Office.

The first part of the study describes the development of software innovation from the 1980s to the present day, locates the sources of software innovations in Finnish industry, and examines the character of firms producing software innovation. Innovation in software is probably becoming one of the most innovative sectors of the Finnish economy, and the pace of its development has been incredible. Almost non-existent in the early 1980s, software constitutes the largest single product group among Finnish innovations today. Firms producing software innovations are clearly different from firms producing other innovations. They are much more likely to be new and small firms, suggesting that the industry is especially entrepreneurial in character. It is also interesting to note that half of the firms innovating software are not really software firms. According to the official firms register, they also represent traditional industries and other services. This result is based on the distinction between the firm sector and the innovation’s product group - a unique approach within the Finnish context, which questions the application of the firm sector perspective in innovation studies addressing software. The results, which show a big increase in the number of software innovations and the young age of innovative firms, are an indication of the recent transition towards a knowledge-based economy and exemplify one of the important Finnish industrial renewal processes since the 1980s.

The second part of the study focuses on the innovation process, and shows that there are many similarities between software and other innovations, but important differences exist, too. The pattern of origin of software innovations emphasizes only three factors, rival innovations, market niche and new technology. Here, the role played by new technology is in contrast to other innovations, which do not rely so heavily on new technology. The innovation process proceeds in very much the same way for software and other innovations. About half of the innovations were

commercialized within two years of conceptualization, and about 60 per cent of innovations reached the break even point. As software innovating firms are typically small, the innovations are generally more important to them than other innovations are to their creators. The difference is explained by the fact that in other innovation group there are many more large firms. The result shows that software innovations are produced and proceed within the firm very much like other innovations. However, software innovations also have special characteristics which are only typical for them, suggesting the innovation group to be a rather homogenous group with special needs. These needs are especially embodied in the significance attached to new technology and public technology programmes, as was revealed when we asked the respondents to consider factors affecting the origin of innovation.

The third part of the study addresses basic public policy aspects and instruments which are designed with particular emphasis on innovation. As software is a key technology in the information society, its relation to public policies designed to advance the adoption and development of new technologies and the transition towards the information society is of interest. When we look at the proportion of innovations with public funding, we observe that almost the same proportion of software and other innovations have received it, i.e. about two thirds. However, Tekes funding is of importance only for software innovations, while a number of other public funding bodies are of importance for other innovations, too. Public technology programmes are more important for software innovations than for other innovations, and about one third of them considered technology programmes important with regard to collaboration. The proportion of innovations developed through collaboration is the same for software and other innovations, being as high as 90 per cent.

However, the pattern of important collaboration partners is specialized and homogenous for software innovations, and rather narrow as compared with other innovations. Customers are considered of special importance with regard to collaboration for software innovations. The results shows that software innovations have strong public policy linkages, but a rather narrow public funding and collaboration structure. The future challenge for public policy, and for industry, is obviously to widen these structures to reduce dependence on only a few institutions and collaborative partners. If innovation processes, innovative firms and software innovators not integrated into the institutional landscape of the Finnish research system on a wider basis, the danger of the software sector’s innovation activities separating from the rest of Finnish society arises.

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1 Introduction

1.1 Background and Methodology

This report is based on research carried out in 1998-2000 at VTT Group for technology studies within the project "Finnish Innovations" (hereafter Sfinno). The Sfinno project aims to develop new perspectives on the Finnish experience of industrial renewal during the last two decades, and is to be continued. Although Sfinno's methodology, some results and data have been previously described and reported in detail (Palmberg et al. 1999 & 2000; Palmberg and Toivanen 1999), we will here provide a resume of the basic information concerning mentioned issues. The basic feature of Sfinno is the establishment of unique database on about 1600 Finnish innovations which were developed in Finland and commercialized in 1985-1998. The data will be discussed in more detail below. (For a detailed description of the database, see Palmberg et al. 1999). With regard to innovation in software, the issues addressed in this report have benefited from several seminars and conferences, where research papers on different aspects of software innovations have been presented and discussed. (Toivanen 1999 & 2000).

The context of the study, as mentioned above, is the recent structural and technological change of Finnish industry. Since the 1980s the relative importance of R&D intensive industries has increased significantly, and especially the rapid growth of the electronics industry, embodied in one company, Nokia Corporation, has transformed the whole structure of Finnish industry. Recently, beginning in the early 1990s, a new tide of change mainly driven by the information technology industry has occurred. The restructuring reflects the growing importance of computer programs in two ways. Firstly, the software industry is one of the fastest growing sectors of the Finnish economy. Secondly, many other industries exploit software effectively and especially in the electronics and communications industries, the innovative character of products is increasingly dependent on software. In many ways, this is also the point of departure for this report, as we try to capture the essential about innovation in software, being of central importance for the information technology industry.

The central point of Sfinno is that it views innovation in Finland from a different perspective compared with earlier studies. Most studies addressing the structural and technical change of Finnish industry have approached the subject from the point of view of industrial clusters and macroeconomic indicators. However, Raimo

Lovio's study on the electronics industry applied an approach which resembles ours. (Lovio 1989). In short, most studies discussing the role of innovation and technology in the transformation of Finnish industry have applied firm or industry level approaches. They will be discussed in more detail below.

In addition, there is the Community innovation survey (hereafter CIS), which is carried out by Statistics Finland and being EU harmonized. CIS is intended to provide basic knowledge on innovation in Finland, and it is a firm survey. CIS forms a complementary study to Sfinno, thus the latter applies the object, and former the subject approach. The object-subject approach distinction follows the one made in the OECD's Oslo manual, which defines basic methodologies for innovation surveys. (OECD 1997). The subject approach acquires firm level information on innovation, whereas the object approach is based on innovation level information. This report will discuss aspects of the subject and object approaches in the study of innovation in software. The main issues concern problems of distinction between the nature of innovation and the sector of the innovating firm, and the role of small firms, as firms with less than 10 employees are usually excluded from the Finnish CIS survey. More recently, Leppälahti has compared the Sfinno survey and the Finnish CIS in detail, suggesting the former to have identified more important and visible innovations, as the latter recognizes also in-house process innovations and more incremental innovations. (Leppälahti 2000).

To put it in a nutshell, CIS focuses on the innovativeness of firms in general by looking at the distribution of innovation activities in the firm population, and produces an estimate of the extension of innovation activity. Sfinno approaches firms through innovations, merely looking at different firm group's share of innovative activities, and produces a description of patterns of innovation.

The best known studies using the object approach include the ones carried out by the Gellman Association and the Futures Group in the United States (Acs and Audretsch 1990), the SPRU innovation database in UK (Townsend et al. 1981; Freeman & Soete 1997), a Swedish study on 100 major innovations in 1945-1980 (Wallmark & MacQueen 1983 & 1991), and a literature-based innovations study in Europe, reported in Kleinknecht and Bains (1993). With the exception of the pan-European literature-based study, all these studies were carried out in the 1970s, long before the present importance of software started to take shape.

Thus, we have no knowledge of the applicability of the object approach in the study of innovation in software. Bearing in mind that software probably demonstrates one of the most innovative sectors of modern economies today, the situation is far from satisfactory. Studies undertaken by the Futures Group and the Gellman Association were not able to identify software innovations, as they anteceded the information technology revolution. Keith Pavitt's much cited paper on sectoral taxonomy of innovations, summarizing and conceptualizing the best results achieved with the SPRU innovation database, does not include software. (Pavitt 1984). Neither are software innovations considered in Wallmark's and MacQueen's resume of their main findings from their study on 100 major technical innovations in Sweden from 1945 to 1980. (Wallmark & MacQueen 1991). Of the more recent studies, a literature-based innovation study carried out in the Netherlands identified about 1600 innovations commercialized in 1989, of which 48 were commercialized by firms classified as computer consulting firms, which probably may be interpreted as software innovations. In total, software accounted for about 3 per cent of all innovations in the study. In short, there seems to be no object approach innovation studies carried out in the last 10 years, during which time software has gained its major role in modern economies.

In general, the growth of software may have come to question the use of traditional innovation indicators, at least in the Finnish setting. Most traditional innovation studies have proven to be problematic when applied to software. In the case of patent statistics, software has always shown poor patentability and is not very well represented in these studies. Palmberg et al. observed, while comparing Finnish patents in 1990-1998 and the Sfinno database, that almost none of the software innovative firms reported in Sfinno would have been identified in a patent-based study. (Palmberg et al. 2000, 14). This is also observable in recent Finnish patent statistics, which do not address the software sector. (Statistics Finland 1999).

Another aspect is offered by the distinction of the innovation's product group and innovating firm's sector. This notion is, of course, valid for all product groups, but of essential importance in software, as many firms not classified as software firms, produce software innovations, too. (Chapter three discusses this in detail). Thus, studies assuming the innovation to be of the same product group as the producing firm's sector may prove problematic. In addition to CIS, this is valid for R&D statistics, too. Chapter 3.1 will discuss these aspects in more detail.

1.2 Origins and Development of the International and Finnish Software Industry

Advanced computing has become one the corner stones of modern economy and industrial power. In recent decades, computing technologies have been one of the major powers facilitating the industrial restructuring experiences that have occurred in all modern economies. The software industry has also become to embody the classical Schumpeterian Mark 1 hypothesis, as the industry has proved to be very turbulent. Since the 1970s, the industry has witnessed a number of great innovator-entrepreneur histories. Indeed, there exists no other industry where the rankings of the largest companies would have changed with same pace. Firms such as Apple and Microsoft, both start-ups in the 1970s, have achieved enormous growth rates.

The software industry emerged in the early 1970s, and many researchers date the beginning of the industry with IBM's historic 1968 decision to unbundle hardware and software, and price them separately. Campbell-Kelly has interpreted global software markets to have grown moderately in the 1970s, but exponentially from 1980 onwards. The growth of markets and software's technological significance was also recognized in public policy concerns. From the mid-1980s onward, the software industry's competitiveness and growth potential have been addressed in a number of inquiries. The OECD 1985 report aimed to clarify policy issues, and integrate the software industry into the arena of industrial policy. (Campbell-Kelly 1993; OECD 1985.)

The national competitiveness in software, and especially differences in it, has attracted much attention by researchers. As the industry has been dominated by US. Firms, at least from a historical point of view, the national level of analysis has seemed to be a relevant point of departure. This observation has been especially attractive to researchers inspired by the National Innovations Systems framework (For the concept see Lundvall 1992; Nelson 1993), who have sought to map the characteristics of national software industries, and compare nations. Among these studies, the volume edited by David C Mowery (1996) compares plausibly the greatest software nations - such as the United States, Western European countries, Japan, and Russia - within the National Innovations Systems Framework. A basic conclusion drawn by the authors is that national characteristics of national innovations and the research system matter greatly for the competitiveness and innovativeness of the software industry. Thus, the study of software industries should begin from the regional or national level rather than the global level.

This is illustrated in the case of the U.S. software industry, as Steinmueller has suggested in his analysis of the industry and its history. The origins of the industry were facilitated by the post-war increase in defensive R&D spending, and by the amount and quality of research carried out at the universities and other institutes. Beginning from the 1970s, the software industry took a new structure and size, as a consequence of the deepening separation of hardware and software, which gave rise to independent software vendors (ISV) in the industry. The relationship between original equipment manufacturers (OEM) and software production had to be changed, since problems were arising in the combination of hardware and software development and production. There followed a pattern of vertical disintegration, resulting in the establishment of ISVs. In turn, the change underlined the user-producer relations in software. Thus, the evolution of the U.S. software industry and its future development is affected by the interplay of the "supply infrastructure" for software creation, including actors such as defensive R&D, universities, computer producers, users and ISVs. (Steinmueller 1996.)

Adding to the analysis of national systems of innovation research, Torrisi has suggested that national differences in the competitiveness of software industries is additionally to be explained by area of specialization. Furthermore, from a more European point of view, Torrisi has underlined the importance of geographical proximity to leading OEMs, the size of the domestic market, the regulation of competition, and especially the evolution of IT-related public policy and public support for software R&D, as factors explaining the performance of national software industries. (Torrisi 1998.)

In his analysis of European software industry, Torrisi concluded that European public policies have in general been poorly adjusted to the specific needs of software, since they were formed in the spirit of "national champions" and were suited merely for hardware and telecommunications industries. Also, policies explicitly launched to support software R&D were late when they were formulated in 1980s, and as a consequence Europe has lagged behind the U.S. Other factors working against innovation in software, according to Torrisi, include copyright issues in particular. In Torrisi’s view, innovation in software in Europe is categorized into three main firm groups: Entrepreneurial start-ups operating on the technological frontier, small and medium-sized software firms specializing in one or a few software products or services, and large firms offering system software or carrying out system integration activity. (Torrisi 1998.)

In their study on the Swedish information technology industry, Eliasson and Johansson addressed its importance for other industries, and its flexibility. They concluded that the industry is more dynamic and flexible than industries in general. In particular, this was expressed in the industry's above-average growth rates. However, the information technology sector should not be considered only in economic terms, but especially with regard to technological knowledge and competencies. The information technology industry should also be viewed in national strategic terms, since it is considered to be of importance for a set of other industries. (Eliasson & Johansson 1999.)

Industry and national level examinations of the software industry usually emphasize national competitiveness and public policy aspects. A complementary view is offered by studies characterizing innovation in software and innovative firms, thus enabling a better understanding of the industry and market dynamics of software. Among these studies, Cusumano and Shelby (1995) have examined Microsoft, suggesting that strategic integration of innovation, product design and marketing are key issues behind Microsoft's success and its dominance of the global operating system markets. In the case of Netscape, Cusumano and Yoffe (1998) have concluded that these rules are valid for other companies and markets, too. Behind the tremendous growth of Netscape was a careful strategy aimed at managing the integration of innovation, product design and marketing. Thus, a deep understanding of technology, the ability to innovate, the screening of emerging technological opportunities, a good sense of customer needs and smart marketing strategies all combined to ensure Netscape's success.

The aspects of software industry outlined above underline the fact that software is an unusual economic commodity. The constantly changing advantage of vertical and horizontal integration to which the firm has to adjust, the persistence of the "creative destruction" type of innovation, the importance of supporting innovation and research systems, the low marginal of reproduction, the ubiquitous state of intellectual property rights, and the significance of marketing and innovation strategies, all help up to make a very complex and difficult sector of high technology industry, not comparable to any other.

Within the Finnish setting, a number of studies have analyzed the information technology sector. However, only a few have had a special emphasis on software. Among these, Nukari and Forsell have studied the Finnish software sector using SWOT analysis. Their study aimed to describe the structure of the Finnish software industry and to identify the main thresholds of future growth. The report was connected to the envisioning of a national software development strategy. In the conclusions, the study addressed the supply of skilled labor, entrepreneurship, private and public venture capital, and networking and internationalization as the main challenges for the Finnish software industry. The study also provided estimates of the size of the Finnish software markets and industry, assessing the annual turnover of firms producing software products to have been about € 600 million in 1996 and € 790 million in 1997, and forecasting a value of € 800 million for 1998. (Nukari & Forsell 1999.)

Autere et al. approached the Finnish software industry within the framework of clusters and from the point of view of exports. The study estimated the Finnish software market to be worth about € 500 million in 1998. (referenced from Market-Visio 1999). The study addressed especially the competitiveness of the Finnish software industry, and regarded the speed of technological change, the degree of internationalization, and the supply of skilled labor to be crucial for Finnish success. Also this report was connected to the envisioning of a national software strategy. (Autere et al. 1999.)

Various science evaluations have intersected the software sector, too. Recently, an evaluation report of the Academy of Finland on mathematical sciences in Finland has proposed a deeper integration of university research strategies and industrial needs, seeking to strengthen the mathematical knowledge base of information technologies. With regard to the information technology sector, the report suggested that specific actions could be taken in science policy and at universities. (Academy of Finland 2000). A larger evaluation of Finnish science, undertaken in 1997, also addressed the industrial aspects of information technology sciences in particular. With regard to information technologies, closer co-operation of public science and technology funding bodies was recommended, thus implying the need for a more integral approach from the point of view of public policy directed at information technologies. (Neittaanmäki 1997).

Besides the above-mentioned, a range of surveys, studies and reports on the Finnish software or information technology sector exists. In addition, there are a number of case studies that highlight different management issues in software product research and development. However, no study has addressed innovation in software in Finland in particular or described the pattern of innovation in software. Neither have any studies assessed the functionality of traditional sector and product classifications in the case of software, even though this is crucial for sector and cluster approaches. Furthermore, public policy issues have been addressed either from the point of view of programme evaluation or strategy envisioning. The nature, character and basic functional mechanisms of public policy instruments, especially with regard to software, are not very well described or examined in the Finnish literature.

1.3 Innovation in Software - Definitional Aspects

Depending on who one asks or reads, innovation in software is different from other product groups or it is not. Here, we will briefly consider some basic aspects of the characteristics of software innovation. In our study, to be reported as software innovation, we required the commercialized product to be essentially of software, i.e. written code (instructions) dictating the operations of a computer. Although most of the identified software innovations are products, a number of them are embedded applications. This reflects the fact that software makes up a very fragmented field of products and technologies, as there exist retail and off-the-shelf software, different market segments and product types, such as operating systems, applications and solutions, not to mention internet security software, enterprise resource solutions, 3D-modelling software, databases etc. Also the technologies and programming languages used are fragmented, and the field is evolving all the time.

The core innovation or innovative solution behind an innovative product reported in our study may vary. It could be a new algorithm or a solution enabling the integration of existing computer programs; it might be product suite or just a single product. The bottom line is that all innovation activity in software captured in our study results in commercialized products and is thus important economic activity.

The model of 'technology integration', proposed by Iansiti (1998) suits some of the cases nicely. According to Iansiti, technology integration is a way to innovate, in which the innovating firm chooses among already existing technologies to build innovative products. Especially in software, where communication between different systems and programs usually requires some level of integration, the model has been very practical. The essence of the model is problem solving and product building on the basis of existing technologies or technology paradigms.

Meyer and Seliger have proposed that software innovating firms tend to produce product platforms, rather than single product innovations. Furthermore, they suggest that, although many start-ups are dependent on a single innovation, they often move forward to build a product platform. By building, sustaining, and further developing the platform, a software firm reduces its dependency on single products. The platform mode, in turn, affects the innovation management in the firm, because innovations to be integrated into the platform come from R&D other than the R&D carried out with regard to the actual platform. (Meyer & Seliger 1998).

Our definition of innovation, applied also to software, is extracted from the one given in the "Oslo Manual" (OECD 1997). Thus, we define an innovation as a technical invention which has been commercialized by a firm or equivalent. We will look more closely at our definition of innovation in Chapter 2.1.

1.4 Structure of the Report

Key issues in this paper are the characteristics of software innovative firms, the nature of the software innovation process, market prospects of software innovations, and public policy concerns with regard to software innovation. Also, careful attention is paid to methodological aspects of acquiring information on software innovation. Although the report examines the patterns of software innovation in Finland in general, special emphasis is laid at small firms with less than 10 employees. This is due to following reasons: this group is usually excluded from the CIS survey, small firms and start-ups are of special interest from the point of view of public policy and they seem to be an important source of software innovations. This emphasis is present throughout the report.

In general, the report proceeds and addresses its research questions in the context of research, methodology, and the technologies outlined above. This chapter has dealt with the research traditions, focusing on innovations by explaining the basic features of the object and subject approaches, which are to be considered in the report. Emphasis was laid on such features as the distinction between the firm sector and product class, large vs. small firms, and in particular situating software within the object approach research tradition. These issues are addressed repeatedly in the report, as one of the main themes is to question our knowledge of innovation in software.

The research practicalities and data are summarized in chapter two, thus providing the reader with an understanding of the basic research procedures of the study. The identification process of innovations and respondents are discussed, the survey and its response rate are reported, and also some characteristics of the Sfinno innovation database are briefly illustrated. For a reader familiar with our earlier reports based on research in the Sfinno project, this chapter is a repetition. Any reader who is dissatisfied with the description and explanation of practicalities and the innovation database should refer to our earlier reports on the Sfinno project, where these aspects are meticulously presented. (Palmberg et al. 1999 & 2000.)

The contexts of innovation, technology and industrial sector are discussed in the preceding chapter, where the origins of the software industry and some of the earlier international and Finnish research are highlighted. The case in point is to show that in software we have a new and increasingly important phenomenon in modern economy, which is not perfectly understood. Discussion of these aspects lay the groundwork for the issues addressed in chapter three, which deals with the emergence of patterns of software innovation in Finland since the 1980s. In general, chapter three aims to provide an overall picture of the growth of innovation in software, and to locate software innovations in Finnish industry and economy. On the other hand, the chapter aims to characterize software innovative firms, by comparing them with firms innovative in other product groups. This comparison, software vs. other innovations, will occur throughout the report, and it is intended to highlight the characteristics of software. Chapter three makes use of all innovations in the Sfinno innovation database, as later chapters will include only survey results.

Chapter four discusses the nature of software innovation and its development process, as we perceive them according to our survey results. Proceeding from the origins of the innovation, we look at the different stages of an innovation’s life cycle, such as the time span from the basic idea to commercialization, and what proportion of innovations have reached break even point or have been exported. Future prospects, predicted by survey respondents, are discussed briefly, too. In general, the chapter provides the reader with basic information about the innovation process in software, and serves to provide a better understanding of the next chapter on public policy, as no dramatic differences between software and other innovation are found.

Chapter five focuses on the role of public policies, and discusses R&D activities that intersect with them, such like collaboration during the innovation process. Again, departing from the survey results, we look at the share of innovations with public support, innovations with significant links to public technology programmes, and at the distribution of important collaboration partners. This chapter discusses in depth some implications of strong and system-minded technology policy - a typical feature of Finnish technology policy - especially with regard to innovation in software. The Finnish technology policy is briefly outlined at the beginning of the chapter, but readers unfamiliar with the subject are provided with necessary references. The discussion on public policies also draws on preceding chapters, especially chapter three, as the discussion on the characteristics of software innovating firms lays additional groundwork for policy conclusions. The chapter does not aim to provide a concise picture of relations between public policies and software innovation, neither does it have any evaluative character. Rather, it should be read as a descriptive interpretation of the links between software innovations and technology policy, contributing to an understanding of the different structure and character of public funding, collaboration and other public policy instruments with regard to software innovations.

The study's conclusions summarize the key findings, and discuss policy conclusions and aspects of studying innovations. While highlighting the major results, the conclusions also survey the prospects for future research and innovation studies, and conclude with an overall assessment of our findings on software innovation.

2 Description of Data and Practicalities

2.1 Sfinno Database and Survey Practicalities

The Sfinno database consists of approximately 1600 innovations, and contains some basic information, such as the product group, commercializing firm and other firm level information, and the year of the innovation's commercialization. In addition, for 800 innovations we have more detailed survey results. The innovation identification and survey practicalities have been discussed earlier in detail in Palmberg et al. (1999 and 2000), and only a brief resume of these aspects will be provided below. The mentioned reports also describe the Sfinno database in detail, although some minor changes have occurred since 1999.

The identification process of innovations begins with the definition of innovation, and ours is linked to the one provided in the Oslo Manual (OECD 1997). Thus, we define an innovation as a technical invention which has been commercialized by a firm or equivalent. The innovation identification process was divided into three methods: (1) We identified innovations from some 20 Finnish technical and commercial journals dated 1985-1998. (2) We contacted technical and commercial experts and asked them to name innovations. (3) We identified innovations from the annual reports of large Finnish firms, and then contacted the firms and worked together with them to prepare a list of their innovations. As a result, we had approximately 1600 innovations commercialized in the 1980s and 1990s. The journals were read by research assistants in 1998, the expert opinion round was originally initiated in 1992, but was renewed to some extent in 1998. The annual journals of large firms were read by research assistants in 1998, and we contacted the firms in 1998 and 1999.

The firm level data was obtained from Statistics Finland, and it includes over 50 variables, including historical data on employment, annual turnover and sector of the firm from 1998 back to 1986. All firm level examinations in the report are based on this data. The innovation data and firm data are linked through a key variable, the official business code (Ly-tunnus). This solution enabled us to link only one firm to one innovation, excluding the examination of firms formerly responsible for the development or commercialization of the innovation. These aspects are discussed further in chapter three.

After completing the identification of innovations, we prepared a mail survey directed at the innovators. The innovators were identified from firm databases and various other sources. Some journal articles included the necessary contact information, and the rest was obtained directly from respondent firms. The survey was carried out in 1999-2000 on about 1300 innovations. The survey resulted in a response rate of about 63 per cent, i.e. nearly 800 responses. The survey coverage is presented in detail in Table 1.

Table 1. Survey coverage

	Software innovations	**Other Innovations**
Questionnaires mailed	190	1104
Overcoverage	13	24
Responses	108	678
Percentage response rate	61 %	63 %

In general, we were able to mail the questionnaire to a larger share of software innovations than other innovations, as we identified 219 software innovations and mailed 190 questionnaires. The overcoverage usually implies that the firm has gone bankrupt, but is not to be relied on here, since we have not systemically identified defunct firms. It should be borne in mind that the non-response group can also include defunct firms. In total we received 108 responses from software innovators, which gives a good basis for this report. The number of responses may be regarded as sufficient for the analysis provided below in chapters four and five.

All innovations in the Sfinno database were classified into a product group according to the information we received from the survey respondents, newspapers, experts, firms, world wide web, or the like. The product classification follows the industrial sector classification Tol95, which is compatible with the Nace used in the European Union, and was carried out in the two to five digit level. The work was done consistently by one of our research assistants, and was checked by the author of this report and by software experts.

This work also forms the basis for this report, as we were able to distinguish innovation groups of different product classes. In practice, we have classified an innovation as a software innovation if the commercialized innovative product is essentially a computer program. The distinction between the innovation's product group and the firm's industrial sector provides us with a unique micro-level perspective on industrial renewal. In the case of a rather new, innovation focused and diffusive technology, the object approach effectively locates the technologies in the economy.

2.2 Interviews

In addition to the data described above, eleven interviews were also undertaken. All of the interviews took place from January 2000 to June 2000, and the interviewees are listed in Appendix 1. They represent software experts drawn from business, research, and public policy. The interviewees were selected from the main software concentration regions in Finland, including the Oulu, Tampere and Helsinki regions. The interviews provided much valuable information and new insights, but are referenced directly only a few times in the report. This is because the report is based on the object approach, and the deeper integration of interviews - not to name true case studies - into the analysis would have proven problematic. The report builds on the Sfinno database, although the interviews have guided and affected the interpretation to some extent. The decision was also affected by the confidentiality assured to our mail respondents and interviewees, since neither the names of innovative firms nor expressed opinions about firms are to be found in the report.

The interviews were semi-structured, and most of them were taped. Naturally, the main themes covered by the interviews varied according to the firm or institution affiliation of the interviewee, the main innovations of the firm, university or in general in Finland, innovation strategy in general, collaboration, role of research institutions and universities, and labor aspects. Public policy aspects formed another part of the structure of the interview, and especially the selective R&D support, technology programmes, and the strategy of main science and technology policies were addressed. Some of the interviews also took a detailed look at the software innovations identified in Sfinno, assessing the quality and coverage and naming missing and important Finnish software innovations.

3 A New Pattern of Industrial Innovation

3.1 Growth of Software Innovation

In our study on industrial innovation in Finland (Palmberg et al. 2000), one of the major findings was the growth of software innovation since the 1980s. Of altogether 1600 identified innovations, over 200 were of software. The development of software innovation could be labeled incredible. Almost non-existent in Finland in the early 1980s, today software has become perhaps the most innovative sector of the economy, being important not only in economic terms but also as a vehicle for political and societal aims, of which the 'information society project' is best known. Although almost a common sense conclusion, our study was the first empirical research to demonstrate the growth of software innovations in Finland over time.

Our research focused on the period 1985-1998, although we collected data also beyond these dates. Figure 1 shows the percentage distribution of software and other innovations by year of commercialization. Before looking at the graph, the reader should be reminded of the limits of our methodology. As most of the innovations are identified from newspapers and the like, there seems to exist a lag of 2-3 years before they are reported. For this reason, we have a decreasing number of innovations for the latest years, probably due to the lag, and definitely not suggesting a decrease in the number of innovations.

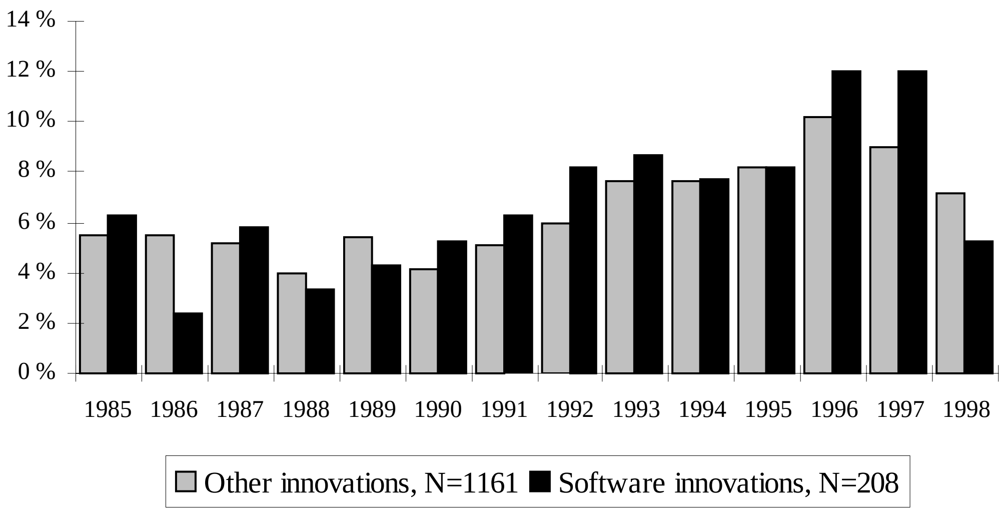

Figure 1. Development of software and other innovations in 1985-1998

The most striking feature of innovation in software is its rapid growth since 1985. Although a number of innovations were developed before that, the last 15 years have witnessed the emergence of a new pattern of industrial innovation in Finland. This has been accompanied by a general increase in innovation. However, according to our results, software innovations are the major contributor to the net growth of innovation since 1985, and the only new product group since the early 1980s with more than just a few innovations. In our previous study (Palmberg et al. 2000) software was the largest homogeneous group of innovations. Other product groups with more than one hundred innovations were instruments, miscellaneous machinery, foodstuffs, and two electronics product groups combined. Interestingly, among identified innovations some fields of software products and technologies were distinguishable as innovation families or paths. Among them were telecommunication software, internet security software, 3D and CAD software, enterprise resource programmes and neural computing. Viewed as a whole, our results on the rate of innovation in software bear witness to a deep and wide change within Finnish industry since the 1980s, which has taken place across all industrial sectors and firm sizes (these aspects will be discussed in detail below).

It should be stressed that the pattern of software innovation consists not only of famous and distinguished software innovations, such as the 1982 prize winning Vaisala Ltd's software for radiosondes' ground equipment, but also of close-to-ground innovations by more or less conventional firms. The nature of innovation in software is similar to other industries; some firms produce technological breakthroughs, but the majority of innovative firms generate only incremental improvements. The bottom line is that all this innovative activity results in new products being brought to markets. Thus, the importance of software innovation in Finland is manifested not only by technological novelty, but in essence by the wide spread innovative activity in the economy, resulting in commercialized innovations.

There are good reasons to believe that the growth of the software industry and software innovation is continuing. Therefore the trend covered in Figure 1, where software innovations are increasingly important in relation to the group of other innovations, is likely to be intensified in the coming years. This underlines the importance of our knowledge of innovation in software.

A basic question concerning software, a newcomer both as a technology and as an industry, is its location in the economy. What kind of firms produce software innovations? - a simple but, for many reasons, largely unanswered question. In addition, software's diffuse character troubles traditional firm and sector approaches in innovation studies, as they do not make a distinction between product and firm. In our object approach based study the distinction was possible, as we first identified innovations and then the firms commercializing them. Table 2 shows the number of software innovations by sector of the commercializing firm, illustrating the locus of innovative activities in software in the Finnish economy.

Table 2. Software and other innovations by sector of the commercializing firm

Sector of firm	**Software innovations**	**Per cent**
Unknown	10	5 %
Mining and quarrying	0	0 %
Food, beverages and tobacco	0	0 %
Textiles, wearing apparel and leather	0	0 %
Wood products	0	0 %
Pulp, paper and paper products	1	0 %
Printing and publishing	2	1 %
Oil and chemicals	0	0 %
Rubber and plastics	0	0 %
Other non-metallic mineral products	0	0 %
Basic metals, fabricated metal products	2	1 %
Machinery and equipment	6	3 %
Electrical and optical equipment	16	7 %
Transport equipment	0	0 %
Other manufacturing, recycling	1	0 %
Electricity, gas and water supply	1	0 %
Construction	2	1 %
Wholesale and retail trade, repair, personal and household articles	19	9 %
Other services	27	12 %
Software	113	52 %
Research and development	8	4 %
Architectural and engineering activities	11	5 %
Total	**219**	**100 %**

Only a half of all software innovations captured in our study are produced by firms classified officially as software firms. Other significant developers include firms in electrical and optical equipment, other services - mainly mobile phone network operators - and wholesale and retail trade, repair of personal and household articles. Obviously, the result questions the use of the conventional firm level and sector approach in the study of software. Firm level innovation studies, such as CIS, which do not make a distinction between firm and product, would be blind to the phenomenon illustrated in Table 2. The result showing that only a half of software innovations are produced within the official software sector suggests that firms operating in 'maturing' industries also maintain and develop software, and that they are responsible for a rather large share of innovative activities in software. A commonly held belief by information and communication technology specialists offers a further explanation of the phenomenon: i.e. that these technologies are well deployed by firms regardless of their sector in order to support their main products, processes and functions. However, the result enables an interesting view of the process of industrial renewal, as our sample includes firms expanding from manufacturing industries into areas such as internet security products. It looks like there are three kinds of firms producing software innovations: firms that by origin produce software; firms that are diversifying into new areas, in this case to software; and firms that deploy software to build added value into existing products or to create new ones within an existing business concept.

3.2 The Entrepreneurial Character of Software Innovating Firms

In the classical studies on innovation, entrepreneurship and innovation are strongly linked, being essential to the core definitions in the conceptualizations of economy and capitalism (Schumpeter 1942). From a more practical point of view, knowledge of firm dynamics and the role of entrepreneurship with respect to industrial innovation are essential for the rationale of technology and industrial policy. In this chapter we look at the characteristics of software innovating firms. Emphasis is placed on small and young firms, as our study is the first Finnish one to look specifically at such enterprises, and they are well represented in our data. Furthermore, small and young firms often lie at the heart of industrial renewal processes, and are an important vehicle for technical, economic and industrial transformation. Thus, they are also of special interest from the point of view of public policy.

As stated above, firms seem to follow few distinct innovation strategies in software. This leads us to ask how entrepreneurship is reflected in the characteristics of firms producing software innovations, and is the picture different when compared with firms producing other innovations? And what is the role played by small and young firms? We have approached these questions by looking at the innovative firms by their age and size.

Table 3 presents percentage shares of software and other innovations by age of the commercializing firm. The age is measured at the date of commercialization of innovation. If the firm was established after the market introduction of the innovation, we have interpreted the innovation to have been originally developed by some other company. Below we consider in more detail the situations when this can occur.

Table 3. Age of innovating firms

Age of firm	Software innovations	Other innovations
One year or less	23 %	12 %
2-4 Years	27 %	16 %
5-9 Years	17 %	18 %
over 10 Years	22 %	33 %
Developed by a firm other than the original commercializer	11 %	21 %
Total	**100 %**	**100 %**
N	**192**	**958**

The relationships between innovation and firm are different in software and other technologies. Firms aged 4 years or less commercialize a half of software innovations and about one third of other innovations. Firms aged 5 years or more introduce about 40 per cent of software innovations and over a half of other innovations. Finally, the difference is played out in innovations developed by firms other than the original developer. In software roughly 10 per cent of innovations belong to this group. In other technologies, the share is double, being roughly 20 per cent. Obviously the role and character of innovation in software, and its relation to the firm, is different from other technologies. This suggests, in turn, that the innovation and growth strategies of software firms are different from those of firms in other technologies.

Our results suggest that entrepreneurship characterizes software. Much more often than in other technologies, a new or young firm is responsible for the commercialization of a software innovation. For other innovations the situation is somewhat opposite, as the number of innovations increases with the age of the firm. The phenomenon is strengthen by the fact that commercialization by some firm other than the original developer is almost twice as common in other technologies than it is in software. Firm acquisitions, transfers of the ownership of the innovation, the establishment of a subsidiary of the original developer, and similar phenomena, are more common in other technologies and industries than in software. This suggests that the innovation and the firm, the innovator and the entrepreneur, are more tightly tied together in software than in other technologies. Young firms producing and commercializing software innovations are typical for Finland.

3.3 Innovation and Size Distribution of Commercializing Firms

The size of the firm when introducing an innovation to the market is an additional indicator of its entrepreneurial character. If the innovating firm is young, and in addition small, there are good reasons to believe that the innovation will have boosted its business. From the above we know that young firms introduce most of the software innovations in Finland. Now we will turn to look at the size of innovating firms by the number of employees. Table 4 compares software and other innovations by the size distribution of innovating firms. Employment data on the size of firms was obtained for the year of commercialization of innovation or surrounding years. The data was provided by Statistics Finland.

Table 4. Size of innovating firms by employees

Employees	Software innovations	Other innovations
<10	41 %	24 %
10-99	28 %	25 %
100-999	13 %	23 %
>999	17 %	28 %
Total	**100%**	**100 %**
N	**183**	**1021**

First we observe that the size distribution of software innovating firms is skewed towards small firms, whereas in other technologies it is relatively even. About 40 per cent of all software innovations are produced by firms with fewer than 10 employees. These small firms are an important source of innovations in other technologies too, as a quarter of innovations belong to this group. However, the gap between these groups is rather large, and shows that small firms are more important for software than for other technologies. In addition, it underlines the entrepreneurial character of software.

Again, the result highlights the differences between the object and subject approaches. The share of innovations introduced by small firms is surprising if contrasted with the results of most recent CIS surveys conducted in Finland. Although firms with fewer than 10 employees are not usually included in the survey, the 1996 CIS did include a small sample of firms with fewer than 10 employees from five industrial sectors. The industrial sectors were chemical products and chemicals, rubber and plastics, other non-metallic mineral products, machinery and equipment, and electrical and optical equipment. The survey results reported relatively little innovative activity in firms with fewer than 10 employees, and less than in firms in industry in general (Statistics Finland 1998, 26-27). A possible explanation for the discrepancy between these two studies may be embedded in the fact that small firms with fewer than 10 employees usually have only one innovation, and in general fewer innovations than larger firms (Palmberg et al. 2000, 16). Due to this, innovation may not be as frequent a phenomenon among small firms than it is among large ones, which usually have many innovations. We should also bear in mind the different character of these studies: CIS aims to provide an estimate of innovation activity in the economy, whereas Sfinno focuses on the description of patterns of innovations. However, small firms with fewer than 10 employees produce a very large share of innovations, especially of software innovations. Bearing in mind that software firms were excluded from the survey of small firms, and in the light of our results, more attention should be paid to this firm group.

How constant is our observation that small firms are the major source of software innovations? To answer this question we look at the size distribution of firms innovating in software in two periods, by innovations commercialized in the years 1985-1992 and 1993-1998, in **Table 5**. Again, we look at the size of the firm when innovating.

Table 5. Size of software innovating firms in 1985-1992 and 1993-1998

	Year of commercialization	
Employees	**1985-1992**	**1993-1998**
<10	43 %	41 %
10-99	28 %	31 %
100-999	14 %	12 %
>999	15 %	16 %
Total	**100 %**	**100 %**
N	**88**	**86**

Table 5 compares software innovations by size distribution of commercializing firms in two periods: 1985-1992 and 1993-1998. The pattern remains practically the same over time, showing small firms sustaining their position as the main source of software innovation. This is probably the case today, although the last two years, not researched here, have witnessed a change in the Finnish software industry. At the firm level, the change has occurred in two ways. The number of software firms has expanded at the same time as a number of firms have grown significantly in different ways, i.e. through recruitment, merger, acquisition etc. However, we have no research results which would suggest that the locus of software innovation in Finland, shown here, would have changed.

3.4 Turnover of Small Software Innovating Firms

After discussing the characteristics of innovating firms with respect to age and number of employees, we now turn to the annual turnover distribution of firms commercializing software innovations, and look at the amount of turnover at the time of commercialization. This will provide additional perspectives on the characteristics of firms innovative in software, and will further assist in interpreting the survey results.

In the discussion on annual turnover we will emphasize small firms with a turnover not exceeding FIM 10 million. This is because small firms are of such importance for innovation in software, and secondly because the relationship between innovation and firm is more easily identifiable in a small firm than in a large one. Table 6 below presents the distribution of firms commercializing software and other innovations. Unfortunately, the comparison is not quite as good as in the tables above, because we lack historical annual turnover figures for so many firms with innovations other than software. For firms commercializing software innovations the situation is better, as we received historical annual turnover figures from Statistics Finland for 163 out of 219 software innovations. However, the number of innovations is big enough to give a good impression of differences in the respective groups.

Table 6. Annual turnover of innovative firms (FIM 1000)

Turnover	**Software innovations**	**Other innovations**
-99	2 %	3 %
100-499	10 %	5 %
500-999	10 %	5 %
1000-4999	28 %	17 %
5000-9999	12 %	10 %
+10000	37 %	60 %
Total	**100 %**	**100 %**
N	**163**	**900**

The result reflects those on the size distribution by number of employees, as firms with rather small annual turnovers are the most important source of new software innovations. A closer look reveals that firms with an annual turnover below FIM 1 million commercialize about one fifth of software innovations, and below FIM 5 million about the half. In comparison, the same shares for other innovations are about one tenth and one third, suggesting that the firms are more mature and stable. Firms with an annual turnover exceeding FIM 10 million are by far the largest group in firms commercializing other innovations. This group of firms is the largest one in software innovations too, but the share remains at roughly one third. Table 6 confirms that firms producing software innovations have special characteristics, as the role played by firms with modest annual turnovers is important. Table 7 will look more closely at the employee and annual turnover distribution of firms commercializing software innovations.

Table 7. Software innovating firm's turnover by employees (FIM 1000)

	Employees			
Turnover	<10	10-99	100-999	>999
-99	3 %	-	5 %	-
100-499	18 %	-	-	-
500-999	24 %	-	-	-
1000-4999	50 %	16 %	-	-
+5000	6 %	84 %	94 %	100 %
Total	**100 %**	**100 %**	**100 %**	**100 %**
N	**72**	**50**	**19**	**15**

Roughly 40 per cent of firms with fewer than 10 employees have an annual turnover of less than FIM 1 million the time of commercialization of the software innovation. Half of the same group has an turnover of FIM 1-5 million, and only 6 per cent of the firms have an annual turnover exceeding FIM 5 million. The result suggests that the software innovations captured in our study are of great importance for these small firms.

3.5 Characteristics of Software Innovating Firms and Aspects Of Innovation Studies

Since the 1980s a pattern of software innovation has emerged in the Finnish economy, constituting one of the largest product groups of innovation today. Of about 1600 identified innovations between the years 1985 and 1998, 219 were of software. Software innovations have also been the largest net contributor to the net growth of innovation in Finland in 1985-1998, and the number of software innovations has increased steadily year on year and will probably continue to do so.

The software industry is the main source of software innovations, but not the only one. The software sector produces about a half of all commercialized software innovations, and the rest is produced in a variety of industrial and service sectors. The finding that half of all commercialized software innovations are produced elsewhere than in the traditional software sector bears witness to technical and industrial renewal processes under way. Firms originally manufacturing something other than software are actively exploring the opportunities that software affords for new business.

The majority of software innovations are produced by young and small firms, giving the industry a special entrepreneurial character when compared to firms innovating other products. A closer look reveals that a half of software innovations are commercialized by firms aged four years or younger. About 40 per cent of software innovations are produced by firms with an annual turnover below FIM 1 million at the time of commercialization. Also about 40 per cent of software innovations are commercialized by small firms with fewer than 10 employees. If viewed in two time periods, 1985-1992 and 1994-1998, the pattern of firms innovating in software remains the same. In all these respects software innovations differ from other innovations. The results suggest that innovation in software is strongly entrepreneurial in character, more so than in other innovative sectors of the Finnish economy.

Two of our results urge a revision of our methods of obtaining data on innovation in software. Firstly, the result showing that firms officially classified as software firms produce only about a half of all commercialized software innovations questions the use of traditional firm level innovation studies in the case of software. Firm level studies not distinguishing between firm sector and product group are unable to identify properly innovative activities in software taking place outside the official software sector. Secondly, the result showing small firms with fewer than 10 employees to be the most important source of software innovations questions the exclusion of small firms from innovation studies. Studies excluding this firm group are not providing a sufficiently concise picture of innovation in software. These claims do not try to downplay the undeniable importance and benefits of CIS, but are intended to contribute to a better understanding of one of the most important and innovative sectors of the Finnish economy.

4 Development and Marketing of Software Innovation

4.1 Origin of Software Innovation

The origin of innovations is of general interest, and we asked our survey respondents to assess the importance of given factors to the commencement of an innovation's development. Factors, listed below in Table 8, include market factors, public policy aspects and more general ones. The survey results presented in Table 8 cover only the percentage share of respondent answers regarding the factor important or of great importance. The original question was a four-scale question, ranging from not important and of minor importance to the above-mentioned ones. If new technologies or new scientific breakthroughs were regarded as important, the respondent was asked to name the technology or discovery. Because we do not know whether the factor has influenced the innovation process at all, we should emphasize the positive answers revealing true impact.

Table 8. Factors regarded as important or of great importance for the commencement of the innovation's development

Factors	Software innovations	Other innovations
Intensification of price competition	16 %	28 %
Threat posed by rival innovation	12 %	25 %
Observation of a market niche	91 %	86 %
Customer demand	83 %	76 %
Public procurement	4 %	8 %
New scientific breakthrough	14 %	16 %
New technologies	60 %	36 %
Public research or technology programme	26 %	17 %
Environmental factors	4 %	33 %
Regulations, legislation, standards	9 %	26 %
Availability of a license	1 %	7 %
N	**98**	**674**

The distinctive patterns of origin of software innovations covered in Table 8 reflect the characteristics of the field. The pattern of origin regarded as important or of great importance is rather homogenous, as the same pattern for other innovations reflects the variety of the group. Also the distribution of factors regarded as important or of great importance for the commencement of software innovations is relative narrow, emphasizing the market-oriented factors, new technology, and surprisingly also public research or technology programmes. Many of our interviewees emphasized these factors too. The importance given to these factors is also echoed in the collaborative and public support structure of software innovations, and this will be discussed in more detail in chapters 5.1 and 5.3, which respectively deal with these aspects.

Market niche and customer demands are the two most important factors of origin for software innovation. In general, these factors were dominant among all respondent groups, and the difference between software and other innovations is only a small one. The role of new technology is regarded as rather important for software innovation, as almost one third of respondents assessed this as being either importance or of great importance. The same share for other innovations remained at about one third. It is interesting to note that respondents of this group most often named software technologies or products as having had a triggering effect on the innovation. Public research or technology programmes were the fourth important factor for software, with about one quarter of respondents regarding it to be important or of great importance. For other innovations, the factor ranked eighth with a share of about 15 per cent, being of equal importance as new scientific breakthroughs. We will look more closely at this in the chapter 5.4, which deals more specifically with the role of technology programmes.

In our survey, three factors, i.e. market niche, customer demands and new technology, were regarded as being important for software innovation by more than 50 per cent of the respondents. Of these, the role assigned to new technology is substantially different from other product groups, thus being something typical for software. Of course, the role of new technology in the competitiveness of the software industry is well acknowledged. Interestingly, there are some surprising results among the market factors: rival innovation and price competition do not seem to be as relevant for software as they are for other innovations. Probably the importance of new technology is reflected here. There is also a large discrepancy in the importance attached to environmental factors, which are not regarded as being of importance for software innovation.

If we look at the origin of innovation our understanding of the relevance of given factors is dependent on perspective. General observations concerning all the innovations may be justified, but due to the discrepancies described above in the case of software and other innovations, only product-specific results seem to make sense and to be informative. According to our results, software innovations have a distinctive, rather narrow and homogenous pattern of origin, which is significantly different from other innovations. Only two factors of those assigned to be of relative importance for other innovations, namely market niche and customer demand, have a similar impact on the commencement of software innovation. Other important factors for software didn't play the same role for other innovations.

4.2 Development Times

One of the main benefits of the object approach is the insight gained into the innovation process. Among these, the time span of the development process and commercialization are of interest. Our survey included detailed questions on these aspects, including the date of the basic idea and the first exports. The results will be discussed here. In the preceding chapters we have presented the distribution of software innovations by year of commercialization. Table 9 presents the duration of the innovation process from the basic idea to commercialization by product group.

Table 9. Time from the basic idea to commercialization of the innovation

Time	Software innovations	Other innovations
Same year	11 %	5 %
1-2 years	44 %	47 %
3-5 years	29 %	31 %
6-9 years	11 %	12 %
10+ years	5 %	6 %
Total	**100 %**	**100 %**
N	**93**	**600**

In general, innovations are brought to market quite soon after the initial idea. One tenth of software innovations are commercialized within a year of the basic idea. This is also the group in Table 9 in which the only difference between software and other innovations, though a small one, is to be found. The overall result, showing the pattern of time span in both groups to be so similar, may be regarded as something of a surprise. Especially the share of software innovation projects lasting longer than 5 years, about 15 per cent, is rather a large one, and testifies to the existence of perseverance in the industry.

4.3 Profitability and Exports

There are number of aspects which make the straightforward measurement and comparison of profitability and export success dubious. Firstly, the profitability of an innovation is not always direct, but may be indirect and therefore difficult to obtain information about. Other benefits and consequences may be important, too. Secondly, our survey, conducted in 1999, set a time limit within which the innovations had to have reached break even point or exports in order to be reported positively here. Thus, old innovations are more likely to report profits and exports than young ones. As we compare software and other innovations, a further aspect is associated with the special market dynamics of software. Quite a few successful software innovations, and software firms, pursue a strong growth strategy, which, in turn, has an impact on the profitability of the innovation and firm. Despite these problems we will discuss the survey results below. The respondents were asked whether the innovation had reached break even point and exports, and if so to indicate the year when it had occurred.

There are no real differences in the shares of software and other innovations which did and did not break even. Of 93 software innovations, 55 per cent had returned a profit at the time of our survey. Of 641 other innovations, the corresponding proportion was 60 per cent. Taking into account the market dynamics of software, the share of innovations which returned profits is surprising large. To some extent, this is explained by the large share of small and young firms headed by an entrepreneur among software innovating firms, which would probably operate on the basis of a constant cash-flow. If the innovation had returned profits, the respondent was asked to indicate the year when this first occurred. Table 10 presents the survey results.

Table 10. Time from commercialization to profitability

Time	Software innovations	Other innovation
Same year	26 %	23 %
1-2 years	45 %	45 %
3-5 years	18 %	22 %
6-9 years	12 %	8 %
10+ years	0 %	2 %
Total	**100 %**	**100 %**
N	**51**	**381**

As we can see, the number of software innovations has dropped to 51, probably due the sensitiveness of the question. Again, there are no real differences in the time pattern of software and other innovations returning first profits. About one quarter of software innovations returned profits during the first year on the market. When viewing the results, one should take account of the fact that most of the software innovations were commercialized during the late 1990s, and may not yet have had enough time to break even. If the question were to be addressed again in a few years time, we would probably have larger shares of innovations which returned profits after 5 years from commercialization.

Our survey included a question on the innovation's share of the commercializing firm's annual turnover in 1998. The question enabled us to make a rough approximation of the innovation's importance for the firm, but proved to be problematic in the case of software, especially if the innovation was commercialized a long time ago. For this reason, only innovations commercialized since 1993 have been included in Table 11.

Table 11. Innovation's share of the commercializing firm’s turnover in 1998

	Software innovations	Other innovations
0 %	13 %	8 %
1-5 %	26 %	33 %
5-25 %	15 %	24 %
25-50 %	8 %	10 %
>50 %	38 %	25 %
Total	**100 %**	**100 %**
N	**61**	**329**

Software innovations are important for firms, and almost 40 per cent of them account for more than 50 per cent of the firm’s annual turnover. When compared to other innovations, the result again reflects the different firm patterns, as large firms are a more important source of innovations other than software. If commercialized by a large firm, even a successful innovation will probably account for a very small share of the firm’s annual turnover. However, the proportion of innovations with little or no share of the firm’s turnover are almost the same, about 40 per cent, in both product groups. The difference between software and others group lies in the proportion of innovations accounting for a very large share of the firm’s turnover, reflecting the role of small firms as the main source of software innovations.

Table 12 shows how the respondents view the current and future development prospects of the innovation. In the survey, the respondents were asked to estimate the innovation’s turnover development in 1999-2001 on a simple scale. Again, innovations commercialized before 1993 were excluded.

Table 12. Expectations of the innovation's turnover development in 1999-2001

	Software innovations	Other innovations
Will increase	77 %	80 %
Will be stable	18 %	14 %
Will decrease	5 %	6 %
Total	**100 %**	**100 %**
N	**61**	**329**

Almost 80 per cent of software innovations are expected to achieve larger turnovers in the near future. The expectations are somewhat lower than for other innovations, but in general our respondents have very similar expectations of future development in both groups. In some sense, the similarity of both groups is a surprise. One might reasonably have expected the survey respondents to predict the turnover of software innovations to increase more than that of other innovations. However, taking into account that about a half of the software innovations had returned first profits at the time of our survey, the expectations are rather positive.

Now we will turn our attention to the share of exports among software and other innovations. To be reported as an exported innovation in our survey, one export transaction was required to have taken place. We therefore have no knowledge of the scale of exports. The majority of software and other innovations have been exported. In contrast to the previous questions, a small difference is observable: of 93 software and 641 other innovations, 58 per cent and 70 per cent had been exported, respectively. Of course, the discrepancy is mirrored in the shares of innovations not exported. The result underlines the role of the domestic market for software innovations, and echoes other results of our survey. Above all, the software innovators tended to emphasize domestic partners in the collaborative pattern of innovation development. This subject is dealt with in more detail in chapter 5.3. Table 13 presents survey results on the length of time from commercialization to first exports.

Table13. Time from commercialization to first exports

	Software innovations	**Other innovations**
Same year	41 %	46 %
1-2 years	39 %	41 %
3-5 years	11 %	10 %
6+ years	9 %	3 %
Total	**100 %**	**100 %**
N	**54**	**444**

In general, the software innovations are exported like other innovations, but with a small delay. Compared with other innovations, a smaller proportion of software innovations were exported after commercialization. However, the proportion of innovations exported six years or later after commercialization is larger for software than for other innovations. The result is hardly surprising considering that exports do not have the same role for software as they do for other innovations.

The results are interesting from the point of view of public policy, since the enhancement of exports of new technology-based products is one of the key aims of Finnish technology policy. The philosophy is explicitly reflected in the latest software technology programme "Spin 2000-2003 Software products -a launch pad for global success". With regard to our results, the programme focus is rather well thought out for software. However, the exports of software products have already captured the attention of Tekes and Finpro (formerly the Finnish Foreign Trade Association). For instance, in 1997 a development programme aimed to enhance exports of software products was undertaken. (Tekes 1998). Other similar initiatives have also been realized, and the theme has recently been examined in a special Tekes report. (Autere et al. 1999)

The time spans of the innovation process and exports of software are rather similar to those of other innovations. Software innovations are commercialized quickly after the basic idea, and over a half of them are brought to market in two years or less. The main differences were found in the role of exports. When compared with other innovations, software innovations are not exported that often, and when they are, it takes more time after commercialization than for other innovations. This suggests that Finnish software innovations have had a tendency towards the domestic market. However, this seems to be relatively well acknowledged, and there are several reasons, including among others the increase of packaged software innovation, changes in firm strategies, etc, which all give reason to believe that the future development will be more international. Also such features as the development and maturation of markets, and especially the future development of standardization, will affect the exports and internationalization of the Finnish software industry.

4.4 Development Process and Market Dynamics in Software Innovation

The character of software innovations, including here only factors of origin and the pattern of innovating firms, are different from other innovations, but the circulation of the innovation process, commercialization and other market transactions occur in very much the same manner in software and other innovations. The result suggests not only that software innovating firms are responding to very specialized needs, but also that the knowledge, technology and resource inputs initiating innovation in software are homogenous, specialized and significantly different from other innovations.

The pattern of origin of software and other innovations are overlapping, but there are important differences, too. In general, the pattern of origin of software innovation is narrow and homogenous, emphasizing only three factors. The "threat posed by rival innovations" and "observation of a market niche" are the two most referenced factors for the origin of software and other innovations. "New technologies" is the third most often cited factor for software innovations, and compared with other innovations, much more weighted. It is interesting to note that "public research or technology programmes" were assigned much greater significance for software than for other innovations. Acknowledging that both "new technologies" and "public research or technology programme" intersect interestingly with public policy aspects, they will be discussed further in chapter five.

Some features of the innovation process - such as the length of time from the basic idea to commercialization, from commercialization to profitability and exports, and the proportion of innovations achieving profits and exports - are very much the same in software and other innovations. In both groups, roughly 50 per cent of innovations are commercialized within 2 years of the basic idea, and in general the distribution of development times is very similar in software and other innovations.

Almost the same proportions of innovations achieved profits in software and other product groups: 55 per cent of the former and 60 per cent of latter reached the break even point. In both groups, almost 70 per cent of innovations achieved first profits within 2 years of the basic idea. Here too, the distribution of the time pattern is almost identical in both groups.

An innovation’s importance for the commercializing firm reflects the pattern of innovating firms, discussed in chapter three, and in this respect some differences between software and other innovations are to be found. About 40 per cent of software innovations account for 50 per cent or more of the commercializing firm’s annual turnover, whereas the corresponding figure for other innovations is one quarter. The result is due to the fact that small start-up firms are the main locus of software innovation.

A small discrepancy is also to be found in the proportion of innovations achieving exports: about 60 per cent of software innovations have been exported compared with 70 per cent of other innovations. 80 per cent of software innovations are exported within 2 years of commercialization, and the corresponding figure for other innovations is about 85 per cent. With regard to expectations of future developments, they are almost identical in both groups. About 80 per cent of innovators in both groups expect future growth of their innovation's turnover.

5 Technology Policy and Software Innovations

5.1 Importance and Structure of Public Funding

Strong technology policy gained broad political consensus in Finland during the 1990s. The overall policy objective is to create a sound knowledge infrastructure to reduce dependence on traditional sectors of economic activity and to transform the Finnish economy into a knowledge-based economic system. The fostering of new business and innovation are at the core of current practice of Finnish technology policy. In general, Finnish technology policy has been organized according to the concept of 'national innovation systems', which was introduced in Finnish technology policy in the early 1990s. The practice of technology policy has been formulated around four main areas of interest: selective public support for R&D, R&D co-operation, education, and the concept of the information society. (Diederen et al. 1999, Science and Technology Council 1996 & 2000; Vuori &Vuorinen 1994.)

In this chapter we look at the technology policy from the point of view of software and other innovations. As the advancement of the diffusion of new technology is one of the prime aims of Finnish technology policy, the dichotomic perspective is not only justified but informs us about one of the main sectors of information and communication technologies.

Selective R&D support is among the most important instruments that technology policy practitioners have in order to support innovation, which is regarded as a means of promoting new business and enhancing the competitiveness of industry. The National Technology Agency (Tekes) distributes the lion's share of selective R&D support in Finland. Our survey included questions on the role of public support for the development of innovation. The respondents were asked whether they had received public support. If the answer was positive, the respondent was asked to judge the importance of funding by source. The answers enabled us to approximate the importance of public funding and its structure for innovation in general and for subgroups in Finland. No questions addressing the additionality of public funding were asked.

Finnish R&D spending increased significantly during the 1990s (OECD 1999). In many ways it reflected the growth of the electronics industry, but the development of public R&D subsidies is also a relevant aspect. In fact, besides selective R&D

support, Tekes grants R&D loans and other subsidies, too. During the 1990s, public R&D funding, distributed mainly through Tekes, increased significantly. In many ways, this is also reflected in our results on the role of public funding. Palmberg et al. (2000) demonstrated that the proportion of innovations with public support increased significantly from the 1980s to late 1990s. In this study, we will not examine the distribution of public support over time in the case of software innovations. However, given the growth figures of Tekes funding from the 1980s to 1990s, the phenomenon should be borne in mind when interpreting our results on software innovations with public funding. The development of Tekes's R&D funding in 1985-1999 is examined in Table 14.

Table 14. Development of Tekes's R&D funding in 1985-1999

Year	Million €
1985	49
1990	109
1995	259
1999	410

Source: Tekes 1993, 1996 & 2000. Note: Figures are deflated.

Table 14 provides us with the overall development of Tekes's R&D funding. We will now look in more detail at the software-related funding. However, as software related-funding is managed in Tekes in the division for information technology, which administers telecommunication and electronics technologies, digital media, applications of information technology, and space technologies (in 1998), the figures should be read carefully. In any case, the figures outline the basic development of Tekes funding in the field. Of the mentioned technology areas, the others obviously fall in the field of software, but in the case of space technologies one should be cautious.

In 1992, Tekes's information technology division provided R&D projects with funding of about EUR 58 million (all Tekes's figures are deflated with 1995 being 100). This was about one third of Tekes's total funding in 1992. In comparison, in 1998 Tekes financed telecommunication and electronics technologies, digital media and applications of information technology with about EUR 104 million. As Tekes's total R&D funding was about EUR 300 million, the software-related technologies' share was about one third. In short, taking into account the overall growth of Tekes spending, we may assume that the software-related R&D spending grew at least in the same proportion.

In our study, the share of innovations with public funding was relatively high, as about two thirds of all innovations did receive it. There is no real difference between software and other innovations in this respect, as 69 % of 98 software and 67 % of 670 other innovations received public funding. However, if we look at the importance of the funding by source, a difference emerges. The survey results in Table 15 show the percentage shares of two respondent groups regarding the source to be important or of great importance for the development of innovation. In the survey, the respondents were asked to estimate the importance of public funding bodies on a scale of four, ranging from not important to very important.

Table 15. Public funding bodies regarded as important or of great importance for the development of innovation

Funding body	Software innovations	Other innovations
Tekes	79 %	69 %
Other MITI	16 %	27 %
Sitra	6 %	10 %
Kera	6 %	16 %
Nordiska Industrifonden	0 %	1 %
EU	3 %	4 %
Other	3 %	4 %
N	**68**	**517**

As expected, both respondent groups, software and other innovators, regarded Tekes to be clearly the most important source of public funding for innovation. However, the ten-percentage-point discrepancy between software and other innovations receiving R&D support from Tekes is interesting, although only a few innovations are enough to make the difference. Also, it should be noted that other important institutions, such like Kera (Regional Development Fund), Sitra (Finnish National Fund for Research and Development) and the Ministry of Trade and Industry (MITI), have a minor role for software innovations. Obviously, the public R&D funding structure of software is narrower than in general. In the case of software the high concentration of public funding to Tekes addresses a further question: how well is Tekes able to adjust its philosophies and practices to the development of the software industry and market. After all, the role of Tekes is not limited to the financing of firms and innovations, as it also actively shapes the software knowledge base at universities. During the last few years, Tekes has also become a major funding body in computer science and related fields at the universities. The interpretation of the result could also be the contrary, suggesting Tekes to have succeeded better than other funding bodies in adjusting its philosophies and practices to the growth of software. This is in line with Tekes's mission, as it is assumed to be one of the prime promoters of new technology in Finland. Also, the result probably reflects the unwillingness of other funding bodies to share risks associated with new technologies. However, it is clear that the structure of software innovation funding is relatively narrow, when compared to other innovation product groups. From various point of views, such as lock-in considerations and the like, we could speculate further on how the phenomenon should be regarded. Broadening the public funding structure of software development should, perhaps, be considered.

5.2 Importance and Structure of Technology Programmes

Technology programmes are one of the key instruments of technology policy. In recent years the number of Finnish technology programmes, especially those of Tekes, has increased. Tekes currently has over 60 programmes, although most of them are rather small. Our survey included a question on the role of Tekes and other technology programmes – mainly those funded by the EU and MITI – in the innovation's development. The respondents were asked to assess whether a public technology programme had been important as regards collaboration associated with innovation's development. If affirmative, the respondent was asked to indicate which public body had funded the technology programme in question. No further questions assessing the relevance of the programme were asked. Evaluation reports are readily available on most of the programmes. (Among the most recent ones in software programme evaluations, see Guy & Stroyan 1998). The survey results enable further perspectives on public funding and collaboration.

In 1998, there were eight national technology programmes in the fields of telecommunication and electronics, digital media and applications of information technology, in which Tekes participated as a financier. However, just a few of the programmes can be perceived as large ones from the point of view of Tekes funding. Only in two of the programmes was Tekes's funding more than EUR 15 million, both in telecommunication and electronics. The third largest programme, "Digital media in health care", received about EUR 5 million. In general, national technology programs related to software fall into the fields of telecommunication and electronics.

In our study, a rather large share of software innovations were connected to technology programmes. Of 108 software innovations, 35 per cent were connected to a technology programme during the development phase, compared with 22 per cent 644 other innovations. A closer look is provided in Table 16, which makes a distinction between Tekes and other programmes. Because some innovations have been connected to both Tekes and other programmes, the percentage shares differ from the above-mentioned figures.

Table 16. Proportion of innovations with important connections to a technology programme with regard to collaboration

Programme	**Software innovations**	**Other innovations**
Tekes technology programme	31 %	19 %
Other technology programme	9 %	5 %
N	**108**	**678**

At one glance, the sum of percentage shares of innovations connected to Tekes and other technology programme seem to be relative high. However, in the case of software, the majority of innovations connected to other programmes are connected to Tekes programmes, too. In the case of other innovations, the same phenomenon is much rarer. In total, one third of our software respondents indicated that the development of software innovation was connected to a Tekes technology programme. As the same figure for other innovations was just one fifth, we can conclude that Tekes programmes play a more central role for innovation in software than in general. In the case of other programmes, the proportion of innovations connected to them is relatively low, reflecting the minor role of EU and MITI programmes for software innovation.

If the innovation's development was connected to a Tekes programme, the respondent was asked to name the programme. The most often named programme was 'Adaptive and Intelligent Systems Applications 1994-1999', which focused on neural computing and fuzzy logic technologies. The programme was explicitly launched to "push technology from universities to firms", as one of our interviewees described. Research relevant to the programme focus also has a strong foothold at Finnish universities. In the case of ’Adaptive and Intelligent Systems Applications’ it should also be noted that the programme has had antecedents, and was extended by a year up to 1999 due to good results. The programme was perceived to be rather successful in Tekes, too, with references to the programme and its achievements featuring prominently in both the 1997 and 1998 Annual Reports of Tekes.

Obviously, one reason for the many-sided public support for artificial intelligence, neural computing, fuzzy logic and knowledge engineering technologies is that the field performs unique research and has been able to engage university researchers, policymakers and firms successfully in co-operation. Also, the future promise of commercial applicability is important for the field. Besides artificial intelligence, neural network and knowledge engineering software innovations, multimedia software was often connected with technology programmes. Again, multimedia is strongly represented at the universities of technology. In all Finnish universities of technology there are laboratories specialized in multimedia software. However, the importance of both of the above-mentioned programmes was also stated by many of our firm interviewees.

The large proportion of innovations connected to Tekes programmes reflects the same phenomenon discussed in the chapter on public funding. Public policy aimed at supporting the development of software is more concentrated than in other technologies. Unlike the access to public funding, where an equal proportion of software and other innovations did receive funding, software innovations were much more often connected with technology programmes than were other innovations.

5.3 Importance and Structure of Collaboration

Collaboration is a central action in the Finnish technology policy based on national innovation systems. In general, collaboration is often assumed to lead to networking, implying effective production and sharing of working knowledge. In practice, collaboration links the different actors of the system. In an ideal case, the collaboration would take place during an innovation process and would generate products which draw on the large national knowledge base and competencies. Although collaboration has its limits, firms usually have to collaborate in order to innovate and create competitive products for the marketplace. However, the dynamics and structure of collaboration in software have special characteristics, which are related to special features of the software innovation process and products. Our survey included a question on the ratio of collaboration, and how important different actors were regarded for the innovation process. This question was similar to the one described above in the case of public funding. These questions gave us a perspective on the structure and dynamics of collaboration in software.

According to our results, collaboration is a frequent phenomenon: 88 per cent of our respondents indicated that the development of the innovation included collaboration. Similar to the above question on the ratio of public funding, the proportion of collaboration is the same in software and other innovations. However, as we know, there are many kinds of collaboration, and, especially in the case of software, many features which should be considered when interpreting the results. The role of collaboration in software differs from other technologies. The main reasons include the replication of software code, weak intellectual property rights, tight market competition, and the role of customer. Many of our interviewees said that they preferred ’closed’ innovation processes, by which they meant a centralized R&D organization without any substantial collaboration. Especially small and medium sized software producers tend to prefer this centralized development model. In such cases, collaboration does not automatically have a project character aiming to develop a specific feature of a product or a product. Rather, it is general monitoring of the branch, or linked to customer deliveries.

On the whole, due to differences in the nature of innovation, we can assume the pattern of collaboration to differ in software and other innovations. In the questionnaire, the respondent was asked to indicate whether any collaboration had existed during the development of the innovation. If affirmative, he/she was asked to rate the importance of given collaborative partners. The results in Table 17 reflect how our survey respondents regarded the importance of the main domestic and foreign collaborative partners.

Table 17. Collaborative partners regarded as important or of great importance for the development of innovation

Partner	Software Innovation	Other Innovations
Domestic customers	78 %	64 %
Foreign customers	37 %	46 %
Domestic consultants	21 %	16 %
Foreign consultants	8 %	7 %
Domestic subcontractors	21 %	34 %
Foreign subcontractors	7 %	18 %
Domestic universities	28 %	33 %
Foreign universities	8 %	8 %
VTT	13 %	21 %
Other domestic research institutes	1 %	11 %
Foreign research institutes	5 %	10 %
Domestic competitors	12 %	4 %
Foreign competitors	8 %	7 %
N	**86**	**676**

The result affirms the importance of the customer interface for software innovation. In general, business-oriented partners, like customers, consultants and competitors, are regarded as more important for software than for other innovations. The role assigned to customers is not surprising. In software the user-producer relationship is accentuated, as software products are often retailed to special market segments, and the customer usually needs a high level of customization in the end product. This, in turn, affects the pattern of collaboration within the industry, as most of the product launches are prepared together with customers. According to the literature, the phenomenon occurs across all market segments and firm sizes, thus being typical for software product development. (See, for instance, Cusumano 1996.)

Another, perhaps surprising, difference is the minor role of foreign collaboration partners when compared to other innovations. The result suggests that innovation in software relies merely on the domestic knowledge base, thus underlining domestic differences. However, recent development might change the situation rapidly. Foreign firms, among them Hewlett Packard, SAP and IBM, have either established or announced their plans to establish software development centers in Finland. (See, for instance, HS 5.6.2000). This will certainly affect the pattern of software innovation in Finland and, although still unclear, the focus will probably be on the fields of mobile communication and related software. However, it is likely that the international collaboration in software R&D will increase in Finland both in small and larger firms.

Another interesting feature of software innovation is the low importance assigned to domestic research institutes, when compared with other innovations. The result is rather expected, as information technology is only one of the nine research fields covered by the Technical Research Centre of Finland (VTT), and other domestic research institutes cover mainly pulp and paper technologies. What makes the result interesting is that domestic universities are regarded as being of almost equal importance for software and other innovations. Although, once again, just a few innovations are enough to make the difference, the result hints at software having different national innovation systems from other technologies, with an emphasis on the universities.

In order to better understand the pattern of collaboration in software, we should consider the role and character of collaboration in this industry. Our study, the survey and the interviews together suggest that a distinction between collaboration during the product development and research collaboration should be made. Of course, the degree of complexity and size of software innovation play a significant role in the shaping of collaboration. Packaged 3D-engineering software and embedded software developed for mobile phone networks have rather different development histories, and distinctive collaboration structures. Especially in telecommunications software collaboration with other firms, key customers and universities play a significant role. However, the collaboration is seldom linked directly to product development. Rather, the role of research collaboration is to develop new technologies and technology generations, i.e. to keep up with the technological frontline. Our interviewees stated that the role of university research in telecommunications software is to research and develop next generation solutions.

From the firm perspective, collaboration is the natural way to monitor the latest research and development at universities. In small firms producing packaged software and business-to-business products, the collaboration is not that common, and more often project-minded. A further aspect is the labor crisis. Like almost everything in software, collaboration is affected by the continuing shortage of skilled labor. Our interviewees suggested it to have special implications for the collaborative pattern. The role of universities in software innovation is more likely linked to the shaping of the national knowledge base, than directly to the firms' product development. The recent growth and structural change of computer science in Finland affects the structure of collaboration, and many university departments have enough to do coping with the increased number of undergraduate students. As a result, universities do not automatically consider research to be their main contribution to the software industry. Quite the contrary, many of our university interviewees stated that the training of engineers for software firms is their prime function, which was, in turn, echoed in the firm interviews. If collaboration in software takes very different forms, varying according to the user-producer relationship, key technology and character of innovation, it would urge a revision of more specific concepts of public policies promoting collaboration in software.

5.4 Public Policy Aspects and Software Innovation

Software innovation is well reached by public technology policy, and in some respects better than other innovations. However, the linkages between software innovation and public policy seem not only to be stronger, but also to be practiced in a rather narrow institutional and instrumental landscape. When compared to other innovations, the result implies that Tekes's software-related policy is almost the only technology policy that has an impact on software innovation in Finland.

The proportion of innovations receiving public funding is almost the same for software and other innovations: almost 70 per cent in both cases. However, the distribution sources of funding were sharply different. The public funding structure of software is relatively narrow, emphasizing almost solely Tekes funding. When compared to other innovations, for which Tekes is the major source too, software innovators do not regard other MITI, Sitra or Kera funding to be of much importance. In addition, the role of EU funding is a minor one, both for software and other innovations.

Roughly one third of software innovators rate technology programmes as being important with regard to collaboration. The difference vis-a-vis other innovations is obvious, since the corresponding proportion in that group is about one fifth. In addition, it is much commoner for software than for other the innovations to be involved in one Tekes and one other programme. In general, our results suggest that EU programmes have only a marginal effect on software or other innovations with regard to collaboration.

Collaboration in software and other innovations is an almost equally frequent phenomenon: collaboration featured in the development of almost 90 per cent of both software and other innovations. If we look at collaboration in more detail, a further distinction between software and other innovations emerges. Again, the pattern of important collaboration partners is specialized and homogenous for software innovation, and rather narrow when compared with other innovations. Customers are the main collaborative partners for both groups, and universities are the third most important collaboration partners for software innovations. Besides these, software seems to have no other collaboration partners of any great significant.

Our results on the degree of public funding and its structure, the importance of public technology programmes, the degree of collaboration and its structure show software innovations to be well integrated into current Finnish technology policy practice. However, software seems to be very dependent on Tekes-related funding and instruments. Our results suggest that this dependency is due to the nature of the technologies associated with software. From the above we know that "new technologies" were among the key initiating factors for innovations in software. Acknowledging that the promotion of new technology, and therefore the ability and willingness to take risks associated with new technologies, is explicit in Tekes's philosophy, the result should not surprise us. Other public funding bodies, which are important for other innovations, seem to be of modest importance for software. There are a variety of possible reasons for the phenomenon. However, the degree of concentration gives room for speculation - especially if the concentration is typical only of software innovations - about the current functionality and basic mechanisms of technology policy, but also about its future development and strategy.

6 Conclusions

The Finnish pattern of innovation has changed since the 1980s, and the emergence of software innovation is one of the main changes. Almost non-existent in the early 1980s, software innovation is the largest homogenous product group among Finnish innovations today. In our study, we identified about 1600 Finnish innovations commercialized in 1985-1998, of which 219 were software innovations. The number of software innovations has increased steadily over time, although most of them have been developed in the 1990s, and the growth is probably continuing.

The study has examined the pattern of software innovation with respect to firm, innovation process and market aspects. Throughout the study, the main findings on software have been compared with other innovations. Software innovations differ from other innovations in three main ways. Firstly, firms producing software have special characteristics, as about a half of all software innovations are produced by small and young firms. Secondly, the characteristics of innovation, including the origin and pattern of collaboration, are special in software. Thirdly, software innovations' technology policy linkages have special characteristics, too. However, the difference in collaboration and public funding is a subtler one. The proportion of innovations with collaboration and public funding is equal in software and other innovations, but as we look at the important collaborative partners or funding bodies, significant differences are observable. Although software innovations have special characteristics, in many respects they do not. The innovation process proceeds very much in an identical manner in software and other products, and profitability and exports show rather similar patterns as well.

The emergence of software innovation to this extent challenges the usability of both traditional innovation indicators and public policies. Only a half of the software innovations captured in our study were produced within the software sector. Thus, innovation studies not distinguishing between the firm sector and product group - including the Community Innovation Survey and R&D statistics - would estimate the extent of software innovation to be about a half of the level that we have identified. The problem is exacerbated by the poor applicability of patent statistics in the case of software. Furthermore, the results suggest software to be a vehicle of industrial renewal processes and technological change, since they reveal that firms operating originally in mature industries are exploring the opportunities afforded by software.

Firms producing software innovations are different from firms innovating other products. Young and small firms, typically start-ups, are the main source of software innovation in Finland. A half of all software innovations are produced by firms aged four years or less, and over 40 per cent by firms with less than 10 employees. The phenomenon is persistent over time, and gives software innovation a special entrepreneurial character.

Market factors, such as customer needs and market niche, dominate among factors initiating software and other innovation. The third ranked factor for software is "new technologies", which is not very important for other innovations. A half of the software innovations captured by the study were commercialized within two years of the basic idea, and about 55 per cent of them returned profits. Almost 70 per cent of the software innovations broke even and did so in two years or less. About 60 per cent of the software innovations had been exported, which is slightly lower than the corresponding proportion of other innovations.

The majority of software innovations are developed with the help of public funding: almost 70 per cent of both software and other innovations. Of Finnish public funding bodies, only Tekes was considered important for software innovations. 80 per cent of software innovations receiving public funding regarded Tekes to have been a funding body of importance or great importance during the innovation process. According to our results, the public funding structure of software innovation is relatively narrow. Moreover, public research or technology programmes are regarded as being much more important for software than for other innovations, especially with regard to collaboration. Tekes programmes were the most often named ones. In addition, our results suggest that EU programmes are of marginal importance from the point of view of software and other innovations. The result showing a high degree of concentration of public funding in software technologies urges the evaluation and consideration of software-related public funding structures in more detail.

Collaboration is a frequent phenomenon in software innovation development, but besides customers there are no significant collaboration partners with regard to innovation. Collaboration featured in the development of almost the same proportion of software and other innovations, being as high as 90 per cent. Among the most important partners were customers, and domestic customers were even more important for software than other innovations. The result confirms the special importance of the customer interface in software, but gives cause for further speculation, too. Obviously, the nature of collaboration is dependent on the developed technology: for instance, it differs sharply in 3D software and telecommunication software, as our interviewees communicated. The nature of collaboration is also affected by the firm dynamics, and indeed, small and new firms collaborate differently than large and old ones. In addition, we did not examine research collaboration associated with the exploration of future technological opportunities, or with more general aims than specified product development. However, the result shows collaboration to have a special pattern in the development of software innovations, with its relatively narrow structure. Furthermore, the collaboration is affected by the special characteristics of software development, varying according to the applied technology and product segment.

Software is a special case of innovation in Finland, although not in all respects. The key characteristics of software innovation reported in the study suggest that public policies related to innovation in software should be managed according to tailored philosophies, rather than general ones. In addition, the nature and locus of software innovation question the use of traditional innovation studies to inform public policymakers. Thus, our knowledge of software pleads for the exploration and application of new, complementary research methodologies. Two key characteristics of the software sector and innovation suggest that emphasis should be laid also on the integration of different sectors of public policy. Firstly, the severe problem posed by the shortage of skilled labor falls in the field of education policy. Secondly, the importance of start-up firms as the main source of software innovations should also be considered in policy areas concerned with entrepreneurship in Finland.

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Appendix 1: List of Interviewees

Name	Firm/Institution	Recent Position
Esa Einola	Instrumentointi Ltd.	Development Manager
Ilkka Haikala	Tampere Univ. of Technology	Professor
Jukka Karjalainen	Nokia Networks Ltd.	Technology Manager
Reino Kurki-Suonio	Tampere Univ. of Technology	Professor
Unto Loponen	Vertex Systems Ltd.	Development Manager
Harri Markkanen	Aldata Solutions Ltd.	Marketing Manager
Erkki Oja	Helsinki Univ. of Technology	Professor
Timo Rajamäki	Sonera Ltd	Director
Juha Röning	Univ. of Oulu	Professor
Veikko Seppänen	Univ. of Oulu	Professor
Matti Sihto	National Technology Agency	Project Manager

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Software Innovation in Finland

In a short time software has become one of most innovative sectors of the Finnish economy. This study addresses innovation in software in particular. The study is part of a larger research project, Sfinno, which aims to provide new perspectives on the recent industrial renewal experiences in Finland. Hence, it contributes to a better understanding of innovations in their entrepreneurial context.

The study is based on a unique innovation database, consisting of about 1600 Finnish innovations commercialized in 1985-1998, of which over 200 were software innovations. In the report we utilize the database and the results of an extensive mail survey, as well as expert interviews. We analyze software innovation from perspectives such as firm level, development, and public funding.

The description of innovation in software reveals that as software and other innovations are in many respects very similar, there are also many important and very distinctive features of software innovations. These include the special entrepreneurial character of firms producing software innovations, the narrow structure of public funding, the seemingly great importance of public research programmes, and the different role of collaboration during the development phase. Special attention has been paid to aspects of innovation that lie in the arena of public policy.