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THE DIFFUSION OF INFORMATION TECHNOLOGY IN FINNISH INDUSTRY: STATE-OF-THE-ART & ANALYSIS*

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ABSTRACT: This paper is an analysis of the diffusion of information technology (IT) in Finnish industry. The analysis is based on the data of two surveys and statistics of the Central Statistical Office. Early years of Finnish computing are introduced as well as the current status of the use. The analysis concentrates on the use of IT in administrative, manufacturing and product applications as a projection of structural features of the industry. The impact of IT on work life is discussed as well as the role of information technology as a part of the industrial infrastructure.

KEY WORDS: Information technology, diffusion, Finland

Contents

1. Introduction

The Early Stages of Information Technology Use in Finland

Computers came to be used in Finland fairly soon after their serial production began. The first users were large governmental bodies, which applied the technology to administrative purposes. Such applications dominated information technology (IT) diffusion as late as the 1970's when with the development of programmable machine tools, production automation became more prevalent in industry, at first parallel with administrative IT then gradually integrated with it. IT had, of course, been applied to process automation already in the 1950's; the applications cannot, however, be regarded as having heralded a new phase in automated production[1], though they undoubtedly remain significant readiness and attitude promoting factors. The developments in microelectronics enabled the exploitation of IT as an integral part of a product and led to the so-called embedded systems, an application which achieved its full fruition as late as the 1980's.

Table 1 is a historical line-up of some significant milestones in the diffusion of computers (the data referring to Finland in italics), and it demonstrates how in a relatively short time IT has emerged as one of the mainstays of industry and society at large. As a user and promoter of IT, Finland has well kept pace with international development. A detailed account of the advent of IT in Finland can be found in a recently published dissertation (Jaakkola 1991, pp. 257-266).

The first computer, the IBM 650, was installed at Postipankki in 1958 and almost contemporaneously at Kansaneläkelaitos (The Social Insurance Institution). The future significance of and increasing demand for the computer were realized in Finland already in the 1950's, and there was an early call for *national knowhow* for computer manufacturing. The principal task of the Mathematic-Machine Committee, founded in 1954, was to design a computer primarily for use in higher educational institutions. The program was carried out at Helsinki University of Technology, which in 1960 introduced the *Esko computer.* During the 1950's, however, the computer market and marketing organizations experienced an unprecedented boom and were soon controlled by giant conglomerates, a development which in turn diminished Finland's chances to launch a domestic computer production program.

The initial computer system increases were as follows (Jaakkola 1991, p. 261):

- 1958 - 1
- 1960 - 6
- 1962 - 33
- 1964 - 65

1. The essential difference between the first (process automation) and the second (current production automation) wave of production automation is the change they induced in business operations as a whole. The first wave was basically about raising the level of process automation. The second wave, together with the above, involves overall changes in companies' organizational and operational decision-making with production automation as a means to achieve them (cf. Jaakkola 1991, p. 155).

Table 1: Some milestones in the history of IT use (Jaakkola 1991, p. 136).

1642:	• Pascal calculator 1966
1833:	• Abacus (Babbage)
1906:	• Electron tube
1919:	• Flip-flop
1937:	• Z1 computer (mechanical; Züse)
1940:	• ABC spesification
1941:	• Z3 computer (relay; Züse)
1942:	• ABC computer (Atanasoff)
1943:	• Colossus computer (UK)
1944:	• Mark I computer (relay) • Z4 computer (relay; Züse) • "Preliminary Disclosure" computer specification
1945:	• "First Draft" (EDVAC specification)
1946:	• ENIAC computer (Eckert, Maughly)
1947:	• Transistor
1948:	
1949:	• EDSAC computer (Wilkes)
1950:	
1951:	• Remington Rand Univac I • Magnetic tape memory
1952:	• Princeton (IAS)
1953:	• IBM 701 • Ferrite ring memory (Whirlwind)
1954:	• IBM 650 • *The Mathematic-Machine Committee is founded*
1955:	• Magnetic disc
1956:	• *ESKO project begins*
1957:	• FORTRAN implementation
1958:	• *Postipankki installs IBM 650*
1959:	• *The Social Insurance Institution installs IBM 650* • IBM 1401 • IC circuits
1960:	• *Esko* • *Finnish Cable Works, Electronics Department* • *First University systems (Turku, Helsinki)* • *Systems in Finland: 6*
1961:	• *Systems in Finland: 13*
1962:	• *Systems in Finland: 33*
1963:	• *Systems in Finland: 51* • *Nokia Computer Division established*
1964:	• *Systems in Finland: 65* • *The Finnish State Computer Centre (VTKK)* • *First PhD in comp. science area* • IBM 360
1965:	• Mouse • *Systems in Finland: 72* • *Univ. Curriculum in Computer Science (Tampere)*
1966:	• *Systems in Finland: 89*
1967:	• *Systems in Finland: 155*
1968:	• *Systems in Finland: 175*
1969:	
1970:	• *Selco 1000 computer, Strömberg* • *Univac 1108 for common university use (VTKK)* • *EDP Institute established* • DRAM
1971:	• Intel 4004 • *Mikko 1 "minicomputer"* • *Systems in Finland: 195*
1972:	• Intel 8008 • Electronic pocket calculator • *Systems in Finland: 242*
1973:	• *Mikko 2 minicomputer* • *Systems in Finland: 254*
1974:	• Altair 8800 commercial "PC" • Intel 8080 • *Systems in Finland: 293*
1975:	• IBM 5100 personal computer
1976:	• MosTec 6502 • Apple I • Z 80 processor
1977:	• Apple II • Vax 11/780 • *Mikko 3 minicomputer* • *Systems in Finland: appr. 7000*
1978:	• Intel 8086 processor • *Selco 1000 discontinued*
1979:	
1980:	
1981:	• Motorola 68000 • IBM PC • Osborne 1 portable PC • *MikroMikko 1 personal comp.*
1982:	• Intel 80286 processor
1983:	• *MikroMikko 2 personal comp.* • *Nokia positive display*
1984:	• Motorola 68020 processor • Apple MacIntosh • *MPS-10 (Ada)*
1985:	• Intel 80386 processor • *Lohja luminescent display*
1986:	• Transputer (INMOS) • *MikroMikko 3*
1988:	• Motorola 68030
1989:	• Intel 80486 processor • *MikroMikko* 4 • *Nokia VGA Overscan display* • *Cray for common university use*
1991:	• *ICL buys Nokia Data*

- 1966 - 89
- 1967 - 155
- (early) 1969 - 184

In 1969, 47 of the operational systems were in the public and 137 in the private sector, with the majority of them (136) located in the Helsinki area, Tampere and Turku both having 15, and the rest of the country 18.

The Mathematic-Machine Committee may well have been the first official body to chart future IT needs in Finland. In the late 1950's, the Committee proposed that the completion of the Esko system would suffice for the country's computing needs for the 1960's, during which decade there was also to be no foreseeable need in a small country like Finland for more than a couple of IBM 650-size systems. The Committee's prognosis represents a typical underestimation of the potential growth of and demand for a new, virtually unknown technology.

The *first IT firms in Finland* were importers of computer systems. The first automatic data processing service (ADP) companies appeared in the early 1960's, to be followed a decade later by the first primarily software producing companies. Since then companies have gradually diversified into their present state. Typical of the 1980's was a quick, virtual market takeover by companies specializing in ADP consulting services.

The 1960's saw the beginnings of domestic computer production in Finland. The Oy Strömberg Ab (Ltd) *Selco 1000 system* reached the market first at the turn of the 1970's, followed in short order by the Nokia Ltd. *Mikko 1 computer.* Altogether ten Selco 1000 units were manufactured before the project was discontinued in 1978, and only one of them is still in use (January 1991) at Savon Voima Oy (Ltd). The Selco 1000 was succeeded by the Selma process computer (later modified into an automation system) and more than 1600 Selma systems have been manufactured since 1978. The Mikko 1 was quickly followed by the *Mikko 2 minicomputer* in 1972 and the Mikko 3 in 1977. The Mikko 2 was widely used because its introduction coincided with developments in banking automation and some other real-time systems. This computer can be hailed as the first commercial success in domestic computer production. Following the poor commercial performance of the Ada-architectured[2] MPS-computer (the first large order in 1984), the bulk of the production shifted to microcomputers, first to domestically built, later on to domestically assembled systems. The Finnish computer industry has also made a name for itself with its high standard computer ergonomics (for example, the Nokia positive display in 1983, the Lohja electroluminescent display in 1985, and the Nokia VGA Overscan display in 1989).

The Background and Contents of the Article

The following is a condensation of two surveys on the use of IT, conducted in 1989-90. The results have previously been published (Jaakkola 1990 and Latvala 1991) and analyzed in a dissertation (Jaakkola 1991). Related studies include Jaakkola 1991a, 1991b, 1991c, 1991d,

2. The "Ada phenomenon" could undoubtedly be counted among the flops of IT future predictions. Despite the thorough design and development of the language, it is yet to become widely implemented, for item choices in software production are not solely rational. The mechanism guiding such IT choices has turned out to be rather rigid and slow to adapt to innovations. At its inception, the Ada language obviously was not sought-after the way some of the many more recent applications, which after passing a certain threshold have fairly promptly achieved wide-spread use. In the 1980's (as still in its fashion), Nokia Electronics invested some FIM 100 million in its then progressive Ada-MPS 10 project. The project was timed correctly: had the Ada language achieved the intended objectives for use, the project would have rolled out finished Ada-architectured products at the peak of demand. Unfortunately, the expected boom turned into a bust.

of which the first two deal with the use of IT in Finnish industry and the latter two with the principles of the diffusion process therein.

The article commences (chapter 2) with a general presentation of IT use in Finnish industry, followed by a detailed review of each of the three major sectors of application (chapters 3-5). Separate chapters are also devoted to IT-induced changes in work life (ch 6) and to the growth of the IT industry (ch 7). The article winds up with views on the significance of IT for industry.

2. The Use of Information Technology in Finnish Industry

Examining the diffusion of IT in industry with respect to its tripartite application (IT in administration, manufacturing processes, and in products), we can make the following general observations. The development and adoption of computer systems (hardware, software) in the above sectors have proceeded at varying rates, with administration being the first to reach wide-scale application capability. That is why long-term IT user companies have typically keyed in first in this particular sector. With experience and knowhow gained in this sector and with updating of systems and applications, most industrial enterprises have proceeded to manufacturing applications and some even to product applications. Thus as a whole, IT use has been spreading in industry via administration-manufacturing-product, with about a ten-year transition period between the stages. IT's change-inducing impact on industry fell on

- administration in the 1960's and 70's
- manufacturing in the 1970's and 80's
- products in the 1980's and 90's

In administration, however, the decentralization of information systems, initiated by personal computers, work stations and networking solutions, occurred as late as the 1980's. This trend has ushered into the sector a new wave of change with its capacity to affect activities and functions no doubt equal to that caused by IT in manufacturing. Equally typical of this trend has been a high degree of applications integration, which undeniably is one of the most significant forces for change in the current IT diffusion. As late as the 1970's and early 80's, an individual industrial concern would typically deploy IT first in administrative functions and only afterwards (after about a five-year lag; Jaakkola 1991, p. 142) in its manufacturing processes. Presently, however, firms are considerably better disposed for exploiting IT because of the declining cost of systems and components and because of their increasing sensitivity to change and the education and training it requires. Administrative IT is now an everyday routine in an average company. Nevertheless, in decision-making there may well linger some discrepancy between product and process priorities: on the one hand, improved manufacturing methods and facilities modify products and at times contribute to fundamentally novel products; on the other hand, product strategies and the decisions thereon govern and guide the development of manufacturing processes.

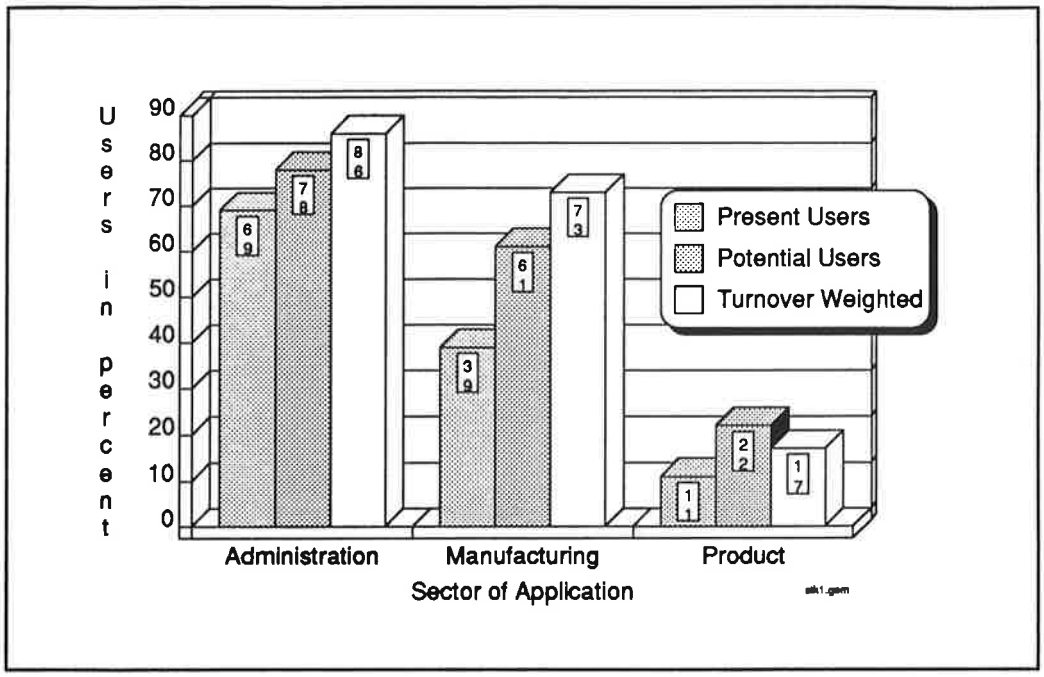

Figure 1. Actual and Potential Use of Information Technology (539 subjects).

Figure 1 demonstrates the adoption of IT in the three main sectors of application (Jaakkola 1991, p. 142); the figures are based on a survey conducted in the spring of 1989 (Jaakkola 1990)[3]. The columns represent the user companies which participated in the survey in proportion to the total user body, the companies' own estimation of their future IT adoption, and the user percentage weighted by turnover.

Administrative IT applications are approaching a *saturation* point. *Quantitatively*, i.e. in the number of users, this sector is not expected to see a major growth: the number of establishments suggests a 9 percent growth potential (at the time of the survey, the percentage of penetration was 88 while the potential measured as 78 percent of the total company pool)[4]. The turnover weighted figures indicate that the users make up 86 percent and the non-users (constituting 31 percent of all establishments) only 14 percent of the total turnover. In turnover figures, the non-user body is comprised of relatively small units, whose organizational structures are not yet at the level fully to benefit from IT. As a whole, administrative IT has shifted from quantitative to qualitative growth; consequently, the changes in the sector have to be examined in the light of qualitative impact and "depth" of use.

Manufacturing applications follow the above pattern: the volume- based (weighted) user percentage is high (73), the unweighted remains at 39 percent because of the low user percentage among small companies. Over 60 percent of the companies not exploiting IT in manufacturing contribute by less than 30 percent to the total industrial turnover.

The percentage of *product applications* is still trifling (11) although the turnover weighted

3. The central numerical data of the survey, some of which is quoted above, are presented in Appendix 1.
4. The analysis of the results indicated differences in interpretation among the respondents. If we include all those administrative adopters that reported subscribing to the services of various data processing centers but did not consider this as application of IT, the user share of the surveyed will increase by 70 companies, i.e., to 82 percent.

part of it exceeds the absolute percentage (17). When all companies with less than 20 employees are discounted (in compliance with OECD methods recommendations), product applications reach 14 percent (companies with less than 10 employees discounted, up to 16 percent).

Despite the fact that the applicability largely depends on country-specific industrial structures, some rough comparisons can be drawn between results from different countries. OECD has recommended procedures for conducting comparable IT diffusion studies (OECD 1989; OECD 1990) and compliant research has been carried out in

- Great Britain (latest survey in fall 1987; Northcott 1988)
- Sweden (survey in fall 1986; SIND 1987)
- Denmark (survey in fall 1987; IHS 1988)

The research and results on Finland (interview in spring 1989, Jaakkola 1990; follow-up study on microelectronic product applications in spring 1990, Latvala 1990) make for a commensurate analysis with the above studies. The results of the comparison are presented in Table 2.

Table 2: The Use of IT in Industry.
Comparison of Surveys in Four Countries.

percentage of companies	Finland	Sweden	Denmark	Great Britain
manufacturing processes	58	57	51	59
products	14	13	13	13

The above comparison shows that the level of IT applications in Finland is on a par with other industrial countries, though the internal applications profile varies from one country to another. For example, the automotive and aviation industries are less significant in Finland in comparison with western industrial nations where such industries are the forerunners of IT manufacturing applications. The process industry could perhaps claim a pioneer's title in Finland, yet the credit for breakthroughs in modern manufacturing applications goes primarily to companies in the mechanical and electro-technical domain. Internationally comparable material on administrative IT is unfortunately unavailable, but it is fairly obvious that in industrial countries, as in Finland, administrative IT has reached a near hundred percent penetration level.

Companies' *assessed possibilities of their future IT use* tend to be rather subjective and dependent on individuals' abilities to predict future trends and to realize intrinsic company needs and IT's capabilities to meet them. These future visions are often linked with phases in company planning and development. In assessing the unfolding of the diffusion process, it is then quite natural that the predicted growth in fast-growth-phase technologies is greater than that among either embryonic or aging technologies.

Percentage-wise, the *difference between the estimated IT user potential in products and in manufacturing* is nearly three-fold (22%-61%). IT has worked its way into manufacturing technology over a lengthy period of time and by now consolidated itself there. In products, however, IT applications presuppose an overall change in company functions: what is required

in addition to traditional product knowhow are vocational preparedness and updated production facilities. These will in turn raise the *adoption threshold* at least for a small-sized company and make the entrepreneur doubt the profitability of this technology option. The Finnish entrepreneurial tradition has also been rather slow to encourage *cooperation* and *subcontracting* as viable threshold lowering *alternatives to self-contained operation.* Of late though there have been more signs of such cooperation and increased subcontracting. [5]

3. Information Technology in Administrative Applications

Some General Observations

The administrative IT user body in industry is large (69 percent of all establishments, 86 percent if weighted by turnover). Practically this means that automated information processing has graduated to conventional technology and that this particular IT application sector (in terms of use/non-use) as such harbors no further potential for change. Yet administrative IT is worth looking into for two reasons:

- administrative applications now cover almost the entire business domain, and the considerable user body therein with its various needs (maintenance, replacements, updating of system etc.) constitute for IT vendors a potential market which is significantly larger than in any of the other sectors. Furthermore, despite the seeming saturation of the market (in numbers of establishments), internal IT use in companies is still showing a vigorous increase as evidenced by the rapid growth in the number of employees using IT at work (Lehto 1989, p. 9).
- though administrative IT is no more a dynamic guiding force in company development, its innovative use can still secure a strategic competitive edge.

In industry, administrative IT is still an appreciable *change-generating force*, especially in terms of the ways and scope of its use. Consider also the present trends in company data systems *integration*: the administrative system often makes up the hub of an overall integrated system and correspondingly dictates the decision parameters, i.e. it *dominates* the decisions made with the other constituents of the system.

The first organizations to use computers in their administration were, of course, big corporations and public administration bodies. With a downturn in prices, computer adoptions increased first among large companies and gradually among smaller and smaller businesses. There is no actual research available on the factors that influenced computer adoptions in the 1960's and 70's; however, an analysis relying on contemporaneous hardware and software technology developments can provide a hypothetical model to trace the progress. The model displays a diffusion process divided into three stages:

- the big user stage (from the 1950's to the late 60's)
- the general appeal stage (from the late 60's to the end of the 70's)
- the common use stage (the 1980's and since)

5. The matter has been extensively treated in the IIASA-authorized TES project (Technology Economy Society) reports on Finland, which deal with the main themes of *flexible production automation and flexible network economy.* An excellent summary appears in the final project report (Ollus 1990).

Computers were first (at the *big user stage*) installed and used by public administration organizations, then gradually adopted by the largest corporations, which

- could afford costly computer systems
- had enough use for them to offset and benefit from the investment
- could supply the expertise to operate them.

Two important factors contributed to the *general appeal stage*:

- decreasing prices of systems
- development of software technology

The advent of the so-called minicomputer class in the early 1970's brought the systems within the reach of mid-size companies. Lower prices were accompanied by two other significant developments: the *emergence of importer-independent software industry* and the partial replacement of *custom-built software by machine-independent modifiable software*. Consequently, computer systems became less demanding to operate and maintain, which in general undermined the dominance of hardware over software. During the general appeal stage IT spread largely among mid-size companies.

The *common use stage* has been characterized by *increased ease of use*. There is now such a wide array of systems with different capacities available as to meet the required IT needs across the lines of business. The essentials are now readiness (company capability) to make use of IT and the attitudes thereto. The *microcomputer* is a typical representative of the common use stage. It has brought computing to new territories of use and application and lowered the adoption threshold for individual as well as corporate users. A key threshold lowering factor has been the use of microcomputers in homes, where the diffusion of the second generation systems is now under way. In contrast to the first generation home computers, the current machines are also those used at work though perhaps with somewhat less features than in their office counterparts.

There has been a parallel route of IT adoption to that discussed above. Ever since the 1960's, *computer centers* specializing in data processing services have performed an important function in the IT diffusion, for they have enabled IT adoptions in companies whose processing needs have not necessitated acquisition of an in-house system. The contribution of the optional route has been twofold:

- on the one hand, it has facilitated IT adoption for off-the-mainstream organizations, i.e., removed one obstacle to adoption
- on the other hand, it has provided a "test run" as a step toward a system acquisition and thus lowered the threshold for the adoption of an in-house system.

If, on the one hand, companies have been moving toward in-house data processing and away from contract services, there has also been a movement in the opposite direction. As companies *distribute their support operations*, data processing related tasks tend to get entrusted either to departments or divisions set up for the purpose or to outside firms. Such moves reflect a change in the organizational structure of the entire business sector, whereby large self-sustained units are being turned into small cost-effective units within an overriding cooperation network.

The Impact of Company Makeup on IT Use

Administrative IT has permeated all company size categories in Finnish industry, except for the smallest (cf. figures in Appendix 1, Table 3). An intriguing phenomenon is size category 10-19 employees, whose user body exceeds that of the next size category (20-49 employees).

Companies in this category--*small, most likely new and with flexible organization*--have been capable of adopting small-scale IT at relatively low cost. In the next size category, the information processing needs cannot necessarily be met with PCs anymore, consequently raising the adoption threshold.

With the smallest category (less than 10 employees) excluded, the user percentage in the rest of the material is as high as 83. Especially the versatility of microcomputers, their accessories and applications and their reasonable prices have helped lower the IT adoption threshold; consequently, exploiting the technology for administrative tasks has become a worthwhile consideration even for rather small-scale businesses. In the two lowest size categories, the user percentage does not exceed 90 because of the data interpretation in the study.[6] Yet the fact remains that the administrative needs of these companies simply cannot be satisfied without automated information processing.

The differences between *lines of business* are minor and can be explained by secondary factors. The chemical industry boasts the highest user percentage (90 percent of all establishments); the least, ascertainable percentage appears in the textile and clothing industry (55 percent of all establishments). The observable differences are reflective of business-specific company size structures and entrepreneurial traditions, which largely explain the variations in corporate IT use in different parts of Finland (Appendix 1, Table 4).

Regionally, the Helsinki area emerges as a clear forerunner in IT diffusion (Appendix 1, Table 5). The higher than average user share in eastern Finland can be explained by the structure of the regional industry (extensive wood processing industry and other modern industries it brought along), but of no less significance is the modern equipment of the new industry which through various incentives was ushered into the region. The impact of these factors is best revealed by examining IT in manufacturing. On the other hand, middle-Finland's (particularly the Ostrobothnia area) mainly handicraft-intensive industry and the above-average share of family businesses in the region lower the user percentage clearly below that in other parts of the country and below the average. There is really no denying the capital area its leadership position, for owing to the region's abundant supply of equipment and expert consulting and assistance, it is the most fertile ground for adopting new technology. The work force in the area is better prepared than anywhere else in the country to make use of new technology, and its shortage, in fact, drives companies to further efficiency through IT applications.

The Organization of IT Activities

Most data processing is executed with companies' *own computers*, with the exception of accounting,[7] for which about a third of the companies consult professional accounting agencies. For various reasons, accounting qualifies as a basic administrative data processing application. Its procedures and principles are determined by law and as an activity it is often integrated with corporate internal accounting, economic planning and supervision. Applied on the company scale, accounting can in general be managed with the data processing system the company can afford. Thus the very way of doing the accounting, whether in-house, via service agencies or without data processing, will involve the company's *strategic, not techni-*

6. The analysis of the survey material classified as IT users those establishments which identified themselves as such. The rest of the surveyed (including those which did not respond) remained "non- users."
7. In accounting, the user share amounts to as high as 75 percent, thus exceeding the overall percentage (69) of administrative IT user companies. This results from the fact that all respondents did not count the above application as use of IT.

cal, decision-making. Besides accounting, other significant ADP applications include payroll and billing, that is, routine monetary transactions as well as computerized tenders and orders. In the administrative sector, IT diffusion has reached the stage where all routine transactions are now computerized.

The fastest growing IT applications occur now within *communications services*. Flexible inter- as well as intraorganizational computer- assisted communications have become the order of the day. Rapid advances in the communications technology and vigorously marketed communication services and applications are furthering the growth (and transition into a rapid growth phase) and expansion of the sector (customer contacts have become EDI-based and most monetary transactions electronic). Also the structural reorganization of banking services enhances the importance of the communications sector for everyday company operations. The change can thus be explained by a directionality which is either *internally necessitated* or *externally imposed* (the nature of banking services).

The impending change in administrative IT involves structural changes in use. Despite its quantitative stagnation, this sector is undergoing a *qualitative change*. The increase in administrative IT applications is coupled with another structural change, viz. the *transition from consulting services to in-house systems*. This development may be due to the above-mentioned trend among companies either to externalize their support functions into separate units or to contract services. Small and new companies often find it advisable to rely on outside services rather than ramify their own organization. These decisions are partly unavoidable because of costs but also because of a need to engage quality expertise for company financial management and supervision. This will enhance the importance of centralized services and conversely diminish and neutralize company self-sufficiency. The present trend is at least partly affected by the fact that decisions made on communications tend to support distribution of activities outside the company.

Microcomputers are rapidly achieving a key role in companies. IDC (International Data Corporation) estimated the number of PC's (business personal computers) in Finland in 1990 to be slightly above 577 000.[8] Microcomputers are becoming increasingly important as components of company computer systems and are replacing, among other things, conventional terminals.[9] The foreseeable trend seems to confirm the present situation: companies will be more and more attracted to PC's as part of their integrated data processing systems. Many companies are also seriously considering local networking as well as work stations, a prominent feature in future manufacturing systems. The downturn of their prices close to the business microcomputer levels will make them appreciable rivals to PC systems. On the other hand, with their rapidly increasing performace, PC's will challenge any rival in demanding tasks and consequently blur the line between PC and workstation. With regard to future change, the above strongly suggests that the dominant *key technologies* will be PC's, workstations, and local networks.

Company data processing is rapidly being decentralized in part to individual work posts (PC's, workstation units), which through networking access an integrated overall system. The overall system may include central or departmental computers for demanding tasks or as workstation servers. *Actual hierarchical distribution* of data processing has not yet been embarked upon,

8. The true figure falls somewhere below this estimate. The following figures serve as reference: in March 1990 the employed numbered 2 249 000, salaried employees apr. 52 percent of these (Tilastokeskus 1991, p. 18); in 1988 the number of establishments in Finland was 147 633 (Tilastokeskus 1990).
9. According to IDC, the operational terminal base in 1990 comes to 227 000 units. The numbers are slightly on the decrease but have for several years now stabilized approximately at this level.

for companies with departmental computers are relatively few and their numbers are not expected to grow substantially. On the other hand, it is important to observe that hierarchical computer systems work to an advantage only in sizable companies, which constitute a minority in Finland's mostly small-company base.

Company data processing has conventionally been *centered* in separate data processing departments with responsibilities to rationalize mainly administrative data management. Data processing has often been viewed as a part of finacial management, which in the current IT climate is not necessarily a practical way to organize data processing. Such a solution will externalize manufacturing systems and their development outside centralized ADP only to handicap any attempts at integration. Thanks to innovative IT use and distributed, workstation- and department-assigned applications, centralized data processing departments are losing stature while decision-making and responsibility for acquisitions, new applications and their implementation are being distributed in companies.

Changes in companies' internal structures have also helped externalize their support functions: among other things, centralized data processing is, particularly in larger companies, separated into independent outside companies with the result of subsequent purchase of computer time and development consulting services from the previously integral, now incorporated data processing department.[10] Consequently, under free competition the mother company is now free to purchase the required data processing services on the market and the incorporated new company free to attract clients beyond its previous attachment (present majority share-holder). In many cases, such ADP service companies form links to maximize their services through specialization and cooperation.

That the companies surveyed were serious about IT can be read from the fact that one third reported having outlined a *particular strategy for an IT sub-field.* To a large degree, however, the companies' IT strategies seem rather *short-term and bent on isolated problem solving.*[11] Although communications are the most rapidly changing section of company IT systems, only 9 percent of the surveyed have incorporated it in their strategic planning. In fact, such communications-inclusive planning is characteristic of companies in the largest company size categories only. More than two thirds of those with a 10 million mark plus turnover set up at least one IT-related strategy.

It does not make sense to examine the diffusion of administrative IT as one unified whole, for during the past three decades this sector has undergone several developmental phases with varying user potential (as affected by its service function) and applications. A long-term review (macrolevel development) has to concentrate on the intrinsic characteristics of each individual phase. Otherwise the rapid changes and potent growth of recent years will appear to dominate the development and to overshadow the previous, in fact, foundational and preparatory uses.

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10. Good examples of this include Rauma-Repola (Modulsystems), Rosenlew (Länsitieto), and Enso (Carelcomp).
11. A study on microcomputer adoption in companies (Ilan 1986) reveals that acquisitions occur as an uncontrollably expanding process, the reason for which is the limited scale of the required investment that enables decisions on acquisitions to be made at a low organizational level. IT applications make a markedly more controlled entry into company production operations, for they call for great investments and contribute to comprehensive reorganization and reshaping of operations. In its simplest form, administrative IT adoptions necessitate no operational changes and can thus be compared to acquisition of office equipment.

4. Information technology in Manufacturing

General Observations

With a few exceptions, the diffusion of IT in manufacturing has been lagging behind administrative applications. [12] The peak of the diffusion occurred in the 1980's when the feasibility and prices of computer systems to facilitate the initial phases of manufacturing processes (product and process design) came within the reach of small companies. A similar price drop in computer controlled manufacturing facilities initiated a corresponding development in manufacturing systems proper.

Administrative IT applications have been rather homogenous across the lines of business, except among the smallest companies. Manufacturing IT, however, displays marked differences between the lines, size, and location of business.

The Impact of Company makeup on IT Use in Manufacturing

The percentage of IT adopters in manufacturing is growing with the increase in company size, and the differences between the size categories are significant (Appendix 1, Figure 3). The company size of over 20 employees represents already the national user average. When the size categories of less than 20 employees are discounted (as is the international practice), the user percentage amounts to 58, thus correlating with the figures in surveys conducted in other western industrialized countries (Great Britain 59 percent, Sweden 57 percent, Denmark 5 percent).

The possibilities and prerequisites for small companies to exploit IT in their manufacturing are quickly being facilitated by

- dropping costs of production facilities
- increased training and user readiness for adoption
- experience gathered from other user sources.

The diffusion has also been expedited by the fact that newly founded companies, usually of the small company category, often from the very first avail themselves of automated manufacturing. Moreover, in the small-company framework there have been only minor problems with such automation and its marginal costs have appeared more affordable compared to other solutions.

The development of IT applications in manufacturing can be examined from two perspectives:

- automation helps companies increase their activity, i.e., their decisions on automation translate strategically into a resolve on *growth.*

12. An OECD study (OECD 1988) analyzed changes in manufacturing automation and came up with the pattern of two consecutive automation waves. Some industries, owing to their particular manufacturing processes, were caught in the *first wave* (in the 1960's), whose type of automation was such that it necessitated no major corporate strategy alterations. The automation did not promote growth beyond that of competing industries, nor did it accelerate the expected rate of growth. Not until the *second automation wave*, with its characteristic flexibility and scope for decentralized operations, have corporate strategies been indirectly affected. At the same time, it has provided companies with a strategic competitive edge and led to an accelerated growth within a company or a particular line of business. The paper and pulp and the chemical industries are typical examples among the first wave adopters. They are presently catching a ride in the second automation wave by reorganizing their processes and operations along with other industries, which almost without exception are exploiting IT in manufacturing straight in the second wave.

- in a growing business, profitability presupposes updating of manufacturing facilities, not for reducing the work force but for its *better administration* through increased productivity gained by automation.

Manufacturing businesses boost their turnover no doubt by developing their manufacturing technology, and ever more sophisticated automation is required to maintain competetive production levels. As a company adopts modern facilities, it is forced to reorganize its operations and marketing strategies. A technology which enhances the flexibility of production lays the groundwork for innovative competitive strategies and thereby rearranges the company's networking with customers, subcontractors, and partners.

The applicability of IT to manufacturing varies among the lines of business as evidenced by the individual business user percentages (Appendix 1, Table 4). The following are some of the factors explaining the differences:

- company structure within a particular branch (predominantly small businesses)
- branch-specific entrepreneurial tradition--small industry and handicraft vs. fully industrial
- distinct adoption thresholds: industries vary in their capabilities to exploit IT in their manufacturing processes
- magnitude of and company readiness for the reorganizations required by the adoption
- varying financial resources and automation's direct bearing upon production and profits
- degree of "modernity" in the industry--traditional industries have to relinquish the old to adopt a new technology; new industries are born out of new technologies

Among the IT adopters for manufacturing, the food processing, the textile and clothing, and the mechanical wood industries appear as distinctly *passive adopters*; as *active adopters* we can identify two process industries, the paper and pulp and the chemical industries, plus the publishing and printing, and the electrical and instrument industries. The mechanical engineering industry is placed somewhat below the above: the user intensity among its subdivisions is rather unevenly distributed though the turnover weight raises its user percentage, an indication that the IT use in the field is concentrated within larger units.

The paper and pulp industry with its high user percentage has been spearheading the IT adoption and with ripple effects thereof has been promoting the diffusion of the new technology among various other lines of endeavor. However, the current *prime mover* of the diffusion is unarguably the engineering industry because of its size. In terms of supply of production facilities, it is ideally qualified for its role as a diffusion catalyst. As such it is also one of the major branches (about one third of total industrial value added) of Finnish industry.

There are marked differences between the various parts of the country in terms of industrial structure. Likewise the infrastructures of companies operating in sparsely populated areas differ from those of comparable (in size and line of business) companies in populated and suburban areas. Over the years, the government has sought with various measures and development policies to offset the differences and to encourage business activity and company preparedness. The measures have focused mainly on remote out-of-the-way areas. Some individual municipalities and rural communities with established industrial structures have also been included in the aid packages as separate cases.

The percentage of the companies exploiting IT in manufacturing rates high in eastern Finland and Lapland regardless of how it is calculated (absolute vs. turnover-weighted) (Appendix 1, Figure 5). Eastern Finlands's 52 percent is, in fact, higher than in the capital area which has traditionally been the forerunner in new technology use. Lapland's 44 percent again exceeds

the user share of the industrialized south. In turnover-weighted figures, the picture remains largely the same: Lapland outstrips eastern Finland.

Possible explanations for the regional differences in manufacturing applications include the following:

- technology intensive lines of business may be overrepresented in the region's industrial structure
- government development policies have attracted a lot of new industry into the region; moreover, with government supportive funding the existing industry has been able to modernize its production facilities.
- the regional industry (e.g. paper and pulp) has through a ripple effect managed to create a technology-benign atmosphere and through personnel turnover broken ground for IT adoptions in new companies and lines of business
- the business and entrepreneurial tradition is not conducive to growth intensive business activity (a good example here is the carpentry industry in the Ostrobothnia region).

It seems that regional policies have managed to renew the industry in eastern and northern Finland. The regional labor reserves, attractive funding arrangements as well as government supported retraining and further education programs are examples of the measures to *create and restructure business activity* also in out-of- the-way regions.[13]

Small labor reserves set limits to companies' growth potential, which in sparsely populated regions has led to the observed expansion of companies within the regional growth centers. Such centers provide better chances than any remote areas to compete over the available labor and above all to employ highly skilled workers.

The Diffusion as a Function of Time

Figure 2 presents the cumulative IT user figures in manufacturing as compiled on the basis of the initial adoption year. The rapid growth phase,[14] lasting a good ten years, began in the early 1980's and soon progressed to a saturation point.

13. The companies in eastern Finland and Lapland have been using public funding approximately one and a half times the national average. On the other hand, they show very few contacts with various organizations providing services supportive of business activities. The renewal process has involved investments essentially in equipment and machinery. The applicants for public funds have mainly been small and new businesses (Jaakkola 1990, p. 76).
14. For the general principles of the diffusion process, see (Jaakkola 1991, s. 40; Jaakkola 1991c).

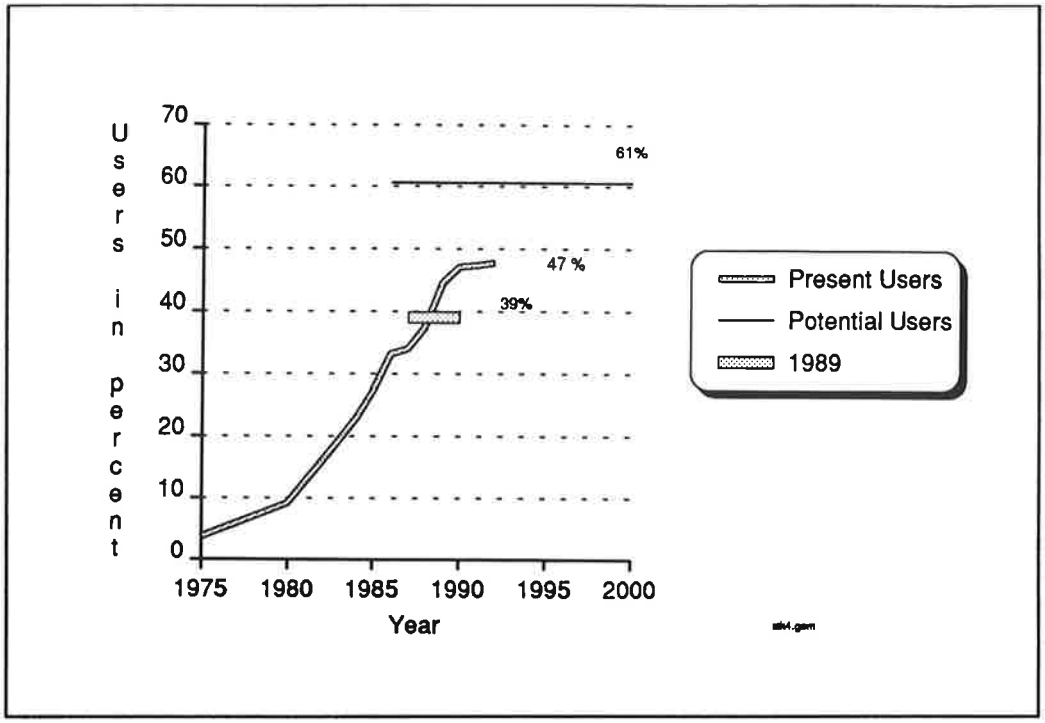

Figure 2. The Diffusion of Information Technology in Manufacturing as a Function of Time (210 user respondents).

The section in the graph from 1989 (the year of the survey) on to 1992 illustrates the trend predicted on the basis of the respondents' estimates and actual investment decisions. The prediction does not reach very far into the future, hence the sharp angle in the graph before the potential user level. The level is based on the respondents' projections of their possibilities to utilize IT in their manufacturing systems.

Figure 3 illustrates the diffusion in each industry. In all of them, IT adoptions in manufacturing occurred primarily within the first half of the 1980's with the exception of the paper industry where the automation standard is exceptionally high.[15] In this sector, initial adoptions accumulated in the 1970's and early 80's. Interpreting the figures, one should consider the average age of companies in the various industries. In an industry consisting of typically new businesses (e.g., the electronics industry), the rather late date of initial adoption is to be explained by the company age structure.

15. No generalizations should be inferred from this juxtaposition. There is no evidence to back up the assumption that early user industries would automatically harbor a larger than average user share.

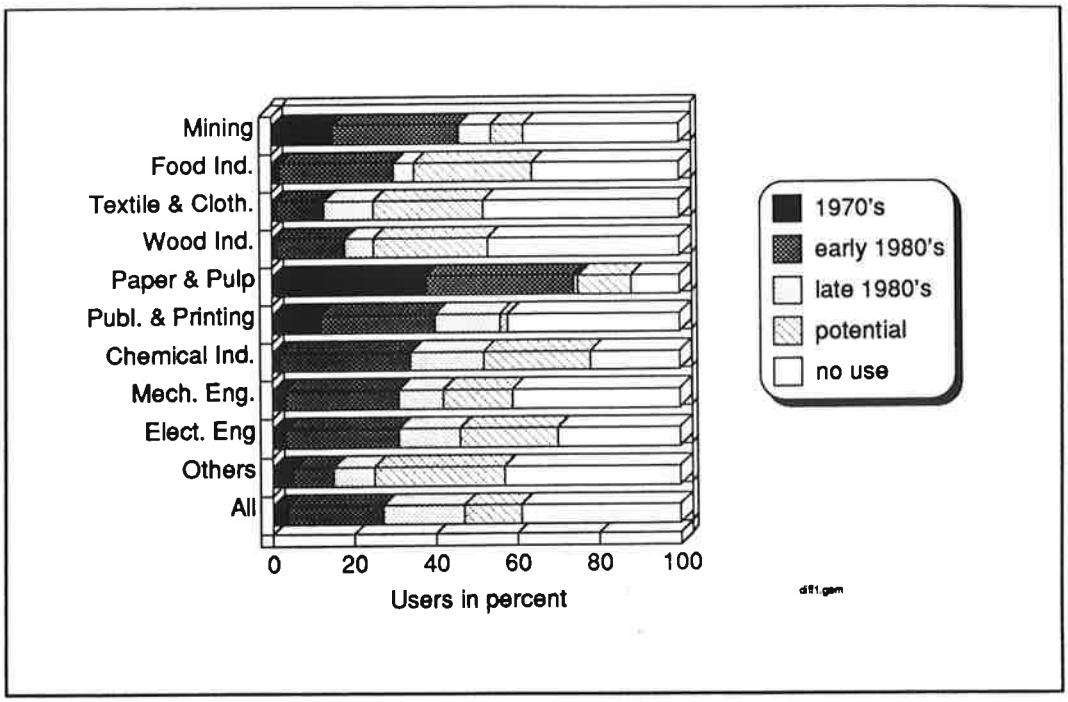

Figure 3. The Distribution of Initial Adoption of Information Technology in Manufacturing in the Various Industries (210/539 subjects).

Sources of Supply for Manufacturing Facilities

In a recent study (Jaakkola 1990), the majority of the IT adopters in manufacturing (62 percent) reported using an outside supplier's standard facilities. Currently most standard facilities feature such flexibility as to meet customers' specifications at the base level. In some cases, IT adoptions in companies have led to self-tailored manufacturing systems, even to an *expansion* of the particular branch in which a company while developing its own production has ended up diversifying its line to become a supplier of the facilities. Sometimes the original main product was superceded altogether or the branching off to a new territory occasioned other radical forms of business reorganization.

In terms of supply of facilities, manufacturing automation can be divided into three phases:

- standard facilities by an outside supplier
- customized facilities by an outside supplier
- in-house designed and manufactured facilities

The majority of the users in manufacturing belong to the first phase, for standard equipment can satisfy most automation needs especially with respect to the least sophisticated production facilities (NC machines and the like). With increasing needs, some of the standard equipment users proceed to the next stage, others, because of their specialized needs, may begin their automation at that level. The essential distinction between the two levels does not primarily involve properties of equipment as such but the capabilities of the company using the equipment to *realize and specify its needs.* [16]

16. In his book on the sources of innovations, v. Hippel (1988) reports that users making incremental changes to other suppliers' products and equipment constitute the most significant source of innovations for new products.

Capability for *in-house facilities manufacturing* represents yet another higher level of the automation culture. Transition to this level may begin with some *minor modifications* of existing equipment, gradually growing to involve the manufacture of whole production systems (in most cases through assembly of modules). Many companies applying automation harbor intrinsic capabilities for this transition (a good example is the machine engineering industry). The distribution of the cultural levels among those exploiting manufacturing automation and particularly the changes over time therein provide a solid basis for assessing the maturity of the adopters at various points in time.

The Effects and Prospects of Manufacturing Automation

Manufacturing automation is being adopted at an increasing rate with a corresponding expansion of the relevant CIM components market. The market share of the traditional CIM components (NC machines) manufactured in Finland is relatively small, whereas that of the latest equipment technology (robots and FMS's) is significant. *Suppliers of automation technology* constitute a notable part of the adopters of IT in products, a fact which through its dynamic infrastructural and ripple effects is a potent catalyst in industrial automation. Innovative adopters have become increasingly valuable on the equipment market because of their abilities to adapt various CIM components to user needs. In view of industrial automation development, such "manufacturers" will in the near future gain importance over suppliers of standard mass-produced goods.

Software suppliers, too, capable of implementing their knowhow on various CIM components will be increasingly sought-after. Well-rounded software engineering knowhow is especially called for when companies seek to upgrade the integration of their information systems by fusing administrative and manufacturing systems.

The increased strategic flexibility of *larger companies threatens small units, traditionally considered flexible*, when the larger units succeed in making use of the latter's most strategic competitive advantage. In effect, such development will bear upon the overall *industrial manufacturing structure* by emphasizing the role of subcontractors and by causing more and more smaller units to become subcontractors to bigger suppliers. The new type of cooperation may, however, turn out to be a considerable resource for small businesses, for it may facilitate their participation in automation development, which especially in small production units will entail radical growth of capacity. In such cases, a business may via subcontract end up marketing part of its capacity or securing other outside use for its production facilities.

Company assessments of the varying importance of IT in manufacturing are rather tentative (Jaakkola 1991, p. 174), which is reflective of the short-term strategic planning characteristic of particularly small businesses. Only very few companies can anticipate with any clarity the trend beyond the next couple of years. However, in the business world and society at large Finnish attitudes about IT's future possibilities are positively expectant (EVA 1985; EVA 1987).

5. Information Technology in Products

General Observations

Advances in microelectronics, on the one hand, and the improvement of the tools (hardware

and software) conducive to the implementation of the technology, on the other, are promoting IT in products to become one of the *momentous applicative changes* for the next few years. Compared to the clearly delineated change observable in manufacturing applications, application procedures regarding products have not yet been established. The development in the sector has been partly affected by education which has *increased readiness* for applications and contributed to the current everyday use of a technology, which as late as the early 1980's was almost unknown. Furthermore, the infrastructure within the electronics industry has been able to support the expansion of product applications in *applicative lines of business*, with the main concentrations in the metal and electrical engineering industries. Outside the industrial sector, technical and ADP consulting services have greatly furthered IT applications in products.

There are basically three channels for IT product applications:

- use of ready-made electronic subsystems in a product
- co-design of subsystems with a partner
- one's own long-term subsystems development

The first channel is not always classified under "IT in products" or "embedded system." The present study lays the emphasis on company *ability to exploit* and benefit from microelectronics and IT in products, regardless of the level of implementation.

The Effect of Company Makeup on Product Applications

The percentage of the companies applying IT in products is modest (below 20 percent) in all company size categories, with the majority of the users being concentrated in the two largest categories (Appendix 1, Table 3). Though products containing microelectronics have long been manufactured, the production has centered in moderately large and large enterprises. Only in companies with more than 50 employees does the user percentage reach the relative percentage of the company size category. The rapid progress in circuit technology, improved design and production facilities for products containing electronics, and falling prices coupled with the feasibility of applicable application-specific integrated circuits (ASICs) bolstered by the industrial infrastructure--all these help prepare even small companies for IT product applications. Microelectronic applications continue to focus on standardized components, but there is already increasing readiness for exploiting more advanced microelectronic technologies.

An interesting exception to the above "general trend" is size category 10-19 employees, where microelectronic applications in products are more common than in the next size category, providing evidence for the *double-peaked diffusion of IT in products* in the industrial sectors: on the one hand, relatively small companies; on the other, mid-size and large companies. This double-peaked phenomenon is most likely evidence of a *renewed entrepreneurial culture*, where highly specialized companies capable of exploiting microelectronics are coming to the fore and filling the wide *knowhow gap* created in industry by an inability to apply new technology. This knowhow gap is considered to be the reason for clinging to conventional technology even when new technology solutions are clearly proven superior and conducive to strategic competitive advantage.

A study conducted in the Netherlands[17] reveals that company product applications involve primarily standard circuits, a practice which enables companies to *boost their turnover faster*

17. By G. Arendsen (IMT + Industrial Marketing Technology, AC, Raermond, the Netherlands). Based on a discussion on a company survey conducted in the Netherlands in the spring of 1990. A public report is not available.

than by increasing personnel to accommodate production. Small companies, on the other hand, unlike their larger competitors, are more prone to *tailored solutions* and exploitation of the most recent microelectronics applications and methods. The investment in design per product sold will thus be higher than that incurred in mass production. Flexibility turns out to be the key for small companies to outcompete their larger rivals in this sector.

The *electrical and instrument and the mechanical engineering industries* are the fields actively spearheading IT applications in products (Appedix 1, Table 4) whereas the nature of the other industries does not favor similar microelectronic applications. The fact that product applications appear at all in the latter industries can be attributed to the somewhat misleading statistical categorizing and an operational *expansion of the industries*. To be able to compete within their own field, the companies have, by way of overhauling and upgrading their production methods and facilities, created new, basic-operations-related implementations, which in respect of their main line have not, however, become dominant. Many of Finland's largest electronics companies were born supplementary to their existing parent industry and only later branched off as independent enterprises. Representative examples of this development are Outokumpu Oy in mining and Kajaani Oy and the Ahlström mills at Varkaus in paper and pulp. In fact, Finland's electronics industry has essentially evolved out of such expansion of operations (Lovio 1989, p. 75).

The companies applying IT to products are clearly concentrated within the two major industries mentioned above, which account for three quarters of the total user body. When the user percentages are examined in this population (to be considered potential for actual product applications), the adopter percentage amounts to 25. In the industry distribution, the adopter percentage in mechanical engineering reads 28 and in the electrical and electronics industry 6. Hence mechanical engineering ranks highest in volume adoption (the industry boasts the largest share, 50 percent, of all the adopters surveyed).

As in manufacturing, eastern Finland outstrips the south also in product applications and is second only to the capital region (Appendix 1, Table 5). The share of product applications among all the surveyed is, however, so low as to eliminate any regional distinction. Turnover-weighted, the middle Finland share soars high--an indication that the regional IT product applications are being carried off by large-volume enterprises. The *concentration of the electronics industry around the city of Oulu accounts* for the above while elsewhere in this geographical section product applications remain passive. No significant product applications appear in Lappland, a phenomenon testifying not only to the *weakness of the industrial structure* but also to a scarcity of skilled adopters. Lapland remains the part of Finland which is not within the sphere of influence of any university level technical institution.

In the regional review, *manufacturing and product applications do not seem to be linked*[18] as evidenced, for example, by Lapland and eastern Finland, which both boast high standards of manufacturing applications. Conversely, no significant product applications groups have emerged in Lapland. Possible explanations include

- dissimilar industrial structures between the regions
- differences in entrepreneurial culture

Southern Finland accounts for three quarters of all product applications. One reason for the concentration are subcontractors that have set up operations within the sphere of large electronics companies and further nurtured IT use in other lines of business. Regional industrial struc-

18. It is to be assumed though that the product application threshold for those applying IT to manufacturing is lower than the average in the whole of industry.

tures sustain the diffusion of a new technology in different ways with regional skills pools, available subcontractor services, and entrepreneurial climate often significantly contributing thereto.

The Diffusion as a Function of Time

The percentage of the companies applying IT to their products is still small (11 percent). The figure climbs to 13 percent when we include those that have already decided on IT use, and reaches 14 percent with the addition of those at the planning stage. On a time scale (Figure 4), the growth is largely similar to that in manufacturing applications (cf. Figure 2).

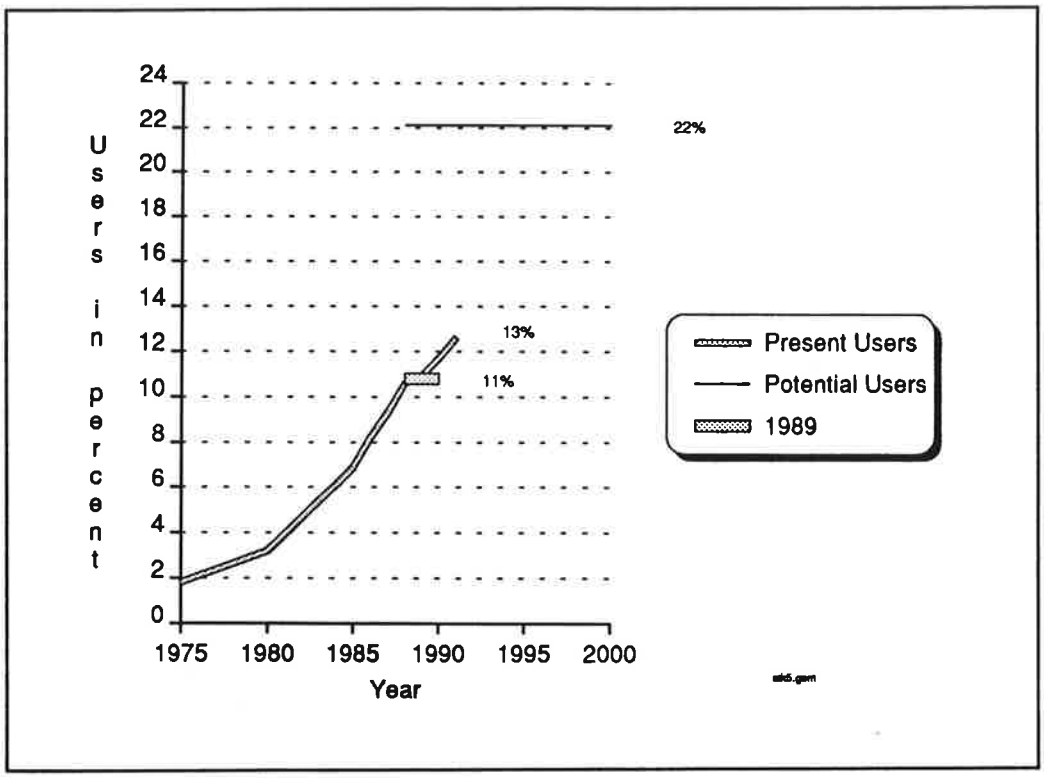

Figure 4. The Diffusion of Information Technology in Products as a Function of Time (Sample size 58/539).

According to this prognosis, the growth will taper off soon, which seems hardly realistic. The companies' own estimations of their capabilities for product applications and their decisions already made do not extend beyond the most immediate future, so the graph can be expected to show only the product designs decided upon thus far. The potential upper limit of the graph (22 percent) represents the companies' envisaged possibilities in general to develop products containing microelectronics. Currently every tenth company carries a line of such products, a figure which is most likely to double in future, i.e., every fifth company will make use of microelectronics in their products. The trend will naturally be most conspicuous among the presently active user industries, slowly manifesting itself among smaller companies.

With respect to the onset of the diffusion, only the electrical and instrument and the metal engineering industries differ from the rest. In the electrical and electronics industries, over 50 percent of the present users began applying IT to products in the 1970's and the majority of the rest in the early 1980's. In the metal engineering industry, on the other hand, the initial

adoptions occurred in the early 1980's (more than half the present users), one third joined in toward the end of the decade and the rest (1/6) had already done so in the 1970's. As the *pioneers* of product applications, the above two industries constitute the *first adoption wave.*[19]. The *second wave* is made up of companies which became users through an expansion in the industry with the onset of adoptions falling mostly in the second half of the 1980's.

Large scale IT application to products is still a rather novel phenomenon and signifies a simultaneous evolution in both basic technology and its applications. Therefore, purely quantitative considerations easily overlook the qualitative changes, which have been made an inextricable part of the overall change by rapid advances in microelectronics. Analysis of the qualitative aspects would, however, require an in-depth company-specific study.

Future Trends

Estimations of possible future IT use in industry are tentatively positive. In the majority of the companies applying IT to products, the 1989 turnover share of such products ranged below 10 percent. In companies applying microelectronics to products, the share of such products fluctuates greatly within the total output. A general trend, indicative of the *all-embracing adoption of new technology*, seems to be either a great or a very tiny selection of products containing microelectronics in the companies' total range of manufacture. Acquired readiness and appropriate manufacturing facilities enable a large-scale adoption of new technology, quickly replacing other alternatives by the modification of either products or product lines. The share in company turnover of the products containing microelectronics is slowly on the increase.

Large companies have already undergone considerable changes while smaller ones are now entering such a phase--a possible sign of the technology diffusion's descending trend down the company size categories. This development is slightly contradictory in terms of the changes generated by microelectronics, for smaller companies view the situation as more stable than the larger ones. A plausible interpretation is that the products of smaller companies are likely to be backed up by more stable decisions than those of larger companies; also production cycles among the former are on the average longer than those among the latter. One may also suspect a lack of future vision and resources, which typically infest smaller companies. In practice, the increased significance of microelectronics manifests itself primarily as *qualitative changes in products and less often as radical new product applications.*

6. The Impact of Information Technology on Personnel Policies

The Need for IT Professionals

The rapid spread of IT use has been accompanied by distorted supply and demand of IT professionals. Company personnel policies appear to be the greatest hurdle for hiring extra per-

19. Product applications do not come about in such adoption waves as manufacturing applications. The wave phenomenon can furthermore be examined in terms of the nature of the application. If we consider the use of the most recent microelectronic technologies (ASIC) as marking the onset of the second wave, then the companies passing directly on to ASIC technology have *skipped one wave* and moved straight to the second IT application wave.

sonnel, though demand for qualified professionals clearly outstrips supply particularly during economic growth. Educational requirements are also climbing with competence being increasingly measured in terms of applicative skills rather than specialties. In practice, employers have been setting higher educational requirements as IT has become an established part of the industrial culture. Particularly large companies tend to practice the basic policy of avoiding extra personnel; small companies are of necessity restricted by their lesser resources, which in terms of personnel employed in narrow specialties are not necessarily used to the best advantage. The general prevailing attitude in large companies has been to cut back the total personnel, thus overshadowing any reason for increasing it for specific operations.[20] Regionally, Lapland and eastern Finland appear to have the most difficulties as to recruiting extra personnel, one reason being the lack or scarcity of institutions providing IT training in the regions.

Companies see the number of their IT professionals (software, electronics, telecommmunications, and skilled ADP users) to be on the increase (Jaakkola 1990, p. 86). The fastest growing specialist group is estimated to be that of skilled ADP users. Particular *IT application specialists* are therefore more in demand than general IT professionals. The second greatest increase is seen among *software experts* while the number of telecommunications specialists is not expected to grow. The projected exiguous growth among the latter results from the fact that in companies the tasks best suited for these specialists have traditionally been lumped and handled together with other functions. Except for the largest, companies presently do not have enough such tasks as to justify hiring extra personnel. The need for telecommunications specialists is viewed as such a short-term phenomenon that reliance on outside expertise makes better economic sense than having such experts on the payroll.

The observations about companies'--and here particularly small companies'--projections about the number of their future personnel can be condensed as follows:

- companies seek to widen and diversify the skills of their employees and lay a particular stress on their abilities to make effective use of company resources
- special services will be purchased from outside
- new facilities and equipment will be selected with a view to avoiding unnecessary hiring of specially trained maintenance personnel

Larger companies seem to follow the above trend by gradually separating the manufacturing operations from their auxiliary development and maintenance functions.

Changes in Employment, Work Life, and Work Practices

Decreased demand for labor is seen as one significant consequence of IT and automation. According to several studies, IT adoption in Finland is not so much guided by concerns about saving labor as a need to *slow down and control the growth of personnel.* Improving the productivity of the available personnel helps to alleviate the pressures induced by labor shortages--an observation borne out by the studies quoted here as well by some extensive labor

20. This shows a short-sighted personnel policy, often hiding behind it trade union politicking, economic factors, and unwillingness to see and tackle in a pervasive manner problems involving company personnel structures. Changes in personnel are an inevitable outcome of adopting automation. Likewise, an economic decline affects various company activities with varying severity. These are fundamental, uncontrollable factors whose regulative effects on personnel policies should be accepted as such. The recruitment of a person responsible for company development should under no circumstances be encumbered by distorted personnel structures, for this would only result in further operational problems.

surveys (Kortteinen 1987; Lehto 1989).

The use of IT in industry is seen primarily as moderating the need to hire extra personnel. Administrative IT is bringing about a slight increase in part-time employment. Labor studies further report that *with growing IT adoptions the numbers of personnel in companies have been on the average increasing rather than decreasing* (Lehto 1989, p. 36). One has to observe though that during the time of the studies (1984 and 1987) the labor force grew as a whole because of the favorable economic conditions. The change in the numbers of personnel is not to be examined only quantitatively but also as a stuructural phenomenon. As jobs in production decrease and correspondingly new ones are created in office and organizational functions, labor structures tend to lean more heavily toward salaried personnel. The dwindling of certain task domains has been successfully compensated by growth in other domains or by personnel moves outside the business, which have prevented negative developments on the labor market. A committee report (Komitea 1985, p. 63) observes that at the microlevel (in terms of a single company) IT may contribute to cutting down labor needs in the short term, but at the macrolevel its impact is the reverse when new employment opportunities are created to foster and make use of the IT-induced regeneration. The problem, however, is that the effects of labor cutting appear more quickly than new job opportunities. Views concerning the comprehensiveness of the turnover process have also been proposed.

Besides structural changes in the labor force, IT has also promoted new work practices. Part-time, temporary, and flexiwork offer new flexibility to both employer and employee. One of the new noteworthy work practices is *flexiwork*, which is gradually though so far slowly and tentatively weaving its way into the fabric of Finnish work life. Flexiwork is seen not only as a flexible work form but also as a *preventive (or retardant) of job-necessitated moves of labor into densely populated centers*. The Kuusamo municipality has initiated a project to adapt flexiwork in various forms to improving the local labor situation, marked by an imbalance between job training and labor demand, and to enhancing through novel work practices (combination of leisure and work, flexiwork proper, temporary project-type work, company home-based work stations) the district's attractiveness as a locale for unencumbered work performance (Jaakkola 1991e).

The progressive transformation of company *organizations from pyramidal to "onion- or diamond-shaped,"* reduces the most easily automatable tasks at the lower end of the organization. For example, automated banking is trimming traditional customer services, which are either eliminated altogether (e.g. bank books, receipt returns) or converted where possible to self-service. Automated banking is an intriguing example in that it is already caught up in the second automation wave. The first automation wave brought in the computer already in the 1970's to assist bank clerks in this early office automation domain. Now less than 20 years later the domain is undergoing a second automation wave, which is washing away some of the main computerized functions of the first wave. Similar developments are surfacing in other domains of office automation, as well as in manufacturing operations.

The Increasing Use of Information Technology

IT has quickly mushroomed in all sectors of the economy. In the 1980's, the Central Statistical Office (Tilastokeskus) conducted two extensive studies, the first (Kortteinen 1986) based on the 1984 employment conditions study and its extensive supplement, the second (Lehto 1989) drawing on the follow-up that accompanied the yearly labor survey (N=4866). Statistically, both studies afford a good overall view of the advance of IT in our country.[21]

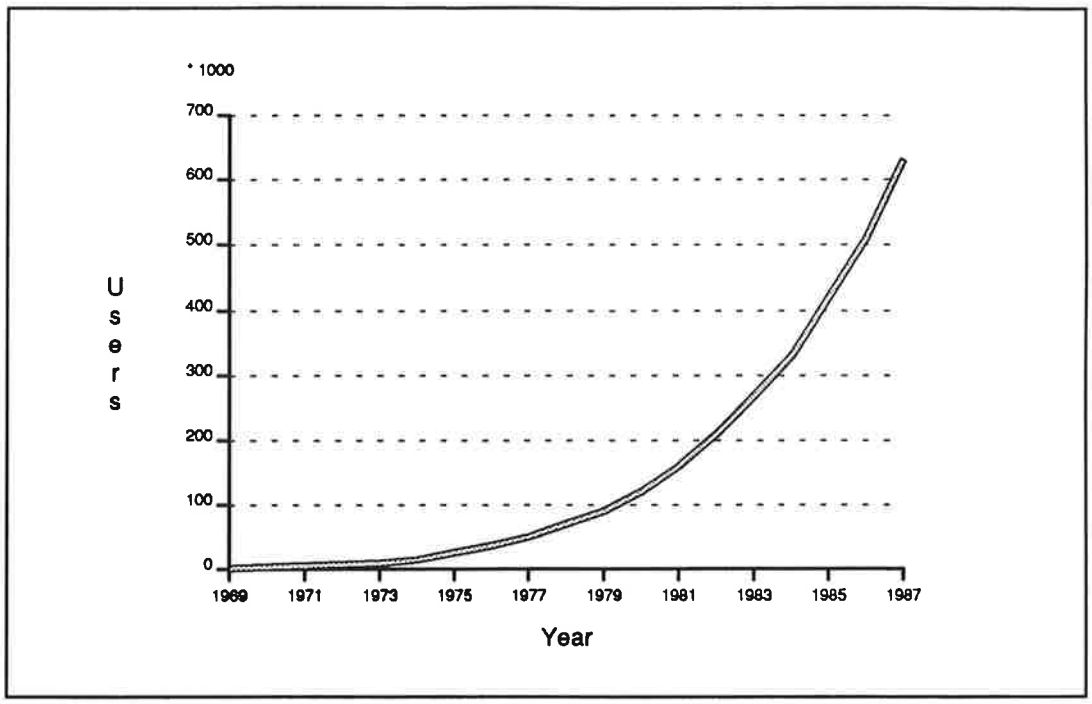

Figure 5. The Growth of Emloyees Using IT (Lehto 1989, p. 9).

The *rapid growth phase* of IT adoption occurred in the 1980's (Figure 5). In 1984, the employees using IT at work numbered 332 000 (17 percent of the labor force).[22] More than half of them had become users during the previous three years. By 1987, their number had doubled (631 000) and their percentage grown to 32. Full-time IT users amounted to only 4 percent of the labor force (Luukinen 1989, p. 5), but more than half-time users already accounted for 11 percent. In assessing the development we have to allow for the dynamism of the applications domain: there has been an appreciable increase of the possibilities and competence to apply computers--e. g. wordprocessing, computerized cash registers and machine tools are now part of the everyday routine.

The use of IT, fostered and spread by the generally favorable public attitude, is predicted to grow unabated. According to study conducted by the Committee for Commerce and Industry (EVA 1985, p. 28), already in 1985 half the Finns had either used a computer system (26 percent) or wanted to use one (24 percent). When the study was repeated two years later (EVA 1987, p. 53), 61 percent of Finns considered IT-induced changes to be largely positive and only 17 percent thought them negative.

The number of employees using IT at work is growing by about 100 000 a year (Lehto 1989, p. 9). The spectacular surge results from the fact that IT has been making inroads particularly

21. The following figures may serve as reference to the present labor situation: in March 1990, the employed numbered 2.249 .000 (Tilastokeskus 1991, p. 18); the main divisions of labor were services 58 percent, industry and construction 31 percent, agriculture and forestry 11 percent (STK 1990, p. 5).
22. The employees who themselves make use of IT at work. IT equipment and facilities include intelligent cash registers or cash terminals, text processing systems, computer terminals, microcomputers, programmable machine tools, computerized monitoring and sensing devices, and other IT-technology-based control, measuring, or monitoring devices.

into the recently most boldly expanding labor sector. The IT user share in various employments in 1987 was as follows (Lehto 1989, p. 12):

- clerical work 72 percent (in 1984 46 percent, a 26 percent increase)
- administrative work 63 percent (a 35 percent increase)
- sales work 39 percent (a 15 percent increase)
- technical and humanistic work 37 percent (a 17 percent increase)
- industrial work 19 percent (a 10 percent increase)
- transport and communications work (mostly telecommunications) 16 percent (a 10 percent increase)
- agricultural and forestry work 10 percent (a 7 percent increase)
- services 10 percent (a 5 percent increase)

Corporate managers and executives are almost exclusively IT users, a development which portends dramatic changes in methods and procedures among those responsible for strategic decisions.

IT has considerably changed the nature of work in many occupations, entailing a labor shift toward salaried employees. *Socio- economically*, the labor force has undergone the following changes between 1970 and 1984:

- industrial and other workers from 59 to 48 percent
- lower salaried employees from 33 to 37 percent
- upper salaried employees from 8 to 15 percent

In the same period the work force increased from 1.6 million to nearly 2 million. The change was partly brought on by changing job contents. With the aid of IT, production and process work becomes control and management oriented, and vacancies occur increasingly in the fastest developing occupations--information services; technical, natural science and humanities occupations; administrative, accounting and technical office work. The growth in these main sectors alone during the above study period was c. 11 percent, in terms of jobs 320 000.

Regional differences in IT adoption remain conspicuous because evidently new methods and applications are *first adopted in administrative and industrial centers* (Komitea 1985, p. 70). Besides different preconditions for adopting new technology, the regional imbalance is further accentuated by the warped economic structures between the various regions as well as by companies seeking to diversify their operations by relocating their production in districts providing the necessary labor reserves. Such districts may turn out to be ones with high rates of unemployment where operations can be moved with government funding. Some IT-intensive operations (research, product development, administration, customer services) are often diverted from production and set up separately in districts with the required infrastructure. For some large enterprises this means relocating overseas. Such measures further upset the geographical imbalance of IT use both within and without a particular geographical entity. Regional centers become more sought-after and attractive to expanding companies in sparsely populated areas whose labor reserves cannot support the growth.

Examination of the employer categories reveals that both the government and the private sector share about an equal amount of IT users (slightly above one third of all labor). Municipalities, rural communities, and their administrative combinations fall clearly behind the above with their less than 20 percent IT user share. The sector is only now beginning to experience wide-scale IT use but is showing promise as a vigorously burgeoning IT applications market.

7. The Information Technology Industry as Part of the Infrastructure

The Background

Few statistics are available concerning the business activities and developments associated with IT production, products, and services. Furthermore, interpretation of the material is complicated by its short-term coverage and unsophisticated classification principles. Additional information is to be had from occasional market and company surveys, of which the annual VTT (Technical Research Centre of Finland) report "Suomen Atk-markkinoiden vuosikirja" (The Yearbook of the Information Technology Market in Finland) is perhaps the best known. It is based on long-term, systematically collected material even though as a statistical survey it is not fully representative and reliable. Especially the varying target groups of companies and partly the incommensurability of the figures interfere with the comparison of yearly studies. The following is an examination of IT development, based first on a VTT survey[23] and then on some statistical reports. It intends to offer a general view of the IT industrial structure in Finland and the structural factors related to IT exploitation.

IT Production as a Business Activity

The VTT study (VTT 1990) was conducted in the form of a survey with 790 participating companies. [24] The total *in-house IT production* value of the surveyed amounted to FIM 9.3 billion and the *overall production* value to FIM 17.7 billion (1989). The gross increase of their in-house IT production on the previous year was 18 percent and that of their overall production 15 percent in the then currency. The VTT study provides a basis for a long-term analysis though comparability of the yearly information is somewhat hampered by the variable sampling of the study. Nevertheless, the figures can be taken as fairly accurate signposts of the present development. They show the steady growth of the industry in the 1980's to have been slightly above 10 percent (real growth) and remaining the same in 1989 even counting the changes in the value of the markka. The total 1990 value of the IT production of the surveyed was predicted to reach FIM 10.5 billion and the national turnover FIM 21 billion.[25] Because of the economic stagnation, however, the growth of the total turnover in some key sectors has come to a halt and even taken a downturn.

The trade balance for Finnish IT products is slightly negative: in 1989 exports accounted for FIM 2.5 billion and imports FIM 2.92 billion (The Customs Administration reported FIM 2.986 billion for the latter). The key export groups were integrated systems as well as equipment and accessories, which altogether accounted for over 90 percent of the total exports.

IT production is centralized both regionally and business-wise. The companies involved in the production are *geographically clustered* in southern Finland, and the yearly alteration in this concentration has been minimal. A clearly declining trend has been evident in the Uusimaa district with a corresponding slight move of the center toward the rest of southern Fin-

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23. The primary source is their latest publication (VTT 1990), supplemented with comparative data from some earlier releases.
24. The survey sought to cover all the companies whose in-house IT production and imports turnover exceeded FIM 100 000. In the 1990 survey (VTT 1990), the company data are up-to-date; the turnover and personnel figures date from 1989.
25. The figures represent c. 2 and 4 percent of GNP, respectively. Both increased by a 0.1 annual percentage point.

land. The business activity has evolved most noticeably in areas where both customer potential and skilled labor are there to back up the growth (Luukinen 1989, p. 20). Thus even if distributed, the activities will gravitate towards regional centers with businesses in the countryside and sparsely populated areas being left to suffer from lack of necessary near-by IT services.

Centralization of demand has led to centralization of services. However, over the past decade select governmental measures have been applied with a view to altering the regional business structures in Finland by improving the incentives for business activity in sparsely populated areas. Consequently, companies have found themselves in a conflicting situation: on the one hand, economic benefits favor decisions to relocate outside crowded centers and conventional industrial neighborhoods, but, on the other hand, the *poor infrastructures* of the new locations would leave the companies dependent on outside services. Also here governmental action has been applied to remedy the infrastructural imbalance, though only after primary industrialization measures have been tried first. An example of such action is the IT acquisitions guiding project initiated by the Ministry of Labor, whereby IT-related services in areas outside the capital are actively encouraged by providing education and creating demand.

The IT business base is comprised of *relatively small companies*. In 1989, the 30 largest companies accounted for 74 percent (76 percent the year before) of the total in-house IT production turnover. The in-house IT turnover of the company rating number 30 amounted to FIM 48.0 million with the average company in-house IT turnover being FIM 13.2 million[26] (the average total turnover was FIM 22.4 million). The total in-house IT turnover of 82 percent of the companies rated below FIM 10 million, and 62 percent reported having less than ten employees. In 1989, the average turnover per employee was FIM 689 000.[27]

By the end of 1989, the companies surveyed by VTT employed altogether 25 700 people (the total personnel). Well over half of them were employed in manufacturing, of the rest one half in marketing, and the remainder equally in research and auxiliary functions. The total figure represents *one percent of Finland's employed labor force*. In the latter half of the 1980's, the growth rate of labor slowed down and was 3 percent in 1989. Despite the retarded growth in personnel, the value-based growth of the manufacturing has been steady (a slightly above 10-20 percent annual real growth over the past years). The combined figure of personnel in the companies is predicted to reach 27 000 by the end of 1990. According to a Central Statistical Office release, IT employees numbered 29 600 in 1988 (Luukinen 1990, p. 5; the VTT figure for the same period was 21 500, half of whom worked in IT manufacturing; consequently, a good two thirds of the jobs are outside IT manufacturing).

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26. The average in-house IT turnover of the companies in the main product categories reads as follows: equipment and accessories FIM 113.6 million, software production FIM 4.7 million, customer services FIM 6.4 million, data processing services FIM 46.3 million, embedded systems FIM 261.1 million. The last figure cannot be considered representative because, owing to the company size classification used, the distribution of the surveyed embedded systems suppliers is distorted.
27. The average turnover per employee in the companies in the main product categories was as follows: equipment and accessories FIM 684 000, software production FIM 429 000, customer services FIM 488 000, data processing services FIM 484 000, and embedded systems FIM 636 000.

8. The Signigicance of Information Technology for Industry

IT users have varying views about their technology in different application sectors. The most obvious reasons for IT adoption in *manufacturing* concern lower *production costs, improved quality,* and reliable operations and delivery; on the other hand, *labor saving* as such was not reported as a significant factor. Only 13 percent of the surveyed in a study (Jaakkola 1990) estimated that IT could replace skilled labor, and even then by easing the shortage of labor rather than by reducing existing personnel. The companies estimate that the reasons for adopting IT coincide with the inherent benefits, i.e., the *greatest expectations concern lower manufacturing costs.*

In *products*, microelectronics are seen as primarily enhancing the *qualities and properties of products.* Their cost cutting effect on manufacturing is rated third in importance. It is preceded by the indirect effect of ever more reliable delivery. The use of microelectronics in products also has its ripple effect on manufacturing technology in terms of saving labor, which the respondents tended to play down (as they did in relation to production methods).

The above results coincide with those provided by another survey (Latvala 1990, p. 149), though benefits were shown to vary between small and large companies. Small companies considered the prime benefits of microelectronics product applications to be better reliability and improved product qualities (including smaller size and lower power consumption). Also larger companies placed improved qualities highest on their list of priorities; however, the second place was given to lower manufacturing costs and the third to lower service and maintenance costs. This may well indicate a strategic difference between small and large companies in their microelectronics product applications: small companies concentrate on customer-specific products, which offer less volume benefits while to large companies the benefits offered by microelectronics appear clearly in terms of volume markets.

When we consider how these benefits may change in the future, the most significant consideration is likely to be the *protection of technical product decisions* provided by microelectronics. In large companies this will be even more pronounced. This keenly anticipated change, especially with regard to a concern which did not rank high at the time of the survey, is reflective of an upcoming change in the market of products containing microelectronics. At the same time, the presently highly valued benefits have perhaps by now been checked as achieved, thus minimizing the importance of any future changes therein.

IT benefits in *administrative applications* differed considerably from those in the two other sectors; the key benefit in the former was reckoned to be the *replacability of skilled labor.* The reason here is most likely IT-induced changes in clerical work, which never underwent such a lengthy process of change over time as did by now far advanced mechanized manufacturing. IT has made it possible to realize within a very short time such administrative changes as in manufacturing took decades to come about. Also changes in business operations with cost-effectiveness imposed on the lowest organizational strata are forcing companies to search for ways and means to lower their overall expenses as a part of their profit- improving strategies. An improved work milieu was seen as an important consequence more so in administration than in manufacturing.

In general, companies tend to be both expectant and reserved with respect to adopting IT. Excessive and non-realistic expectations often result in disappointments with concomitant retardation or even cessation of an incipient development. This may happen even if the tech-

nology is not to blame but its *inappropriate use.*

As a general rule, those companies which have resolved on exploiting microelectronics in their products view the technology as *strategic for the products.* Conversely, the main reason for adhering to conventional technologies is that microelectronics do not suit the particular products of the company. Other quoted main obstacles are "no need," high development costs, lack of knowhow, and inadequate preparedness for use. Such impediments or restraints (particularly the last two) can be eased with education and by *promoting interaction between companies and their cooperation with research establishments.*

Automation is first applied to the least demanding tasks, and it seems to *proceed in waves* so that early IT-facilitated tasks become less numerous in the next wave. The current second automation wave differs essentially (in both production and administration) from the first: where the first wave aimed to back up operations, the second involves their rationalization and modification. Such a wave or phase movement reflects the maturation of the technology. In view of the present technological level, the first wave concerned the application of an immature technology to its targets--a phase which cleared the way for the second wave with its considerably less operose IT adoptions.

The latest IT users are initiating their applications now in the second wave with more freedom for their technical solutions than was afforded the first wave adopters. Furthermore, new adopters benefit from the experiences of their predecessors, the IT positive climate they created, and the ready-formed IT-supportive infrastructure.

Of all the three sectors, administrative IT applications have clearly entered the phase of qualitative change, a situation parallelled by the primary-level IT applications in manufacturing methods. The number of user companies is increasing with the emergence of new ones and with the expansion of small companies past the threshold of gainful use. In the latter case, decisions are made on a "mature technology,"[28] which is universally recognized and allows a low adoption threshold. The mature technology can be innovatively exploited for a pronounced competitive edge over other IT users.

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28. In this context, the term signifies a manageable level of technology use. The technology as such may progress by incremental steps and create for the user unforeseen possibilities of application, manageable because of the user's familiarity with the basics of current technology and implementable because their adoption threshold is lower than in fast growth phase technologies.

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APPENDIX 1.
Numerical Data, State-of-the-art of the use of IT in Finnish industry

(Source: Jaakkola 1990; Jaakkola 1991a)

The figures represent percentages of the surveyed, proceeding in order of administration, manufacturing, product. "Absolute" denotes the user percentage of the surveyed, "weighted" the user turnover percentage of the surveyed turnover percentage, and "user percentage" the distribution of the users among the categories. "Category percentage" denotes the percentage of a particular category in the study sample.

Table 3: Overall Review

%	Users	Potential	Weighted
Administr.	69 (N=371)	78	86
Process	39 (N=210)	61	73
Product	11 (N=58)	22	17

Table 4: Company Classification According to Size (Size of Personnel)

	Categ.perc.	Absolute			Weighted			User percentage		
0 .. 9	36.3	45.4	15.3	6.1	52.7	18.0	5.7	24.0	14.3	20.7
10 .. 19	13.5	87.7	26.0	11.0	90.3	21.9	7.2	17.3	9.1	13.8
20 .. 49	18.4	76.8	48.5	7.1	77.4	57.1	4.5	20.5	22.9	12.1
50 .. 99	11.0	83.1	57.6	18.6	87.1	60.2	15.5	13.2	16.2	19.0
100 .. 199	9.5	90.1	80.4	17.7	87.9	81.0	19.1	12.4	19.5	15.5
200 ..	7.6	90.2	87.8	19.5	90.0	89.1	21.4	10.0	17.1	13.8
Total	96.3	69.0	39.0	10.8	86.4	73.3	16.6			

Obs. The percentages do not add up to 100% because the size category making up 3.7 percent (20 subjects) was not included.

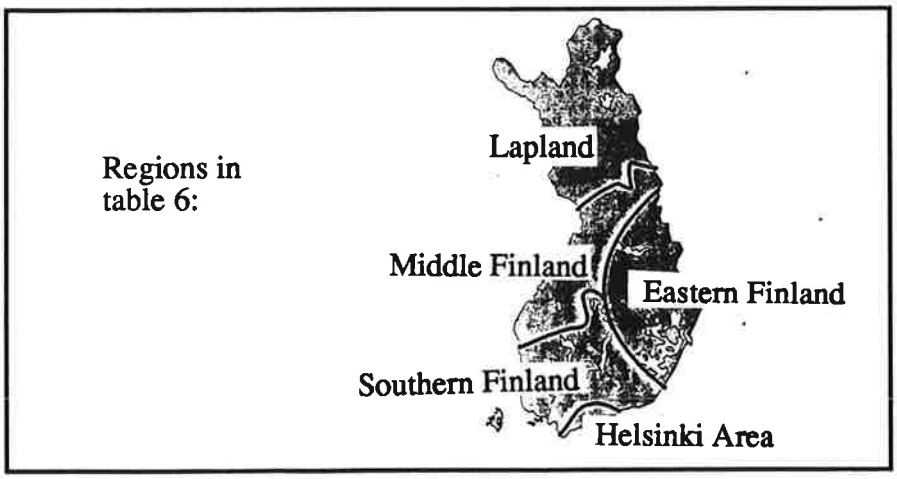
Table 5: Classification According to Line of Business

	Categ.perc.	Absolute			Weighted			User percentage		
Mining	2.4	69.2	53.8	7.7	85.0	93.5	25.7	1.7	3.3	2.4
Food	11.3	78.7	36.1	0.0	95.0	62.2	0.0	13.0	10.5	0.0
Clothing	11.9	54.7	25.0	3.1	80.0	65.2	0.5	9.4	7.6	3.5
Wood & furnit.	16.5	59.6	22.5	4.5	84.0	60.9	0.7	14.0	9.5	6.9
Paper	1.5	75.0	75.0	12.5	75.0	99.0	0.4	1.6	2.9	1.7
Printing	9.3	76.0	58.0	6.0	90.0	83.1	9.2	10.2	13.8	5.2
Chemistry	10.8	89.7	51.7	5.2	92.0	74.7	9.0	14.0	14.3	5.2
Mech.eng.	26.9	68.3	42.1	20.0	77.8	78.5	40.8	26.7	29.1	50.0
El.eng.	3.9	73.3	46.7	46.7	86.0	78.6	75.4	5.9	6.7	24.1
Others	3.9	47.6	23.8	4.8	80.0	61.6	0.2	2.7	2.4	1.7
Total		69.0	39.0	10.8	86.4	73.3	16.6			

Obs. The percentages do not add up to 100% because of the cumulative rounding.

Table 6: Classification According to Region

	Categ.perc.	Absolute			Weighted			User percentage		
Helsinki area	19.9	76.6	45.8	15.0	93.6	74.9	23.9	22.1	23.3	27.6
Southern Finland	51.2	68.1	37.7	10.1	86.1	71.5	16.6	50.4	49.5	48.3
Middle Finland	16.3	61.4	26.1	8.0	78.1	61.1	19.2	14.6	11.0	12.7
Eastern Finland	9.0	70.8	52.1	12.5	88.1	82.9	9.6	9.2	11.9	10.3
Lapland	3.4	66.7	44.4	1.0	73.1	91.0	0.1	3.2	3.8	1.7
Total		69.0	39.0	10.8	86.4	73.3	16.6			



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