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Keskusteluaiheita – Discussion papers

No. 733

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ICT CLUSTER – THE ENGINE OF KNOWLEDGE-DRIVEN GROWTH IN FINLAND

The research has been funded by the Ministry of Trade and Industry to whom I express my gratitude. This paper will be published in an OECD publication forthcoming in 2001 under the NIS (National Innovation Systems) Programme.

ISSN 0781-6847 07.09.2000

PAIJA, Laura, **ICT CLUSTER – THE ENGINE OF KNOWLEDGE-DRIVEN GROWTH IN FINLAND**. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2000, 29 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 733).

ABSTRACT: The momentous growth in the information and communications technology (ICT) industry has marked the rapid industrial restructuring in Finland. The welfare of the economy is increasingly connected to a sector that has incredible growth potential and that relies on knowledge-based factors of production. Today, the sector accounts for a third of exports while in 1980 the share was 4 per cent.

Despite the prominent role of the Finnish ICT equipment industry both in domestic and international contexts, the cluster development lies heavily on the foundation built in the operator sector during the early phases of the history.

In the retrospect, the ICT cluster looks like an outcome of an well-orchestrated master plan. However, many of the factors with great impact on national competitiveness have been more or less coincidental in past- or at least motivated by other than industrial policy objectives.

KEY WORDS: Information and communication technology (ICT) cluster, competition, specialisation, innovation patterns, industrial policy

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TIIVISTELMÄ: Tieto- ja viestintäklusterin ennennäkemätön kasvuvauhti on johtanut Suomessa nopeaan teolliseen rakennemuutokseen. Talouden menestys kytkeytyy enenevässä määrin alaan, jolla on mittaamattomat kasvumahdollisuudet ja joka hyödyntää luotuja tuotannontekijöitä. Alan osuus viennistä on noussut kolmannekseen vuoden 1980 neljästä prosentista.

Huolimatta viestintälaiteteollisuuden merkittävästä kotimaisesta ja kansainvälisestä asemasta klusterin kilpailukyvyn kehitys pohjautuu pitkälti puhelintoiminnan varhaisiin kehitysvaiheisiin. Tieto- ja viestintäklusterista on kehittynyt kansainvälisesti merkittävä innovaatiojärjestelmä, joka on kuin taitavasti toteutetun suunnitelman tulos. Kuitenkin monet merkittävästi kansalliseen kilpailukykyyn vaikuttaneet tekijät ovat menneisyydessä syntyneet muista kuin talouspoliittisista lähtökohdista.

AVAINSANAT: Tieto- ja viestintäklusteri, kilpailu, erikoistuminen, innovaatiorakenteet, teollisuuspolitiikka

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1. Introduction

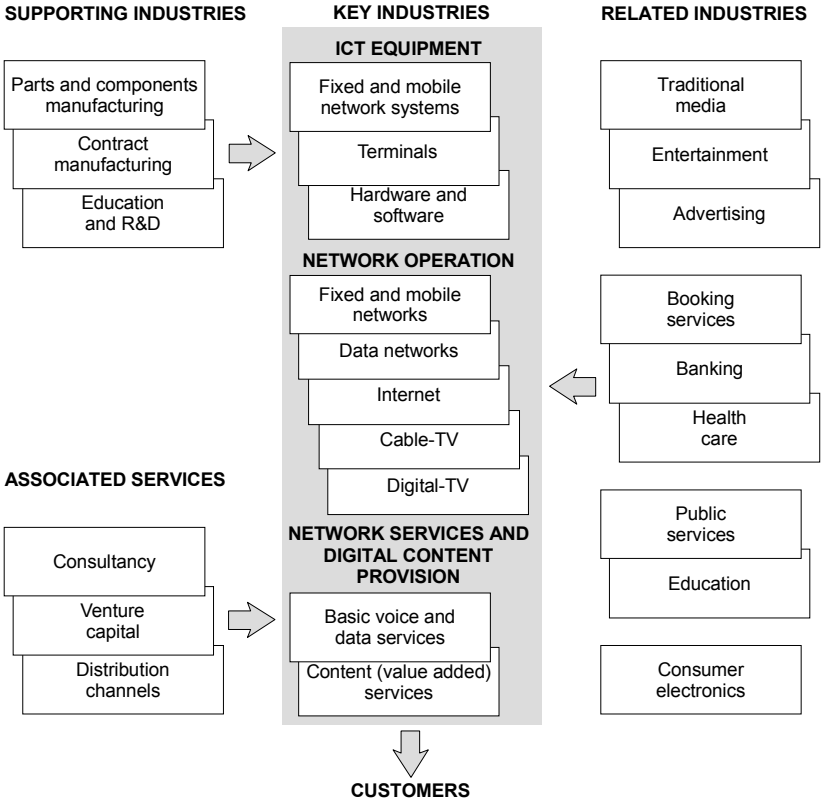
Information and communication technology (ICT) fuels the ongoing 'third industrial revolution'. Like steam power and electricity at their times, ICT is a powerful agent of change influencing virtually all walks of life. The effects on the demand-side (i.e., *application* of the technology) are perhaps more important in considering overall economic impacts of the technology. However, the supply-side of ICT and related services (i.e., the *provision* of the technology) has grown to a sizeable business on its own right.

In what follows, we study the Finnish ICT cluster primarily from the 'supply' point of view by exploiting Porter's (1990) cluster application. Given the myriad of roles ICT plays in our lives, the cluster composition may be quite different depending on the particular context and point of view. In the Finnish context telephone operation and later in particular mobile equipment are at the centre stage.

2. Cluster identification

The ICT cluster is depicted in figure 2.1. In Finland the cluster centres on telecommunications equipment manufacturing and service provision as the key industries. The universities and research institutes have been successful in producing competent human resources and world-class R&D to support the cluster development. The electronics industry, in turn, has evolved highly specialised for the needs of the key activities. Digitalisation of content, provided by related industries, is seen as the most prominent factor in boosting the future demand for telecommunications infrastructure. The venture capital market, as an example of associated services, has emerged as a new and important source of funding that has greatly enhanced the preconditions of the cluster growth.

Figure 2.1 ICT cluster chart



In recent years, however, it has become increasingly difficult to place firms on the cluster chart. Three megatrends, namely *convergence* of networks, terminals and services, *digitalisation* as well as *deregulation* have drastically stirred the clear-cut cluster chart that we had a few years ago.[1] The cluster actors are gradually penetrating each other's domains, blurring the competitive environment. In the near future, for example, both terminal suppliers and operators compete in providing the same technical solutions (e.g. user authentication) or service access (e.g. mobile portal).

Furthermore, cluster actors merge vertically (e.g. content providers, packagers, distributors and service provides; or, business consultants, IT integrators and new media) to take hold of a wider range of the value chain. A number of firms in different communications fields have taken part in the global wave of cross-sectoral mergers.

3. Cluster mapping

3.1. Economic relevance in the domestic market

The key figures of the ICT cluster for 1998 are presented in table 3.1.[2] The gross value of the cluster was EUR 17,5 billion. Manufacturing of equipment and their electronic components dominated the cluster, accruing two thirds of the value, while telecommunications services represented one fifth of the turnover. The significance of software supply and other IT services is underestimated in the table since ICT equipment include an important amount of software, and the construction of telecommunications networks involves IT services that is included in the sales of the equipment manufactures.

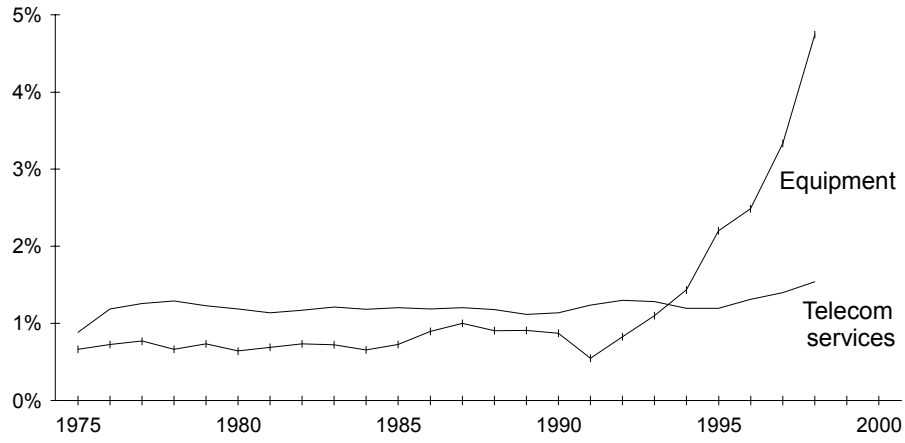
Table 3.1 Key economic indicators of the ICT cluster in 1998

	ICT manufacturing		ICT Services				**Cluster (total)**	
			Telecom services		Software, IT services			
	Euros (mill.)	Share of prod.	Euros (mill.)	Share of prod.	Euros (mill.)	Share of prod.	Euros (millions)	Share of prod.
Production	11,631	100%	3,408	100%	2,500	100%	**17,538**	100%
Value added	3,728	32%	2,045	60%	1,724	69%	**7,497**	43%
Labor cost	951	8%	682	20%	706	28%	**2,339**	13%
Exports	9,543	82%	110	3%	932	37%	**10,585**	60%
Imports	1,694	15%	150	4%	578	23%	**2,422**	14%

Source: Statistics Finland, Ministry of Transport and Communications.

The value-added generated in the cluster was 43 per cent of the gross value, ranging from 32 per cent in manufacturing, to 60-70 percent in more labour-intensive services. Figure 3.1 reveals the breakthrough of communications products in domestic production. Since *Nokia's* recovery (from 1992 onwards), the value-added in ICT manufacturing has grown at the average annual rate of 35 per cent. In 1998, the cluster contribution to the GDP was 6.6 per cent.

Figure 3.1 The share of ICT value-added on GDP



Source: Statistics Finland, Ministry of Transport and Communications.
Note: The figure excludes software and IT services as well as computers due to lacking data. There is a slight discontinuity in the data between 1994 and 1995 due a change in statistical classification.

With 75,000 employees, the ICT cluster accounted for 3 per cent of the total national employment in 1998. Nokia alone employed 21,000 persons in Finland and thus accounted directly for almost 30 per cent of the cluster employment. According to estimations Nokia employed indirectly an additional 14,000 persons through its first-tier subcontractor firms.[3] As production networks go further to sequential tiers, the employment effect of the major firm is significant, but cannot be readily quantified. However, without the chronic shortage of skilled labour the employment potential of the cluster would allow much higher recruitment.

During the severe recession in the first half of the 1990s the ICT cluster was able to maintain much higher employment rates than the economy as a whole (figure 3.2).[4] The unprecedented deterioration in total employment was further aggravated by the coinciding full liberalisation of the telecommunications market. Highly automated and digitised systems underlie the necessity to reduce and restructure personnel in view of opening competition. During 1990-94 *Telecom Finland* (later *Sonera*) cut down human resources by over 40 per cent, while in the private sector reductions were more moderate. In 1998, however, the operator employment rose back to year 1990-level – yet with marked changes in the educational structure.

Figure 3.2 Annual employment growth in the ICT cluster and in the economy as a whole

Source: Statistics Finland.
Note: The ICT cluster lacks complete data for computer manufacturing employing approximately 3000 persons on average between 1995-98.

At the same time, Nokia started to focus increasingly on telecommunications. The company had a vast need for competent people with versatile skills. Nokia recruiting compensated for the outflow from the operator sector. The timing of Nokia's expansion was ideal for both the economy and the company. Nokia did not need to compete for skilled people unlike today.

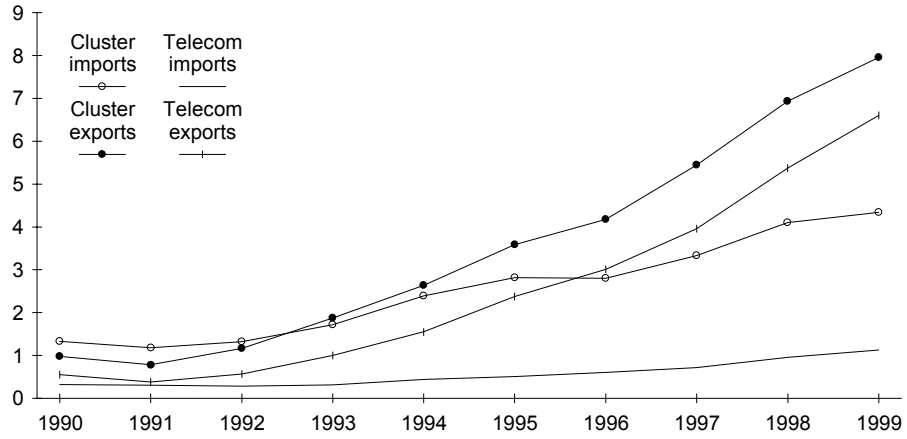
Despite the relative importance of the cluster in the economy, the share of ICT firms is under 2 per cent (4,000) of the total. In addition, the firms are relatively small from global perspective. By sales, Nokia is a leader in its own class in Finland, though in the global market it is still behind many of its peers. Also Sonera, despite its rapid growth and aggressive penetration in new markets, is still a minor company in the international playground.

3.2. Foreign trade and international market position

In 1998, the export share of the total ICT cluster production was over 60 per cent (table 3.1). In telecommunications services exports represented still an insignificant share, while in equipment manufacturing about 85 per cent of the sales was accrued abroad. In 1999, ICT product exports represented 20 per cent of the total exports while 1990, the share was only five per cent.

Figure 3.3 of the trade balance in cluster products illustrates the dominance of telecommunications equipment in the Finnish ICT cluster trade. On top of telecommunications equipment exports there is a margin of other ICT exports that has kept constant in value over time. In imports, the electronics industry is dependent of standard components (semi-conductors).

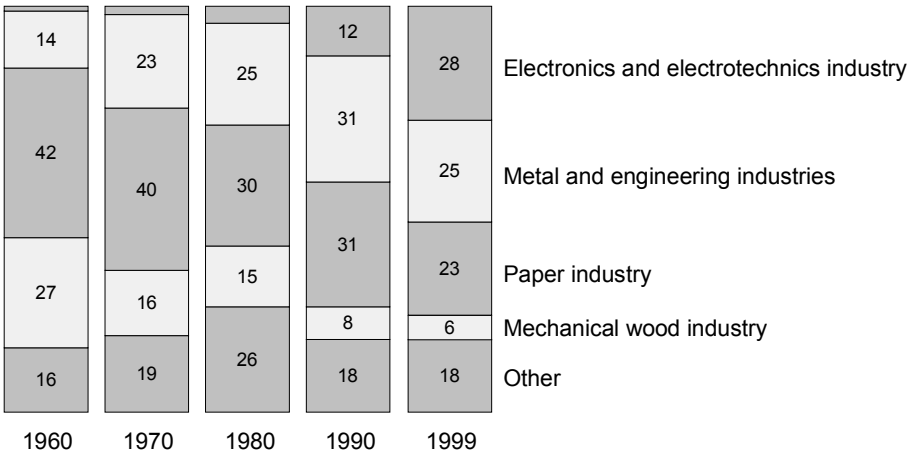
Figure 3.3 Foreign trade in ICT and telecommunications products (millions of Euros)



Source: National Board of Customs.

The pace and intensity of the growth in the Finnish electronics industry has been extraordinary throughout the 1990s. It has lead to an industrial restructuring in the former forest and metal based economy, in which knowledge has replaced capital, raw materials and energy as the dominant factors of production. During the past decade, Finland became the world leader in high-tech trade surplus (high-tech exports/imports ratio) among indigenous high-tech producers. The share of electronics and electrotechnics exports has almost tripled at the expense of pulp and paper and metals, representing close to 30 per cent of the total manufacturing exports (figure 3.4).

Figure 3.4 Export shares by industry groups 1960-1999

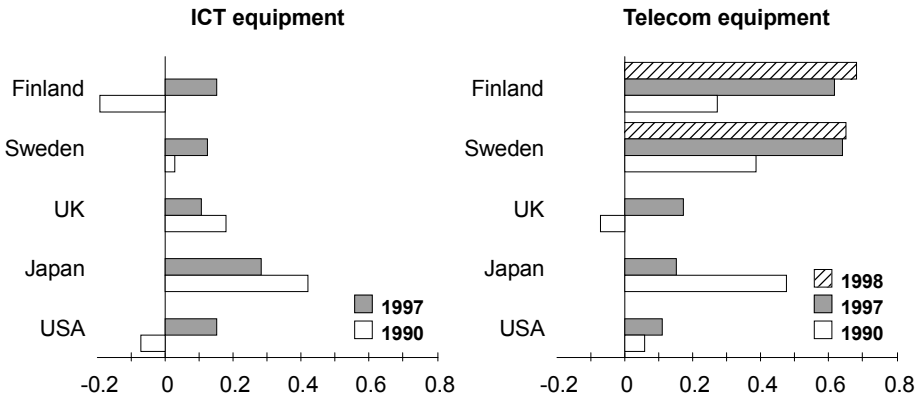


Source: National Board of Customs.

In OECD comparison, Finland ranked the second in ICT exports specialisation after Japan in 1997, sharing the same position with the US (figure 3.5 *left*). However, the assortment of the ICT exports differs between the countries in that Finland is focused on telecommunications equipment while Japan and the US are specialised in information technology.

Limiting the comparison to telecommunications exports reveals that Finland ranked the first in specialisation in the OECD in 1998 (figure 3.5 *right*). During the 1990s, Japan has lost its lead to the two Nordic countries, which have been racing for the leading position. In absolute terms, Finland's share of total OECD telecommunications equipment exports was 4,4 per cent in 1997, by which it reached the seventh position in cross-country comparison.[5]

Figure 3.5 Export specialisation in 1997 (RSCA index)



Source: OECD.
Note: The 1998 data was not yet available for all countries. See Appendix 2 for the definition of the RSCA index.

4. Components of the cluster system

4.1. The emergence of the ICT cluster from historical perspective

Despite the prominent role the telecommunications equipment industry has played in the recent industrial structural change in Finland, a glance at the history reveals that it was the network operation - rather than equipment manufacturing - which formed the ground for the industry to develop.

Unlike in most of the European countries, **the telephone network operation** was not monopolised by the state. Initially this fragmented market structure was a political outcome. At the time the first cables were being laid, in the 1800s, Finland was a Russian Grand Duchy. In order to complicate the potential seizure of the national telephony by the Tsar, the Finnish Senate granted many licences in telephony operation. In the 1930s, there were no less than 815 private local telephone companies. Once Finland become independent, the national public telecommunications operator (PTO) was established to operate the network left behind by the Tsar.

An important characteristic in the Finnish telecommunications market has always been the tendency of early adoption of new technology – both in the provider and customer sector. Among other things, the multi-operator market structure can be found behind this inclination, since individual operators pursued early adoption of the latest network technology in order to outperform neighbouring operators. Advanced foreign technology was available for the operators since the Finnish market has always been open to competition. Further, the telephone companies were mostly cooperatives pursuing the interests of their owners. This objective materialised in technical improvements and cost-based pricing.

Despite their monopoly power in their concession areas, the local operators could not rest on their laurels. There was continuous pressure from the part of the PTO who had the right to redeem and regulate private companies. There were several intentions throughout the decades to nationalise the private operation, but there was neither enough political coherence nor financial means to realise such endeavours.

In 1921, the private companies founded the *Association of Telephone Companies* which aimed at administrative cooperation and joining forces in face of the PTO. The Association grew a powerful opponent to the public carrier. It dominated local operation in growth centres while the PTO had monopoly over long distance and international calls, and the authority to grant new licences and to exercise control over the private sector.

Between 1950-65, the number of operators declined dramatically as structural regulations - in view of general network development - forced minor companies to merge with either a bigger company or the PTO.

In 1971 the *Nordic Telecom Conference*, consisting of national Post and Telegraph Administrations, initiated a research project on an automatic Nordic mobile telephone (NMT) network, which was going to set the foundation for the consumer-oriented mobile communications. The Conference agreed upon the rules on the cross-border roaming, billing and, perhaps most notably, the openness of the technical specifications. The introduction of the NMT in 1981-82 made the Nordic countries (Denmark, Finland, Norway and Sweden) world's largest mobile market in the early 1980s.

Based on their experience, the Conference played an active role in initiating the *Groupe Special Mobile* (GSM) in 1982, and in designing the pan-European digital mobile network.

As soon as the mobile networks started to attract users the private operators recognised the need to enter the mobile service market – even though the full potential of the market was severely underestimated. Private licence applications were rejected by the regulator-PTO that pleaded to the natural monopoly nature of the mobile telephone market.

Having been repeatedly denied a licence to operate an NMT network, private operators established with their main corporate customers a joint venture, *Radiolinja*. It was to operate a GSM network that was constructed and leased by local operators.[6] However, to provide nation-wide services Radiolinja needed a licence.

The private GSM licence application gave a decisive stimulus to swift deregulation and full liberalisation of the telecommunications market (with the sole exception of the NMT network), finalised in 1994. The Telecommunications Services Act of 1987 separated the administrative and operational functions of the PTO, transferring the regulatory authority to the *Telecommunications Administration Centre*, which was established under the Ministry.

As the winner of the regulatory battle, in 1991, Radiolinja was the first operator in the world to launch commercial GSM services - and the only one to meet the initial time schedule of the GSM design group.

The liberalisation meant fundamental organisational and regulatory changes for the PTO that was changed into a public corporation with no budget obligations to the Government. The PTO started to improve actively its service and price efficiency. It launched GSM service soon after Radiolinja - thus, among the very first in Europe. In 1994, the PTO was demerged, and *Telecom Finland* became a limited company with state as a major shareholder. In 1998, the name of the company was changed to *Sonera* to refresh the organisational image and to pinpoint the change in the strategic focus redirected to mobile and media services The Government has reduced its ownership and indicated further privatisation in due course.

Unlike in many other countries, **the telecommunications equipment market** has always been open to competition. The multi-operator market structure provided a large customer base that attracted several manufacturers to the market regarded as a test laboratory. Upon the birth of the Finnish equipment industry, foreign competition put an immense challenge on national actors.[7] On the other hand, the presence of foreign suppliers catalysed local distribution of knowledge.

The roots of the Finnish radio technology development go back to the 1920s. The wars against the Soviet Union revealed the strategic role of radio technology whose development was initiated in *Valtion Sähköpaja* of the Finnish Army. In the 1950s it introduced its first radio phones and automated base stations.

After the wars, Valtion Sähköpaja was organised under the PTO and renamed *Televa*. In the 1970s, the company started investing in digital technology. Despite in-house opposition, a couple of persistent engineers managed to proceed with their digital exchange project that ultimately led to its introduction – only a short time after the leading foreign competitors.[8]

Suomen Kaapelitehdas (founded in 1917), in turn, was a cable manufacturer for the telecommunications industry. In the 1950s, the new managing director perceived the business potential of electronics. Regardless suspicion within the company's management, innovative but costly R&D in new radio and digital technology were sustained in the 'back stage' of the factory.

The trade relationship with the Soviet Union was decisive to the development of the technical knowledge of the company. The Soviet Ministry proved a demanding but also patient customer. Thus, Suomen Kaapelitehdas had an invaluable opportunity to develop modern digital technology. The voluminous exports provided also necessary income and contacts to develop later exports of telecommunications equipment.

The third central company in the industry development process was *Salora* (founded in 1928). Like in Televa and Suomen Kaapelitehdas, radio technology was being developed aside the core activities, TV and radio set production. Unlike the two other companies, Salora was a strong TV-brand also beyond national borders and had experience of serial production and marketing.

A pivotal stimulus to the birth the Finnish radio communications industry was given in 1963 by the Finnish Army. It put out an invitation for tenders for a radiophone that was to meet challenging technical requirements. It was the first time the firms were given an economic motive to develop a radiophone, generally regarded as a toy for a marginal group of users. In fact, rather than a business opportunity, firms considered the competition a chance to give a physical form to the knowhow cumulated 'behind the curtains'. Five companies (*Televa, Kaapelitehdas, Salora, Vaisala* and Swedish *Sonab*) bid for orders. Ultimately, the Army did not have the funds to redeem the phone, thus the contestants had to look for other customers. Indeed, for all the participators the prototypes served in developing new portable phones, some of which became new export articles.

In 1966, Suomen Kaapelitehdas was merged with *Suomen Gummitehdas* and *Nokia*, a 100 year-old paper factory that gave its name to the new corporation. The merger secured further R&D investments in digital technology that was now regarded as one of the strategic business areas.

In the 1970s the state-owned Televa and Nokia founded a joint venture. Combining the forces proved a crucial step towards the later breakthrough of Nokia. The introduction of the digital exchange finally in 1982 had required a lengthy, costly and laborious period of development both in Nokia and Televa. But it was with this product launch that Nokia finally convinced the market of its competence vis-à-vis foreign manufacturers. For years the exchange was for the most successful export article of Nokia

In 1979, Nokia and Salora, in turn, joined their complementary resources. The fifty-fifty owned *Mobira* was established to market and develop radio technology and especially the NMT terminal that was under design in the Nordic Telecom Conference. The joint venture was perfectly timed as it enabled the launch of the first NMT phone approved to the new network. Finally, in the period 1986-87, Nokia got full ownership of both Mobira and the State's share in the joint venture, in which occasion the Finnish telecommunications industry was organised under Nokia's roof.

The introduction of the NMT in 1981-82 marked the start of a fast-expanding new industry. The Conference had an outspoken objective to press down the prices of equipment by promoting technical compatibility and competition between manufacturers.

The Conference made active use of the manufacturers' knowledge during the NTM design phase. In Finland, Mobira was among the most active cooperators providing its expertise in terminal technology. At that time, however, the Finnish industry was not yet able to contribute to the design of the network specifications.[9] There was strong pressure from the PTO's side to engage the industry in cellular exchange development. Ultimately, the alliance between Salora and Nokia (i.e. Mobira) encouraged the companies to supply an NMT base station in 1981 – which later turned out to be crucial in maintaining the position in the emerging market.

Mobira became famous for its 'crazy' organisational spirit that referred to the passionate, pioneering and risk-taking style with which it pursued its ambitious targets both in technology development and internationalisation. The same kind of stamina and general enthusiastic – if not fanatic - attitude towards new radio technology has been seen behind much of the technological progress in the Finnish telecommunications industry.

The second half of the 1980s was a period of intensive foreign market penetration which Mobira fuelled by allying with established local actors.[10] International cooperation taught the company the importance of cost-effective production, effective distribution, marketing and especially the brand - which was later going to distinguish a Nokia phone from other portables in the challenging consumer market.

In the turn of the 1990s, Nokia run into a crisis that was almost to destroy the company. In the search of rapid growth and global market presence the company ran into serious production and financial difficulties. This coincided with the collapse of the Russian trade and abrupt recession in the economy. Coincidentally Nokia was almost taken over by *Ericsson*. The crises gave a stimulus to a drastic dismantling of business sectors - varying from the manufacturing of tissue paper and rubber boots to cable machines and consumer electronics – preserving exclusively the telecommunications activities.

At the same period, however, the world witnessed a wave of mobile market liberalisation. The coinciding boost in global demand for digital mobile equipment and Nokia's global preparedness in providing them virtually saved the company from a dive that would probably have destroyed the company.

Motivated by the recession hitting hard on consumer demand, Nokia was the first mobile phone manufacturer to invent the key to the end-user markets. It was crucial to dismantle the luxurious image of the portable phone. Consumers were approached with softer aesthetic design and user-friendlier customer interface, which turned out to be more important than introducing new technical solutions in each new model.

In 1999, Nokia accounted for about 30 per cent of the world's mobile phone market, and the phones represented two thirds of the group's turnover.

4.2. The facets of the competitive advantage

Firm strategy, structure and rivalry

Nokia dominates the ICT cluster both by size and effect. The share of the company's domestic sales of the cluster turnover was close to 50 per cent and of the cluster exports 66 per cent in 1998. Nokia is not alone, though. There are several Finnish firms in the **equipment industry** that have found narrow niches in the global market. Especially in the wireless technology Finnish

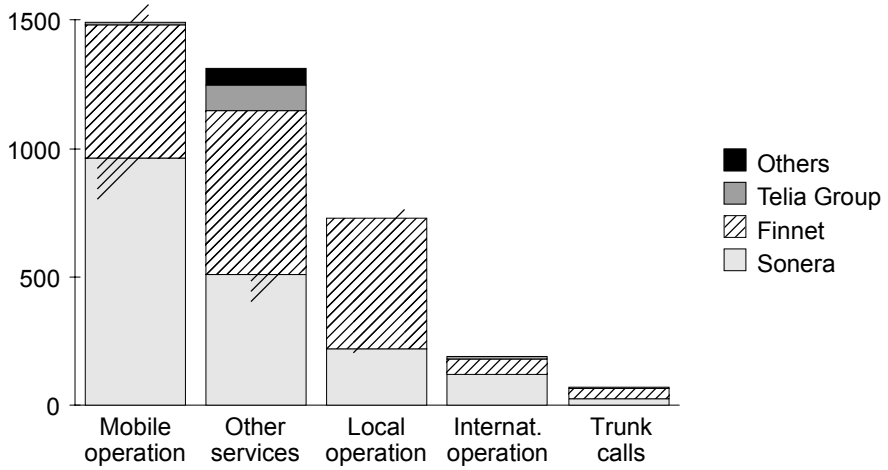
firms have got a head start, and some of them are likely to climb to the top of the ranking list (table 4.1) in the near future.

Comptel has attained world's leading position in mediation device solutions (subscriber data management solutions for operators). *Tecnomen* was the first to develop a unified messaging system and leads now the market of enhanced network service systems. In spring 2000, *Iobox,* one of the myriad of new technology based start-ups, was named as one of the 100 most important companies in the world by Red Herring (a technology business magazine).[11] The company offers localised mobile content services over different platforms. *SSH Communications Security, F-Secure* and *Softstone* have established their positions in narrow but fast growing niches in the highly fragmented data security industry.[12] In fact, the network security solutions are becoming the backbone sector of the Finnish software industry. *Benefon* – founded by an ex-manager of Nokia - has attacked a global niche with analogue and GSM/GPS navigator phones. *Linux* is a particular chapter in the Finnish ICT history. With its reputation as an efficient, fast-performing and low-cost system, Linux has been suggested as a possible alternative to *Microsoft's* predominance. [13]

The small home market and global competition define the scope and perspective of company strategies. The Finnish market provides a valuable development and test ground, but the actual business environment and reference groups are global from the early outset.

In 1999, there were over 120 **telecommunications operators**, some of which operate on leased network capacity. Despite the high number of participants and fully liberal competition, the market is dominated, by equal shares, by two actors, *Sonera* and the *Finnet Group* (the renamed Association of Telephone Companies, an alliance of 46 private local operators and their jointly owned subsidiaries), which generate 95 per cent of the telecommunications service turnover. Operator market shares in different services are depicted in figure 4.1. Owing to the lack of technically and economically viable solutions, competition in the local loop has not taken place as anticipated.

Figure 4.1 Operator market shares in 1999 (in million Euros)



Source: Ministry of Transport and Communications.
Note: 'Other services' include data transmission incl. ISP, cable-TV, business solutions, equipment sales, international calls of the 'others' (RSL Com Finland, Globetel, Global One, Telenordia) and Telia's advertising and equipment sales units.

In mobile services, Sonera's main competitor Radiolinja is owned by the largest private operator *Elisa Communications*. Swedish *Telia* has not succeeded in eroding any significant share of the GSM market since its entrance in 1997.[14] The third national GSM licence was granted in 2000 for a group of private operators.

Table 4.1 Some Finnish ICT cluster firms in 1999

Firm	Line of business	Sales (mEUR)	Personnel
FINNISH FIRMS			
NOKIA*	phones and network systems	116,654	51,177
SONERA*	telecom operator	10,991	9,270
TIETOENATOR*	IT solutions	7,251	11,058
ELISA COMMUNICATIONS*	telecom operator	6,364	5,489
ELCOTEQ NETWORK*	electronic manufacturing services	4,439	4,733
NOVO GROUP	IT solutions	1,841	2,100
PERLOS*	mobile phone enclosures	1,674	1,378
ASPOCOMP*	printed circuit boards	1,186	1,886
PKC GROUP*	communications cables	673	730
SCANFIL	mechanics and electronics manuf.	631	756
JOT AUTOMATION GROUP *	industry automation	586	565
EIMO*	mobile phone enclosures	460	681
DATATIE	data network services	420	255
TECNOMEN	enhanced network service systems	301	430
SAMLINK	electronic banking systems	268	229
BENEFON	mobile phones	233	296
FOREIGN ACQUISITIONS (acquierer/new name in parentheses**)			
NOKIA DATA (**ICL INVIA***)	information technology	2,099	2,000
MARTIS (**TELLABS***)	network access and transfer systems	*2,088*	*902*
NK CABLES (DRAKA HOLDING NV)	communications cables	*1,638*	*1,221*
KYREL EMS (**FLEXTRONICS INTL. FINLAND**)	electronic manufacturing services	*861*	*532*
SALORA-LUXOR (**SEMI-TECH TURKU**)	televisions	*711*	*700*
NOKIA MAILLEFER (**NEXTROM**)	communications cables	*697*	*390*
LK-PRODUCTS (FILTRONIC PLC)	RF filters, access products, antennas	*496*	*849*
SOLITRA (**ADC TELECOMMUNICATIONS**)	integrated RF solutions	*382*	*802*
ENVISET (**ESSEX COMMUNICATION EMS**)	electronic manufacturing services	*349*	*278*
FOREIGN FIRMS WITH R&D			
HEWLET-PACKARD	information technology	*2,230*	na
ICL	information technology	2,099	1,902
SIEMENS	phones and network systems	1,774	1,329
ERICSSON LM	phones and network systems	1,140	1,056

Note: Figures in *italics* are 1998 data.
* Consolidate figures. ** Figures refer to the companies in **bold**.

Cable and electrical networks do not yet support interactive communications in Finland, mainly due technical and economical impediments. However, the network owners will exploit their infrastructures in communications service provision in the near future.

Finland granted UMTS licences for all four GSM operators in early 1999, first in the world. In the same year, licences in digital-TV operation were granted. It is expected that the analogue TV network could be waived by the end of 2006.

In the recent years, the Finnet Group has been breaking up into smaller camps due tightening competition that has aroused friction within the Group. As the revenue from basic telephony services is declining, operators need to specify their strengths and refocus their strategies. Some companies have enlarged their service base by mergers and acquisitions over traditional sector boundaries. Private companies also envisage cooperation in UMTS service provision. However, knowledge of and credibility in the local market are valuable assets on which local operators may build their customer relationship management strategies.

Network services and infrastructure provision are separating as operator business areas, since network capacity is accessible to any service provider. In view of declining return on investment some operators are planning on withdrawing from network ownership. For example, Sonera's purposeful service development and brand building are directing the company increasingly away from network operation.

Liberalisation and new business opportunities in the global arena have motivated some operators to increase their international operations. Foreign subsidiaries as well as international joint ventures in mobile operation, and international R&D cooperation in new technology are strong indications of the swift revolution in the once monopolised and regulated market.[15]

However, according to industry expectations there will be virtually room for four to five global telecommunications companies. There is a fervent battle for market positions going on in the global market. Governments are moving aside from their traditional domain to free the hands of the national players. Consequently, Sonera and Elisa Communications are looking for global partners with whom to share the uncertain future.

Factor conditions

Liberalisation of capital markets at the end of 1980s has remodelled the institutional environment of corporate funding. Firms have access to international resources, and especially the emergence of venture capitalists during the 1990s has opened unparalleled opportunities for innovative technology-based start-ups to enter the market in a very early phase of product development. Successful investment cases in the turn of the 2000s have boosted the amount of available venture capital, which has actually become the most common source of capital for start-ups. The share of the ICT cluster of total capital investments has been around 30 per cent during the last years.

The availability of venture capital has reshaped the role of public risk funding traditionally the prime resource for risky enterprises. There has become new kinds of investment syndicates where the public sector carries the technology risk and a venture capitalist the commercial risk of an enterprise.

The improved accessibility of capital has drawn more professional and growth-oriented entrepreneurs into the field. Respectively, the investors are more field-specialised due the increased number of funds and investment companies. As a result, start-up enterprises have become more ambitious with greatly improved potential of successful international launch.[16]

The strong growth in the capital market has been one of the most noteworthy contributors to the ICT cluster growth and increased versatility. Further, a phenomenon like Nokia would not have been possible for a small country like Finland without foreign capital investments. Foreign ownership (around 90% in Nokia) shares the ownership risk in a country that is increasingly dependent of the unsettled ICT sector.

The level of R&D investments on ICT has been in intensive growth. However, the bottleneck impeding full-scale exploitation of the available funding is the shortage of skilled labour. Owing to the lengthy lead-time in education, increased intake has not yet alleviated the problem. (See chapter 5 for more detailed discussion on human resources and R&D activities.)

Demand conditions

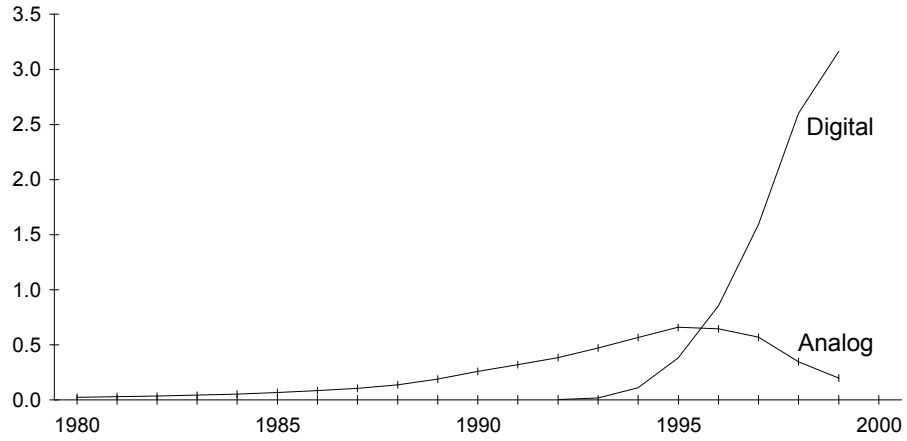
Since 1996, Finland has been the leader in mobile penetration (figure 4.2). In 1998, mobile subscribers outnumbered wired subscribers. Mobile phones

have established their role as consumer products; in 1999, households held more mobile phones (78,5%) than fixed telephones (75,8%). Altogether, 60 per cent of households have both terminals, while 20 per cent of them rely solely on mobile communications. Furthermore, mobile phone replacements have exceeded the number of new subscriptions.[17]

Consequently, the share of fixed communications of operator turnover is declining at the expense of mobile communications - from 99,7% to 40% between 1991-99. However, the rapid increase of ISDN subscriptions, due to growing Internet penetration has supported the demand for fixed line services. Finland ranked the first in Internet host penetration rate, by 121 per 1000 inhabitants in 1999.[18]

Demand for analogue services has been vanishing since the introduction of digital network (figure 4.2). In fact, analogue services are being closed down to release frequencies for digital services. The decline has been supported by favourable pricing and more elaborate service supply in the digital networks.

Figure 4.2 Number of analogue and digital subscriptions (millions)



Source: Ministry of Transport and Communications.

Since the liberalisation, the general telecommunications price level has declined about 25 per cent in real terms – in mobile and international calls in particular.[19] The threat of competition pressed prices already before its full opening and made Finnish telecommunications services cheapest in OECD comparison in mid-1990s. However, along with the OECD market liberalisation, Finland's efficiency in fixed line charges has deteriorated – yet in line with the general rebalancing trend (towards higher local charges) in member countries. However, in data (including Internet) and digital mobile services Finland is leading in lowest pricing in the OECD in 1998.[20] Low pricing – together with the introduction of cheaper portable phones replacing auto phones – were major factors behind the breakthrough of mobile communications.

The enthusiasm of the Finns in adopting the mobile phone has been attempted to explain by the technology-attracted nature of the people. Also the high level of basic education has been seen behind high mobile diffusion. All the same, the home market has provided technology developers a fruitful ground to experiment future products and services. After the global breakthrough of Nokia and Sonera the Finns seem to have adopted mobile phones as a symbol of nationalism.

In the early 1990s, Nokia utilised the advanced home market to develop consumer-oriented terminals. New models were designed to reflect individual life-styles and consumer aspirations investigated in polls – an innovation that was soon imitated by competitors. Today, the Finnish market has lost its importance in absolute terms (2 per cent of Nokia's total revenue) in global operations, but the market still serves as an important laboratory since the domestic demand anticipates future trends in foreign markets.

The client-supplier relationship between the operator and the manufacturing sectors has a long tradition in cooperation. To be able to exploit the variety of competing equipment operators needed to build up their technical knowhow required in matching up different network solutions. Consequently, they developed into advanced and demanding collaborators with which manufacturers designed networks.

Supporting and related industries

In the recent years, the structure of the ICT cluster has reached sufficient scale and scope to support competitive global operation. The domestic **supporting sector** has evolved very specialised for the needs of the original ICT equipment manufacturers (OEM). The growth in production volume *and* in the share of outsourcing, together with increasingly sophisticated needs of the key companies have generated an ever growing number of new suppliers. By the same token, established firms have been encouraged to redirect their production towards the needs of telecommunications growth companies.

The Finnish supplier sector has focused on highly customised inputs while in standard components - requiring large scale and effective distribution channels - Finnish OEMs rely on imports. No less than 92 per cent of the electronic component market value is composed of imports.[21] In the domestic market, special competence can be found in contract manufacturing of parts and components (e.g. ASIC, rf-filters, printed circuit board production and surface mounting technology, hybrid circuits, silicon wafers), electronic manufacturing services (EMS), automation and precision mouldings.

Nokia has been an exceptional as compared with many other ICT manufacturers in that it has not component production of its own. Instead, it relies on market supply, which on one hand guarantees independence of basic technologies, but on the other, makes the company reliant of outside resources. Owing to established supplier relationships and market power, Nokia has succeeded in ensuring sufficient inflow of components even during global shortage. For smaller actors, however, scarce supply has created bottlenecks in production.

The increased outsourcing of OEMs has transferred an important share of activities to EMS companies. Their service may include complete production process, from component sourcing and production design to production, testing and delivery to the customer's distribution channels. The OEM does not necessarily need to take in the end product at all. There are some 240 companies in the field whose total value of gross production has grown at an average rate of 25 per cent over the last five years.[22] Companies have expanded not only organically but also by acquiring manufacturing works of their customers.

Many supplier relationships have been stretched to OEMs' foreign markets. Suppliers' global presence has become increasingly important for efficient outsourcing. This has created great growth opportunities - but also risks for

relatively small Finnish firms since foreign investment decisions can not rely on one customer relationship.

Providing generic technology, the ICT has a constantly growing number of **related industries**, producing complementary or value-adding services to the infrastructure. The industries with most promising prospects are those producing digital content.

The digital content industry in Finland is in its early phase of evolution. There are numerous signs of an emerging industry, but innovative enterprises still often lack the skills crucial in professional business development and large-scale market penetration.

However, favourable development and global competence of the Finnish content industry have high rankings on the national agenda (see also section *Government*). In 1999, the government initiated the *Content Finland Programme*, an inter-ministerial agenda for the period 2000-2003 to improve the preconditions of Finland to develop in a leading country in providing – in addition to telecommunications technology – content industrial products. It contains eight ministries under which new content products for a wide range of application areas will be developed in cooperation with businesses and other financiers.[23]

In Finland, the sectoral boundaries between the communications and the media industries have blurred in line with the international trend. There was an intensive wave of mergers within the media industry in the late 1990s: two major multimedia groups, *SanomaWSOY* and *Alma Media*, were created by merging companies in different media sectors. In the same period, the media houses made important territorial conquests towards the ICT key activities. [24]

Government

The original cluster study in Finland was coordinated by ETLA in the early 1990s.[25] The study was exploited by the Ministry of Trade and Industry in preparing new policy guidelines, outlined in the *National Industrial Strategy*.[26] However, the government did not delineate any targeted 'cluster policies', but instead clusters have been widely used as conceptual tools in industrial policy design by a number of national institutions. Perhaps most importantly, cluster thinking has been effective in creating a dialogue between the public sector and cluster parties by providing them a common language.[27]

Even though all government actions matter for the national competitiveness, *competition, technology* and *education* are the domains in which policy actions have most direct effects on the ICT cluster.

Competition policy. The regulatory approach in telecommunications policy bases on pro-competitive policy, light handed regulation and technology neutral competition. The market is subject to general competition and consumer protection legislation. The telecommunications authorities pursue minimum interference policy, intruding mainly in cases of inadequate competition. The approach is less interventionist than in many other OECD countries. Some mandatory EU requirements have been enforced reluctantly in Finland, regarded as regressive to the liberal market functioning.[28]

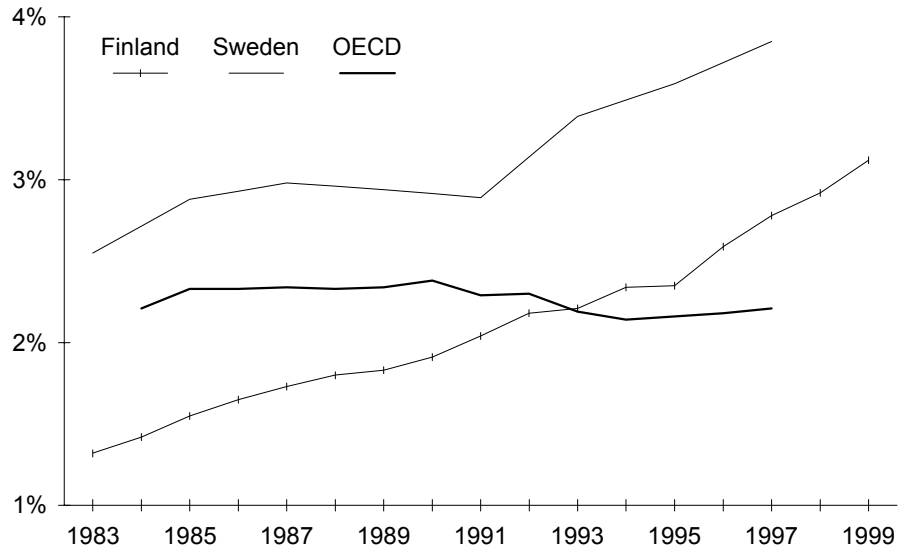
Despite the policy objective to enhance high speed transmission capacity in Finland, the government decided in 2000 – unlike in Sweden - not to engage in direct infrastructure provision, to insure technology neutrality and free functioning of the market. In line with the liberal policy, Finland granted the

third generation network licences free of charges in comparative tendering, among few countries to date, to support free distribution of new technology.[29]

By the mandate of the Parliament, the government is intending to withdraw from the telecommunications business. Yet, there has been political debate on the share the state should ideally retain in the nationally important sector.

Technology policy. In 1999, the R&D expenditure in Finland reached EUR 3,7 billion, representing over 3 per cent of the GDP. With this share Finland ranks the second in the world in R&D input, which reflects the government's decision in 1996 to increase systematically R&D funding (figure 4.3).[30] The target for years 2001-2004 is to increase the funding in line with the GDP growth rate. The share of public R&D funding was stipulated at 40 per cent, but due to intense growth in private R&D investment the share has rather declined, being about 30 per cent in 1999. The public decision to increase the level of R&D funding was made in counter to significant downsizing of general public expenditure throughout the 1990s. Specific attention has been attached to the cross-sectoral diffusion of knowledge, thus, a share of these funds was directed to sectoral ministries' cluster programmes.

Figure 4.3 R&D expenditure in some OECD countries (% of GDP)



Source: OECD, Main Science and Technology Indicators 1999.

The convergence and globalisation have compelled the public funding to be redirected from technology-orientation (forepart of the innovation chain) towards market-orientation (end of the chain). The new approach has materialised in a series of digital media technology programmes, catalysing export-oriented digital content service production.[31] Contrary to established technology-oriented practice, R&D funding has been allocated also to *service* development, to support creation of interactive multimedia concepts and production platforms. Important weight has been put on cooperation between actors in different phases of the value chain, including newly emerged venture capitalists.

Education policy. The rapid growth in the electronics industry has exhausted the resources of available skilled labour. The government has reacted by increasing openings in higher education institutions. Between 1993-98, the total intake in universities grew nearly twofold and in polytechnics nearly three-

fold. However, this has not erased the chronic lack of educated labour in the cluster.

In early 1998, the government adopted a programme for increasing education in the information industry fields between 1998-2002. The programme includes both ad hoc measures and permanent increases in the offering of professional education, concerning in total over 20,000 students.[32] Since 1999, there are 12 postgraduate schools in information technology in which the number of students has also been increased.

Coincidental factors

The turn of the 1990s contained several external incidents with significant repercussions on the Finnish ICT cluster - turning the electronics industry ultimately to an average 30 per cent annual growth rate.

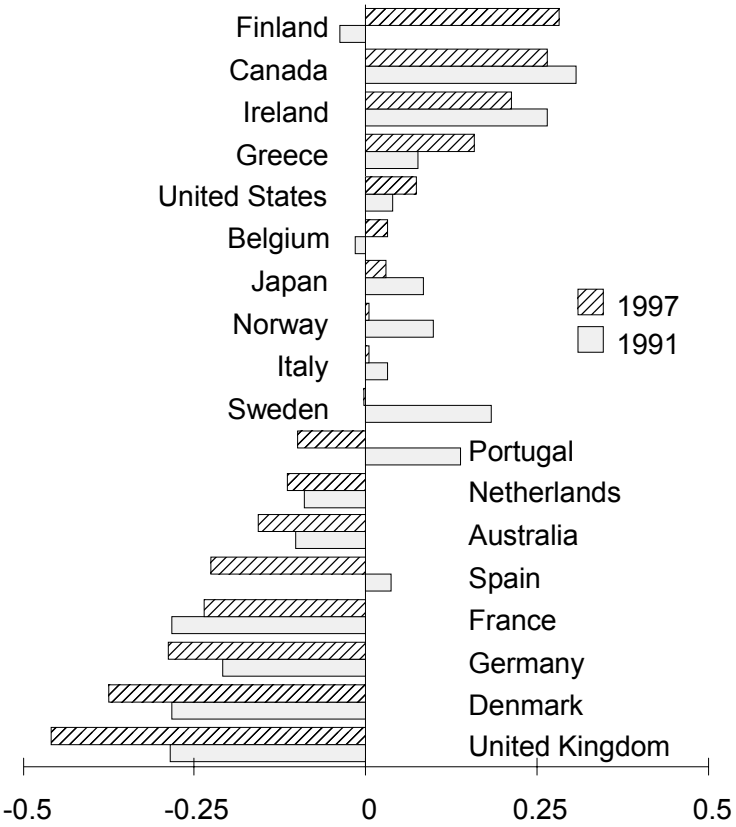
The most influential external factor was the worldwide deregulation of telecommunications. Between 1989 and 1999 the number of mobile operators increased from 35 to 94.[33] The opening of the East European markets gave an additional boost to the demand for mobile equipment. In contrast, the collapse of the Soviet Union and the deepest recession of the century in the Finnish economy hit hard on the cluster's demand in the first half of the 1990s.

Simultaneously, GSM licence application of Radiolinja and the subsequent liberalisation of the Finnish market gave an important boost and a first mover advantage to the Finnish cluster. Had Radiolinja postponed the licence application, the funding sources – abundant in the late 1980s - would have probably dried up on the edge of the economic slump about two years later.

5. Cluster innovation patterns

In OECD comparison, the share of private ICT-related R&D of total manufacturing R&D was highest in Finland in 1998 (figure 5.1). The relative increase of the share is remarkable between 1991 and 1997, as Finland has turned from a below-average investor into a leader. In Finland, the expansion of the exports has been highly attributable to domestic R&D activities, unlike, say, in Ireland where high ICT export rates tended to rely on imported capital and technology.[34]

Figure 5.1 ICT R&D specialisation in some countries in 1991 and 1997 (RSCA index)



Source: OECD, ANBERD.
Note: See Appendix 2 for the RSCA index formula applied here.

The share of the electronics industry is two thirds of total private R&D expenditure, which is highly attributable to Nokia. The company's position in the national R&D field in its own class. The company accounts for more than 20 per cent of the total national R&D expenditure.[35] The R&D intake has grown in line with the company's net sales, thus at an accelerating rate over the last years.

Finland has become an experiment and research field for a number of multinational ICT manufacturers (e.g. *ICL, IBM, Siemens, Hewlett Packard, Ericsson, Lotus)*. They have also intensified cooperation with local firms, and some have entered the market by acquisitions. [36] Finnish-based R&D units are considered as knowledge sources or training centres from which employees are sent to other units to distribute the latest information on technological development, especially in wireless communications.

Finland has remained the main R&D base also for Nokia despite its network of 52 research centres in 14 countries. According to an estimate, around 60 per cent of the company's R&D input are spent in Finland.[37]

Since the mid-1990s, there has been a strong tendency towards intensified collaboration in the ICT sector. Nokia has acted as an effective catalyst in the cluster. One of its key strategies is to engage actively in R&D co-operation with technology firms to induce innovation and to stay in the technological lead. The number of the first-tier high-tech partnerships has been estimated to total some 300 companies in Finland.

There are still plenty of opportunities to be reaped. Our ongoing study on vertical relationships in the Finnish ICT cluster implies that the suppliers would be willing to expand further the client relationship and to take more responsibility in the design phase of product development.

Technology development in supplier firms is often client-dependent. However, as indicated by our study, R&D cooperation has not overpowered independent technology development. As Nokia-dependence tends to grow excessive in many supplier firms, many of them regard individual product development as an important means of retaining or increasing independence of clients. The more generic the product, or the less strategic position the supplier has in the network, the more important it is for the firm to improve its skills in different fields of the core competence.

Telecommunications equipment and network services contain an ever-growing amount of software, which has switched the focus of both manufacturers and operators, like Nokia and Sonera, heavily towards software development. Proportionally, Sonera has become one of the most R&D intensive operators (table 5.1), while Nokia's R&D allocation was in 1997, perhaps surprisingly, below industry average. However, in the light of current market capitalisation Nokia seem to have been relatively effective in exploiting the fruit of investments.

Table 5.1 R&D expenditures as % of total revenue for some telecommunications equipment manufacturers and operators in 1997

Manufacturer		Operator	
Ericsson	14.5	AllTEL	6.3
Nortel	13.9	Sonera	3.5
Lucent	11.5	France Telecom	3.4
AVERAGE	**9.9**	Telia	3.3
Motorola	9.2	NTT	3.1
Alcatel	8.9	Telenor	3.1
Nokia	8.7	**AVERAGE**	**2.5**
Fujitsu	7.8	BT	2.0
Siemens	7.6	Deutsche Telecom	1.8
NEC	7.0	AT&T	1.6
		Vodaphone	1.4
		Cable&Wireless	1.2
		KDD	1.0
		KPN Telecom	0.8

Source: OECD.

The interaction between the industry and ICT-oriented universities (in Helsinki, Lappeenranta, Oulu and Tampere) has active and long traditions in product and process development. An important party in the science-industry dialogue is also the *Technical Research Centre* (*VTT*; founded in 1941), the largest public research unit in Finland. VTT's research projects are mainly comissioned by organisations – both private and public - in which VTT applies its expertise in electronics, information technology and automation.

Especially earlier in the history, boundaries between industrial and science organisations tended to blur in R&D cooperation - in which the intellectual property rights of the object were not the premier concern. Intrinsic enthusiasm towards new technology, and in many cases personal relationships built during studentship, have been strong drivers in cooperation. Today, ICT academics still have strong connections to the industry e.g. through a number of board memberships.

The shortage of skilled employees has further activated the discourse between the universities and the industry. Companies communicate their needs concerning skill requirements, and they participate in training and education in polytechnics and universities. As the skills currently required by companies can not often be found in textbooks, on-line knowledge transfer from the industry has been regarded as a crucial means of improving the level of education. Consequently, the industry has engaged in contributing to the implementation of the government programme for increasing education in the information fields.

6. Conclusions: government policies and cluster dynamics

The Finnish ICT cluster has been evolving for a hundred years. From the outset, certain government actions have served as a crucial catalyst in the development of the telecommunications industry. The cluster as we see it today looks like a product of a master plan in industrial policy: an internationally attractive and vigorous industrial system boosting innovation and external trade.

If we consider the role of the government in the cluster evolution process the primary motives and initiative in implementing telecommunications industry-related policies have varied over time. However, ultimately a great majority of the actions have served as the 'appropriate' measures of the government that Porter (as in Rouvinen and Ylä-Anttila, 1999) has identified, creating a context that encourages upgrading and establishes a stable economic and political environment.

The most influential policy measures have been those affecting the competitive environment of the cluster. Unlike in most of the countries, the government granted local operator licences to a great number of companies. At the end of the 19th century, the dispersed market structure was motivated by the Finnish Senate's objective to ensure sovereignty in telecommunications under the Tsar's reign. It is also noteworthy that after the independence the numerous political attempts to nationalise private operation did not realise.[38]

Regardless of self-legislative motives, this strategy proved most invaluable for the subsequent technological development of the telephony network. *First*, individual operators pursued early adoption of the latest network technology - mostly in order to outperform neighbouring operators and thus, to promote community authority.[39] Probably under public ownership there would not have been equal ambition nor financial means to construct as an advanced infrastructure as there were under private interest, for in the first half of the 20th century public resources were in scarce supply. *Second*, the telephone companies were mostly cooperatives pursuing the interests of their owners. This objective materialised in technical improvements and cost-based pricing. *Third*, a large number of operators provided a customer base for several (foreign) equipment manufacturers. They regarded the Finnish market as an important test field for new technology, and thus the operators could choose among a variety of competing solutions.

The division of infrastructure between public and private ownership had its repercussions, as well. To struggle against the threat of public take-over private operators needed to keep up with upgrading equipment and to join their forces to oppose the national carrier-regulator. Owing to the long tradition in a kind of a duopolist market, the preconditions for equitable competition were in place after the full liberalisation in 1994 – unlike in many liberalised monopoly markets where the incumbent tends to thwart emerging competition.

Another 'peculiarity' in the Finnish market has been competition in equipment supply. Unlike in many other countries, there has not been an exclusive relationship between a monopolistic manufacturer and the PTO. *Televa* as the primary (but not exclusive) state-owned supplier for public establishments was not capable of assuming the role of an exclusive purveyor, and thus it could not replace foreign supply. As foreign manufacturers had production facilities in Finland there was no political interest to favour inferior domestic technology, and therefore, the borders were kept open for foreign supply. This environment was extremely challenging for the emerging domestic industry.

The combination of dispersed ownership and free supply of equipment provided for independent decision making in operator companies. This in turn had dynamic effects on the industry evolution. To enhance supplier-independence operators needed to develop their technical knowhow so as to be able to match a variety of incompatible equipment. In this manner competent operators were even able to press the price below the level prevailing in foreign suppliers' monopolised home markets. In addition, it made these operators not only advanced and demanding customers, but also valuable collaborators for manufacturers. Finnish operators' knowhow in interface technology was appreciated in international markets where operators were usually tied to a single supplier's equipment.

Government bodies have played the crucial role of a demanding customer, which is one of the "proper" tools of industrial policy. During the early stages, in 1960s and 1970s particularly, authorities ordered frequently solutions to their communications need (closed networks). In the most decisive case by the Army, a couple of firms with incubating knowhow on radio technology got the required motive to come out with physical products, which virtually served as prototypes for exportables.

The role of the PTO as an insistent and proficient customer materialised in particular in the requirement for the first analogue mobile exchange, despite Nokia's firm reluctance. It is questionable whether the company would have got a comparable first-mover advantage in the opening market without the PTO's persistence.

In the role of the national administrator the PTO decided on the participation in the Nordic cooperation in mobile network construction, which virtually paved the way of the industry to the vanguard of international mobile markets. Like in other European countries, the PTO was management-driven with extensive independence in decision making. The role of the government was to grant funds for prolonged and resource-intensive network investments according to the PTO's submission. The patient, arm's-length government control proved perfect as the PTO management was well ahead of its time. The Nordic cooperation guaranteed the participants a position in the later GSM design forum. For the industry, the Nordic market became an invaluable training centre for future challenges.

The decisive stimulus for the liberalisation came from private operators. The first signals of the end of the static state where received at the end of the 1970s, when they started to fight for the right to provide data services, which they got in 1988 after a painstaking dispute and a new Telecommunications Act. The licence for mobile operation required even stronger willpower, turning ultimately into a political dispute. The manoeuvre to penetrate the state's overpowered domain had wider repercussions than anybody initially anticipated: At the end of the day, the whole telecommunication field was opened to competition, among the first in the world.[40]

In the retrospect, it seems astonishing that the political arm-wrestling provoked by the second GSM licence application did not incite any industrial policy considerations. The focus was primarily on ideological issues and on the economic justification of parallel networks in a small country.[41]

However, once opened, competition in mobile networks spurred quick growth in telecommunications services through declining prices and improved service. Had there been no competitive pressure, the PTO would have postponed the introduction of the digital mobile network, since there were still important profits to be reaped from the analogue NMT network investments.[42] For the

equipment industry, the delivery of the network for *Radiolinja*, the first GSM operator in the world, was a reference that lifted it to the international stage. In the subsequent international wave of liberalisation, Nokia was well equipped to take off.

Apparently, there was a pinch of good luck, rather than well-thought-out policy objectives behind the perfect timing of liberalisation, the implications of which were momentous: The Finnish telecommunications sector got a head start in the exploding GSM market, and its stimulus was substantial in supporting the revival and restructuring of the economy.

All in all, the Finnish ICT cluster case presents a good example of the fact that virtually all government actions – intentional and unintentional - have implications for national competitiveness via the dynamic system or 'diamond' of the cluster.[43]

Finally, the turn of the 1990s marks a change in the government approach in economic and industrial policy. Public ownership and the regulatory framework were seen in a new, more liberal light – with direct implications to the ICT cluster. The concept of national innovation system was adopted in policy outlines.[44] The *National Industrial Strategy* [45] was shaped on the basis of the cluster approach, which has had clear reflections on subsequent government actions emphasising inter-organisational cooperation as well as accumulation and transfer of knowhow.

Once started the swift liberalisation and deregulation of the telecommunications clearly reflected calculated and industrial policy-oriented consideration of the authorities. During the liberalisation process, the Ministry of Transport and Communications adopted a broad-minded and problem-solving orientation and communicated actively with the parties concerned. After the GSM licence dispute politics have not played a role in the industry administration, but decisions have been directed by competitive and technological objectives.[46]

The growth of the ICT cluster to the third major export sector has been considerable (see figure 4.3). It has finally lessened the economy's dependence of the fluctuating raw material based industries. Further, the economy is increasingly relying on a sector that has incredible growth potential and that relies on created factors of production. Hence, the well being of the cluster creates welfare to the economy. As a consequence, the dialogue between the public sector and the industry has become very close and active – perhaps more so than in many other countries. The scale of the future challenge is of such magnitude for a small open economy that the government and the industry can no longer operate separately.

Appendix 1: The NACE codes utilised in the calculation of economic indicators for the ICT cluster

ICT Manufacturing

32100 Manufacture of electronic components

30020 Manufacture of computers etc

31300 Manufacture of insulated wire and cable

32200 Manufacture of radio transmitters etc

32300 Manufacture of radio receivers etc

ICT Services

Telecom services

64201 Telephone communication

64202 Other telecommunications

64203 Data transmission services

Software and IT services

72100 Hardware consultancy

72200 Software consultancy and supply

72300 Data processing

72500 Maintenance of office machinery etc

Appendix 2: Measuring the export specialisation of a country

Specialisation of a country in product exports can be measured by RCA (Revealed Comparative Advantage) index, which is calculated as follows:

$$RSA_{ij} = \frac{X_{ij} \Big/ \sum_i X_{ij}}{\sum_j X_{ij} \Big/ \sum_i \sum_j X_{ij}},$$

where X_{ij} is the exports of the cluster *i* from the country *j,* and $\sum_i X_{ij}$ is total exports from the country. The nominator calculates the share of the OECD cluster *i* (the sum of the cluster *i* exports from all the OECD countries) of total OECD exports.

RSA can be scaled between –1 and 1, which yields RSCA (Revealed Symmetric Comparative Advantage) index. If RSCA index equals zero, a country is as specialised in the cluster *i* exports as the OECD in average. If RSCA index exceeds zero, the country is specialised in the cluster exports.

References

Ali-Yrkkö J., Paija L., Reilly C. & Ylä-Anttila P. (2000), *Nokia – a big company in a small country*. ETLA – The Research Institute of the Finnish Economy, Series B162. Helsinki: Taloustieto.

Hernesniemi H., Lammi M. & Ylä-Anttila P. (1996), *Advantage Finland – The future of Finnish Industries*. ETLA – The Research Institute of the Finnish Economy, Series B113. Helsinki: Taloustieto.

Hienonen R. (2000), *Elektroniikan- ja sähköalan kehitysnäkymät 2000…2005*. Helsinki: VTT Automaatio.

Häikiö M. (1998), *Alkuräjähdys*. with English summary: *The Big Bang of GSM – Mobile phone revolution*. The story of Radiolinja, Finland, 1988-1998. Helsinki: Edita.

Ministry of Trade and Industry (1993), *National Industrial Strategy for Finland*. Publication 3/1993. Industry Department. Helsinki.

Ministry of Trade and Industry (1999a), *Elektroniikan sopimusvalmistus*. Report of the electronic manufacturing services (EMS) industry. http://ktm.tt-tietopalvelut.fi/ktm/fin/select1.html

Ministry of Trade and Industry (1999b), *Sisältötuotanto – sisältö- ja kulttuuriteollisuus*. Report of the content industry. Http:/ktm.tietopalvelut.com/ktm/fin/ssisalto1.html

Ministry of Transport and Communications (1999), *Suomen telemaksujen hintataso*, Publications 14/99.Helsinki.

Ministry of Transport and Communications (2000a), *Case Mobile Finland*, Publications 16/2000. Helsinki.

Ministry of Transport and Communications (2000b), *Televiestintätilasto 2000*. Helsinki.

Mäenpää K. & Luukkainen S. (1994), *Teletekniikasta monimuotoiseen viestintään – Teleklusterin kilpailukyky*. ETLA– The Research Institute of the Finnish Economy, Series B96. Helsinki: Taloustieto.

Mäkinen M. (1995), *Nokia Saga*. Jyväskylä: Gummerus.

OECD (1999), *Communications outlook 1999*.

OECD (2000), *Cellular mobile pricing structures and trends*. DSTI/ICCP/TISP(99)11/FINAL.

Paija L. & Ylä-Anttila P.(1996), *The impact of structure and competition on employment in the telecommunications cluster – case Finland*. ETLA - The Research Institute of the Finnish Economy, Discussion Papers no. 549. Paper presented at the OECD Workshop on Economics of the Information Society, Istanbul Dec. 14-15, 1995.

Pajarinen M, Rouvinen P. & Ylä-Anttila P. (1998), *Small country strategies in global competition. Benchmarking the Finnish case*. ETLA - The Research Institute of the Finnish Economy, Series B144, SITRA 203. Distributed by Taloustieto., Helsinki.

Porter M. (1990), *The competitive advantage of nations*. London: The Macmillan Press Ltd.

Puhakka M., Rönkkö P. & Steinbock D.(2000), *Growth and internationalisation of technology-based, new companies within the Finnish ICT cluster*. In the forthcoming ICT cluster study report of ETLA - The Research Institute of the Finnish Economy.

Pulkkinen M. (1996*), Miten jättiläisiä horjutetaan?* In: Miksi Nokia, Finland? Eds: Lemola T. & Lovio R. Juva: WSOY.

Pulkkinen M. (1997), *The breakthrough of Nokia mobile phones*, Doctoral Dissertation. Helsinki School of Economics and Business Administration, A-122.

Romanainen J. (2000), *Cluster approach in technology policy*. A presentation outline distributed in the OECD Cluster Focus Group workshop 'Do clusters matter in innovation policy?' in 8-9 May 2000 in Utrecht, the Netherlands. TEKES – the National Technology Agency.

Rouvinen P. & Ylä-Anttila (1999), *Finnish cluster studies and new industrial policy making*. In OECD, Boosting Innovation – the cluster approach.

Tavaila P. (1989), *Suomen teletoimen organisaation kehittyminen*. In: Ministry of Transport and Communications, Televiestintätilasto 1989.

TEKES – the National Technology Agent (1999), *Suomalainen uusmedia – Eväät kasvuun ja kansainvälistymiseen*. Technology Programme Report 3/1999.

Toivola K. (1992), *Poimintoja teletoimen historiasta*, vol.4. TELE Matkaviestinverkot.

Turpeinen O. (1996), *Yhdistämme*, vol.1-2. Helsinki: Edita.

Statistics Finland (2000), *Joukkoviestimet - Finnish Mass Media 2000*. Helsinki.

Endnotes

[1] Luukkainen & Mäenpää (1994) carried out the telecommunications cluster study as part of the national cluster identification project, coordinated by ETLA (Hernesniemi et al., 1995).

[2] Clusters do not follow sectoral boundaries. Sectoral data inevitably includes firms not active in the cluster, and alternatively, excludes many important actors. For example, national statistics do not yet enable quantification of digital content production, which is however largely included in the data on telecom operation and software production. Further, it is necessary to combine the data for electronic components (inputs) and ICT equipment (outputs), since many of the input suppliers are classified under the sector code of their main clients. Despite classification problems, the national data applied here covers the crucial business sectors of the cluster. See Appendix for the NACE codes included.

[3] Ali-Yrkkö, Paija, Reilly & Ylä-Anttila (2000).

[4] Paija & Ylä-Anttila (1996).

[5] Shares of OECD telecommunications exports in 1997:

1.	USA	20.5
2.	Japan	14.5
3.	UK	9.7
4.	Sweden	9.5
5.	Germany	8.6
6.	France	6.1
7.	Finland	4.4
8.	Korea	4.4
9.	Canada	4.2
10.	Mexico	4.2

Source: National Board of Customs.

[6] This was made possible by the Telecommunications Services Act of 1987 that authorised full telecom service provision within concession areas.

[7] In 1970 the turnover of Siemens corporation was FIM 12 billion (EUR 2 billion) of which FIM 3 billion accrued from telecommunications while the total Finnish State budget was FIM 15 billion (Mäkinen, 1995).

[8] Ericsson, Alcatel, ITT and Siemens.

[9] In fact, Salora had been most reluctant to start developing an NMT base station as it was focusing on terminals. Nokia instead had been directing all of its resources on the development of a digital exchange for fixed networks.

[10] For example, Mobira came ashore the US under an OEM agreement with *Tandy Corporation* which offered an extensive distribution channel. Alliance with *Alcatel* and *AEG* for marketing and system development opened the doors of the French and German PTOs and gave credibility to the emerging mobile manufacturer. Cooperation was gradually terminated after the company was capable of independent supply of a GSM system in 1991.

[11] Nokia was the only other Finnish firm ranked in the list.

[12] For example, SSH Communications Security was awarded in 1998 the European IT Prize by Esprit programme of the European Commission as being 'a representative of Europe's strengthening position in information technology and telecommunications'. The cryptography and authentication technology (SSH Secure Shell) for Internet has become a de facto standard for logins.

[13] The kernel (the central part of the operating system) of a UNIX-like operating system was developed by Linus Tordvals at the University of Helsinki in Finland. As a publicly open and free system, extendible by any contributor, it soon gained supporters from all over the world. Linux comes in versions for all the major microprocessor platforms, and it is distributed commercially by a number of companies.

[14] Telia owns networks only in major cities, while for nation-wide services it has a leasing contract with Radiolinja. There are other mobile service providers in the market, as well.

[15] Sonera has 12 joint ventures in mobile operation, and it is actively looking for more. The newly established mobile technology units (*Sonera SmartTrust* and *SoneraZed*) are targeted to international markets. Sonera has a number of alliances with leading global ICT companies with which it develops new solutions for mobile communications. The largest private operator Elisa Communications, in turn, has advanced through acquisitions in the German city carrier market.

[16] Puhakka, Rönkkö & Steinbock (2000) have studied the capital market developments in *Holtron Ltd*.

[17] Ministry of Transport and Communications.

[18] EITO 2000.

[19] Ministry of Transport and Communications.

[20] In digital mobile service prices, Finland ranked first in residential services but seventh in business services. Ministry of Transport and Communications (1999), OECD (Communications Outlook 1999).

[21] Hienonen (2000).

[22] Ministry of Trade and Industry (1999).

[23] Ministry of Trade and Industry (1999), http://www.minedu.fi/opm/hankkeet/sisu/index.html.

[24] In 1998, *Alma Media* was created through the merger of the major newspaper publisher *Aamulehti Group* and the leading commercial TV Channel, *MTV3.* The group is also a major shareholder of the single national commercial radio channel, *Radio Nova.* In 1999, through the merger of *Sanoma,* the largest newspaper house, and *WSOY,* the biggest book publisher and *Helsinki Media,* the second biggest magazine company (the biggest owner of TV Channel Four) was created the second largest multimedia house in the Nordic countries. SanomaWSOY has also cable-TV and high speed data networks as well as ownership in *Finnkino*, the Finnish market leader in movie theatre operations. Both groups hold digital-TV licenses granted in 1999. They have put up new media units to develop and provide digital services, i.e. digital publications, Internet and open mobile portals.

Another cross-border penetration was made by *Talentum*, a leading business and technology magazine publisher, that acquired two Finnish new media companies (*Satama Interactive* and *Sansibar*), and formed a joint venture in content provision with Sonera in 1998.

[25] Hernesniemi et. Al (1996).

[26] Ministry of Trade and Industry (1993).

[27] See Rouvinen & Ylä-Anttila (1999).

[28] Ministry of Transport and Communications.

[29] The choise of third generation technology standard is not restricted by the licence.

[30] According to the decision, a part of the proceeds from privatisation is earmarked for public R&D funding.

[31] Digitaalisen Median Sisältötuotteet (Digital Media Content) Programme initiated in 1996. See: TEKES (1999).

[32] http://www.minedu.fi/minedu/education/

[33] OECD ((2000). According to an OECD study, the number of competing operators correlates positively with the growth of a market, thus the market will be expanding along with further licencing.

[34] See Pajarinen, Rouvinen and Ylä-Anttila (1998).

[35] An estimate since Nokia does not publish country-specific data on R&D expenditure. See Ali-Yrkkö et al. (2000).

[36] In 1999, Hewlett Packard set up the *Mobile E-Services Bazaar*, an innovation centre in Finland to coordinate mobile services development in Europe. The objective is to gather together communications technology developers from different fields to cooperate in innovative e-services development. Nokia, in turn, coordinates *Nokia Artus Developers Program* in which innovators and operator-clients are matched to cooperate in new services development.

[37] Ali-Yrkkö et. al (2000).

[38] There were occasional acquisitions of operators by the state motivated primarily by national defence and technical concerns. Yet, the acquisition of the private trunk network (43% of which under L.M. Ericsson's ownership) was stimulated by economic and nationalistic interests.

[39] To be precise, the technical range of private operators was wide, varying from dilapidated to highly developed, but on the average companies were pursuing technical progress.

[40] With the exception of the NMT network that is being gradually closed down.

[41] Häikiö (1998)

[42] Häikiö (1998).

[43] Rouvinen & Ylä-Anttila (1999).

[44] Romanainen (2000).

[45] Ministry of Trade and Industry (1993).

[46] Häikiö (1998).

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