Chapter 5

CASE STUDY:

Little Finland's Transformation to a Wireless Giant

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Introduction—The 21st Century in Beta?

In the "new economy" boom, Finland became labeled as a country where ". . . the 21st century is in beta" (Wired magazine, September 1999) and, for a time, its corporate icon Nokia was Europe's most valuable company. Technology enthusiasts expected Linux, an open source operating system with Finnish roots, to replace Windows on virtual desktops.

In a decade, Finland went from being one of the least information and communication technologies (ICT) specialized countries to becoming the single most specialized one. Currently the Finnish ICT sector, with Nokia as its locomotive, consists of some 6 thousand firms and accounts for approximately 10 percent of Finland's GDP. Although in what follows ICT is discussed at large, the Finnish story is mostly one of (digital) mobile telecommunications.

In the early 1990s, Finland's prospects seemed gloomy. In 1990, it was hit by the most severe economic crisis in any OECD country since World War II. Real GDP dropped by over 10 percent in just three years, and unemployment had risen to nearly 20 percent by 1994 (Honkapohja and Koskela 1999). Among the factors contributing to the crisis were a downturn in the nationally vital forest-related industries, disruption in the country's sizable eastern trade due to the collapse of the Soviet Union, a speculative bubble in the domestic securities and real estate markets fueled by uncontrolled credit expansion and favorable terms of trade, and mismanaged financial liberalization, which eventually led to credit crunch and excessive private sector indebtedness (Kiander and Vartia 1996).

In the latter half of the 1990s, Finland was nevertheless one of the fastest growing countries in the world. Its remarkable recovery and stellar performance are in considerable part attributable to developments in the ICT sector. But how did Finland become a success story in ICT? Does the Finnish experience hold lessons for other countries?

Section Two provides background information on Finland and its macroeconomic developments as well as a discussion of the country's transformation from a factor- to an innovation-driven economy. Section Three discusses ICT-related history and developments in Finland, with an emphasis primarily on mobile telecommunications. Section Four briefly outlines the key factors underlying the "Finnish miracle." Section Five discusses future prospects for the ICT sector. Finally, Section Six concludes with general considerations of the "Finnish model" and related policy issues.

From Factor- to Innovation-Driven Economy

Historical Backdrop

During the 20th century, Finnish GDP per capita grew at an annual rate of close to 3 percent, that is, faster than in any other European country. Admittedly, as compared to the countries in the vanguard of the first industrial revolution in the late 1800s, the starting point was relatively low. Many of the basic preconditions for growth were nevertheless in place at that time. Institutions such as well-functioning educational and banking systems, as well as a good transportation infrastructure, were important in the take-off phase. Similarly, national identity and culture were strong enough to facilitate economic growth. After completing the liberalization of both internal and external trade by the end of the 1870s, the path for industrial growth and new business activity had opened.

The role of institutions was important, not only in the take-off phase of industrial growth, but also later when the economy moved from factor- to investment-, and later, innovation-driven stages of industrial development.

Finland's most important—and virtually only—endowment of natural resources, forests, proved to be the decisive factor in the take-off phase. Quick advancement in prosperity towards the end of the 1800s and in the early 20th century was based on rapidly growing exports of forest-related products—first timber and later, pulp and paper. From the late 1950s to the late 1970s, the Finnish forest industry carried out massive investments and transformed itself gradually into a global technology leader with the most modern and efficient production capacity in the world (see Raumolin 1992). By the late 1980s, the forest sector had developed into a competitive industrial cluster that today provides high value-added paper grades, as well as forestry technologies and consulting services (Hernesniemi, Lammi, and Ylä-Anttila 1996; Ojainmaa 1994; Rouvinen and Ylä-Anttila 1999).

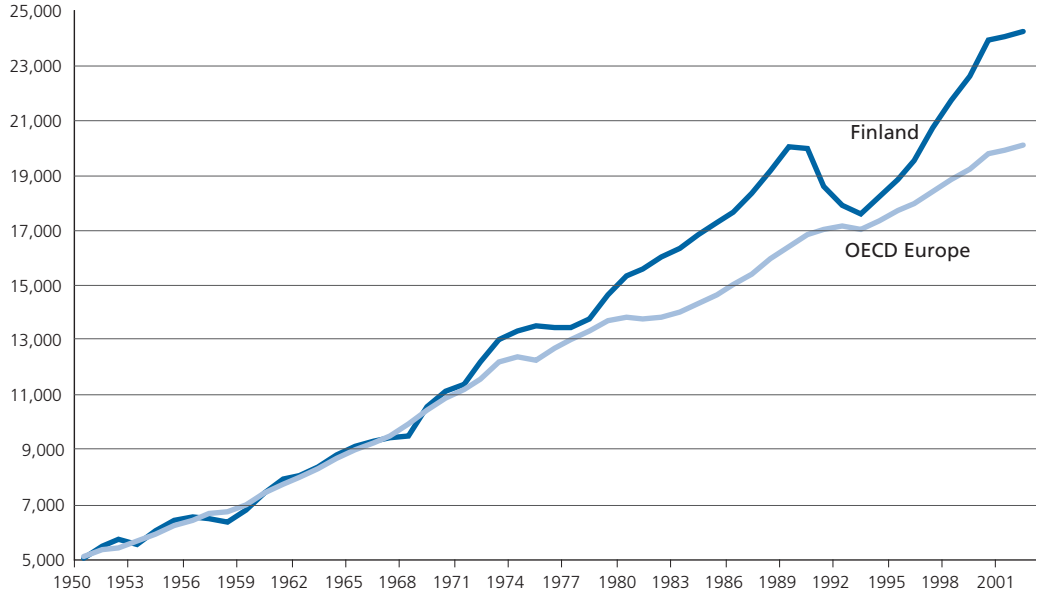
The latest phase of forest cluster development is the integration of ICT into pulp and paper making processes and maintenance services. The strong forest cluster with roots in traditional factor-driven industries is finding interfaces with the knowledge-driven ICT cluster. Furthermore, the global consolidation in pulp and paper, as well as in other traditional industries, has spawned new ICT markets as the demand for electronic means of integrating geographically dispersed activities has grown.

A Small Nordic Welfare State

Geographically, Finland is about the size of Germany or the US state of New Mexico. Yet with only 5.2 million inhabitants, it is sparsely populated. The climate is cold, but not quite as harsh as might be expected from the second most northerly country in the world.

Finland's economic and social institutions are similar to those of other Nordic countries. It can be appropriately characterized as a Nordic welfare state: it is an egalitarian country with relatively even income distribution and minimal class distinctions.

Figure 1. **The Fastest Growing European Country in the Postwar Era: GDP Volume in Finland and OECD-Europe (in 1995 prices and purchasing power parity exchange rates)**



Sources: www.SourceOECD.org, Penn World Tables.

Smallness is both an advantage and a disadvantage. There is some evidence in the economic literature that smallness retards economic growth. Small countries have less scope for utilizing scale economies in production and marketing. On the other hand, small home markets drive firms to specialize and seek foreign markets. Most small countries can be described as open economies with large exporting sectors. In Finland the share of exports in GDP is currently close to 50 percent.

Smallness and a homogeneous society might also be beneficial for the diffusion of new knowledge in specific areas such as ICT; in the world of rapid technological change this could be a competitive advantage.

While smallness and specialization increase a country's sensitivity to external shocks, small economies have developed various ways to cope with the problem. These include not only macroeconomic policies but also many kinds of networks and social security systems. Networking and cooperation in society in general, and in the business sector in particular, have proven to be important in developing new technologies. In many ways Finland can be characterized as a "network society" (see Castells and Himanen 2002). Of course, social networks, often labeled social capital, can become too tight and finally an obstacle for change and industrial transformation. Thus far, however, networking and cooperation have been an advantage rather than a disadvantage in Finnish industrial development.

Structural Transformation

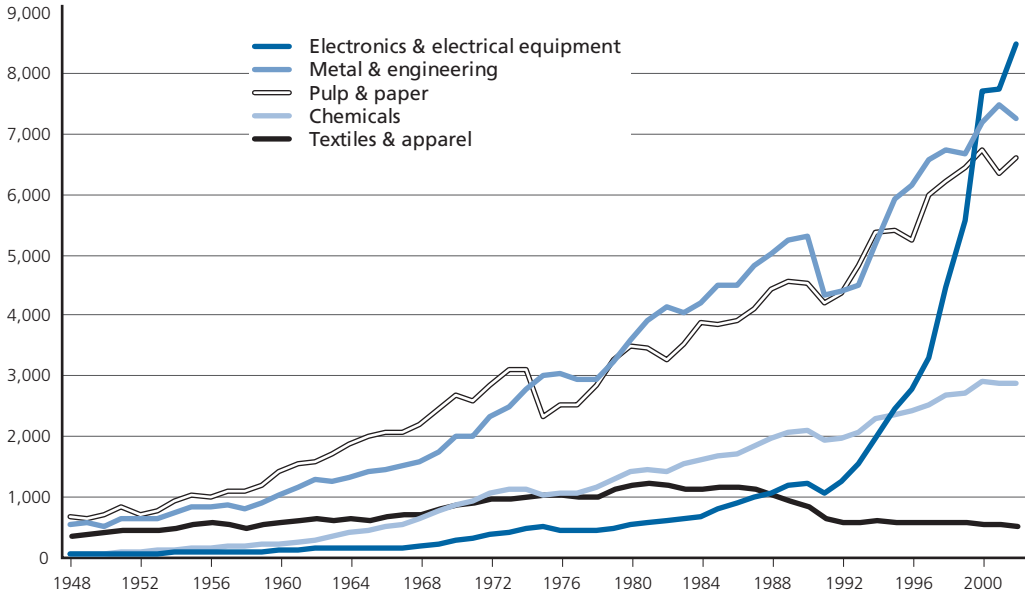
In addition to the aforementioned immediate reasons for the recession of the early 1990s, rigidities in economic and political systems and corporatist structures were among the underlying causes. The deep recession led to a clear shift in policy thinking. Greater emphasis was put on long-term microeconomic as opposed to short-term macroeconomic policies in an acknowledgment that the foundations of sustained national competitiveness are largely created at the micro level—in firms, financial institutions, and various innovative policy agencies.

The European integration process also fueled the shift in policy. Finland joined the European Union in 1995 and, unlike the other Scandinavian countries, adopted the euro from the outset. However, this also meant that the scope for national macroeconomic policies was considerably reduced.

The recession of the early 1990s was a watershed between the investment- and innovation-driven stages of national development. The country's R&D intensity grew rapidly as the business sector increased expenditures on innovative activity. Public R&D funding also rose at a time when virtually all other public expenditures were cut in the midst of the recession.

The transition to innovation-driven growth was considerably aided by widespread telecommunications deregulation in Europe and elsewhere, as well as by technological developments in the ICT sector. Both of these developments have contributed to the booming demand felt since the early 1990s.

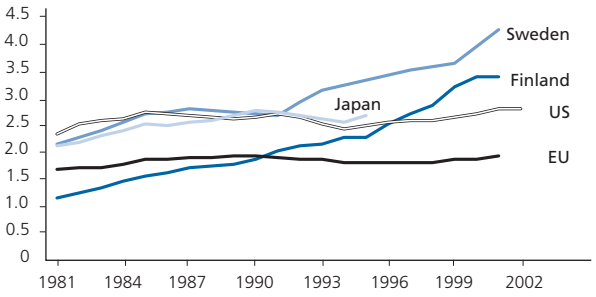
Figure 2. **Explosive Growth in Electronics Since the Early 1990s: Finnish Manufacturing Production Volume by Industry (€ billions in 2000 prices)**



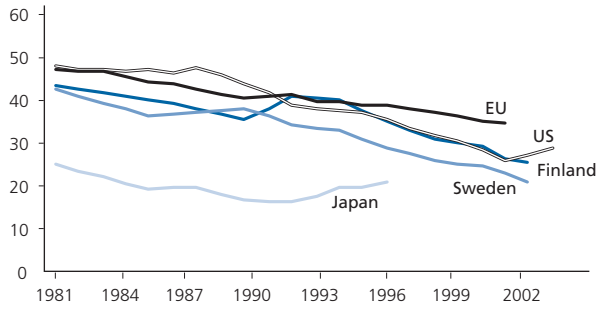
Sources: ETLA database, Hjerppe et al. (1976), National industrial statistics by *Statistics Finland*.

Figure 3. **The Second Most R&D-Intensive Country in the World**

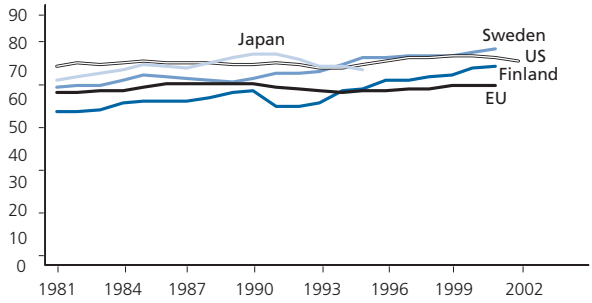
Gross domestic expenditure on R&D
(GERD) per GDP %



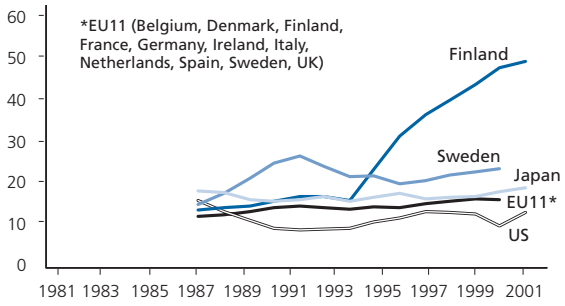
Share of GERD financed by government
%



Share of GERD performed by the business sector
%



Share of communications equipment manufacturing (ISIC 32) in total business enterprise R&D (BERD)
%



Sources: OECD Main Science and Technology Indicators Vol. 2003 release 01; OECD R&D Expenditure in Industry (ISIC Rev.3) Vol. 2002 release 01 (for the lowest pane).

The change in the 1990s in Finnish industrial structure and exports was unique both nationally and internationally. In less than a decade, electronics became the most important single branch in production and exports. The Finnish industrial structure that was previously raw material-, capital-, energy-, and scale-intensive, is now primarily knowledge-intensive. Finland's relative R&D intensity—the share of the gross domestic research and development expenditure (GERD) of GDP—is the second highest in the world (3.5 percent in 2002), with only neighboring Sweden surpassing it.

Innovation-Intensive Growth

Entering a phase of innovation-driven development presumes the interplay of several factors. High social cohesion, a consistent and predictable policy environment, sound basic infrastructure, as well as a just and efficient legislative and juridical environment are necessary preconditions. While these were all in place in Finland before the boom, the key factors were rising investments in R&D and a strong commitment to education.

Due to increased investments in the education system, by the late 1980s, younger generations of Finns were among the most educated in the world. Education that would enhance technological change was prioritized in the policies of the 1960s and 1970s. Among the OECD countries, the Finnish educational system lags behind only the Korean and German systems in terms of its relative emphasis on natural sciences and engineering. It is not only graduate level science and technology education that matters; a high general level of education is equally important for adopting and utilizing new technologies. Basic education continues to be the focal point of the Finnish educational system.

As will be discussed below, most of the structural change is attributable to the ICT sector. And within that sector, mobile telecommunications equipment manufacturing and Nokia dominate. In the latter half of 1990s the Finnish economy grew at an annual rate of approximately 5 percent. The contribution of Nokia to that growth was on average more than half a percentage point. In 2000 it peaked at one and a half percentage points, when the GDP growth was 6 percent.

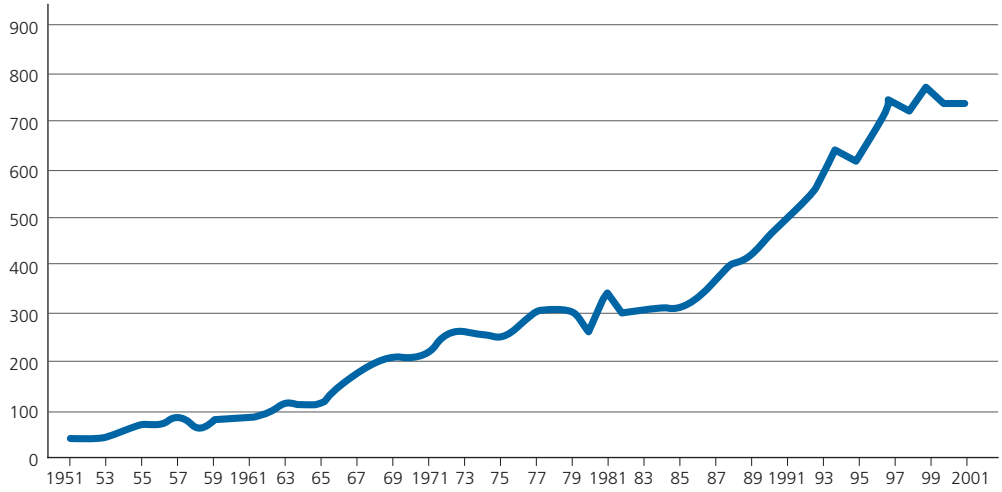
World's Most ICT-Intensive Country

Initially Competitive ICT Markets

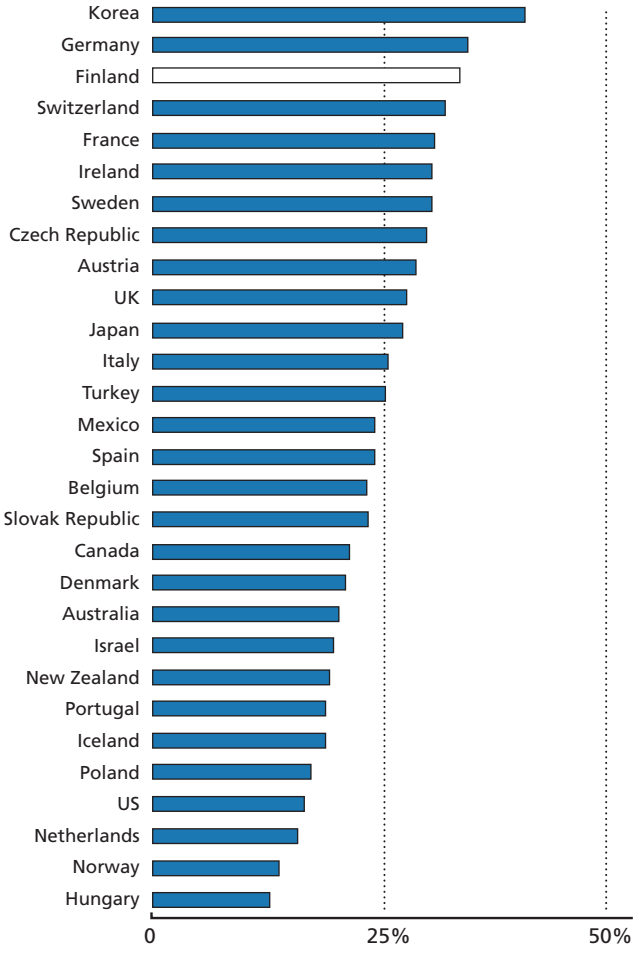
Up until the worldwide deregulation and liberalization boom of the 1990s, Finland had been one of the most competitive telecommunications operators and equipment markets in the world—a position it had occupied for over a hundred years.

Figure 4. **Heavy Emphasis on Natural Sciences and Engineering Education**

(a) Finnish postgraduate degrees in natural sciences and engineering



(b) Share of tertiary type A graduates in engineering, manufacturing, construction, life sciences, physical sciences, mathematics and statistics, and computing in all graduates



Sources: KOTA OnLine (top, www.csc.fi/kota/) and OECD (2002a).

The origins of this exceptional market structure can be traced back to the Telephony Decree of the Finnish Senate in 1886, which distributed numerous private operator licenses in order to circumvent Russian telegraph regulations.[1] Upon gaining independence in 1917,[2] an additional public telephony operator (PTO) and regulator was established to operate the telegraph and military telephone network left behind by the Russians. In the 1930s there were over 800 private telecommunications operators in Finland. Even today there are some 40 significant operators.[3]

From the outset, Finnish telecommunications equipment markets were open to foreign suppliers. Thanks to its small multi-operator market, Finland became a test market for the latest technology. Private operators' interest in state-of-the-art technology was fueled by the threat of being taken over by the PTO in case of underperformance. In order to integrate different manufacturers' network equipment, operators had to develop technological expertise, which was later exploited by the emerging domestic equipment industry.

Table 1. **In the mid 1970s the Equipment Market was Dominated by Foreign Suppliers: Finnish Telephone Exchange Equipment Market Shares in 1975, a Total of 161 million (2000 prices)**

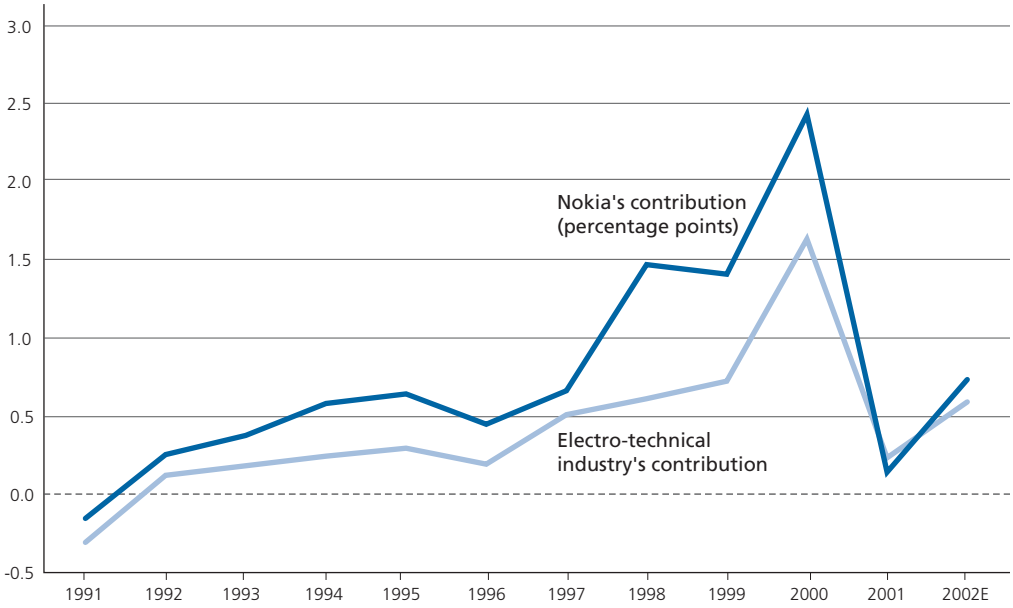
Ericsson (Sweden)	60%
Siemens (Germany)	25%
Televa (Finland)	8%
ITT (United States)	7%

Source: Häikiö (2001a, p. 162—countries of origin added by the authors).

Emergence of Wireless Communications

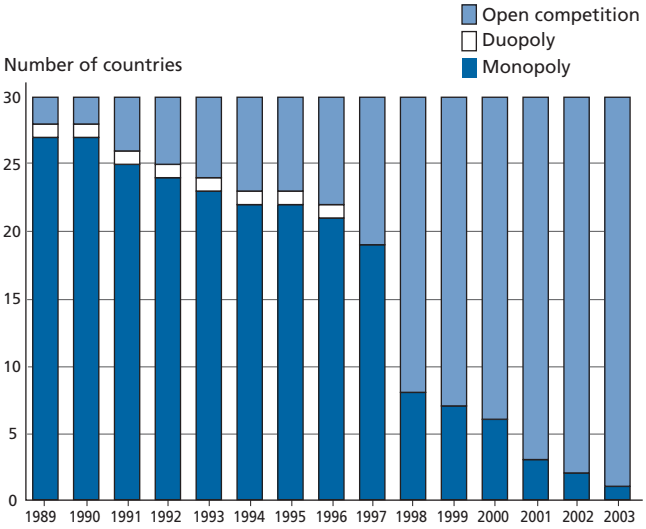
Applications of radio technology were developed in three companies around 1920: Salora (a Finnish consumer electronics company), Suomen Kaapelitehdas (Finnish Cable Works), and Radio Laboratory (under the Ministry of Defense). Fervent engineers, often objects of suspicion and

Figure 5. **In the Peak Year of 2000 Nokia Accounted for One and a Half Percentage Points of Overall GDP Growth:** Contribution of Nokia and the Electro-Technical Industry to GDP Growth in Finland (percentage points)



Source: Authors' update of Ali-Yrkkö and Hermans (2002).

Figure 6. **Rapid Worldwide Transition to Open Competition in Telecommunications:** Fixed Telecommunications Network Operator Market Structure in the OECD Area



Source: OECD (2003).

Table 2. **Nordic Suppliers and Global Heavyweights Competed in NMT Handsets:** Market Shares in NMT Handsets in 1985 (83,525 units in total)[4]

Mobira (Finland)	25.7%
Ericsson (Sweden)	16.9%
Panasonic (Japan)	8.9%
Storno (United States, until 1977 Denmark)	7.1%
Dancall (Denmark)	6.5%
Mitsubishi (Japan)	6.1%
NEC (Japan)	6.0%
Siemens (Germany)	5.6%
Motorola (United States)	5.6%
Simonsen (Norway)	2.3%

Source: Nokia Mobile Phones (as cited in Häikiö, 2001c, p. 134—countries of origin added by the authors).

opposition by conservative colleagues and managers, worked on applications of radio technology on the sidelines of main business activities.

In 1963, a call for tenders by the Finnish army for a battlefield radio spurred companies to give physical expression to their accumulated expertise. Ultimately the army did not have the resources to purchase the system, but the prototypes served as the forerunners of commercial handsets.

The Auto Radio Puhelin (ARP, Car Radio Telephone) network was introduced in 1971 as the country's first mobile telephone network providing nationwide service. It provided good geographical coverage but was not technologically sophisticated. In the mid 1970s the service had some 10 thousand subscribers. Although ARP did not turn mobile communications into a major business, it provided experience and customer interfaces for companies such as Nokia, Salora, and Televa, the main suppliers of terminals and network equipment in Finland. It also indicated that there was commercial potential in mobile services.

Box 1. **Managing the GSM as a Technological and Regulatory Discontinuity**

The telecommunications industry is characterized by generations of new standards with the potential to alter the competitive landscape. The GSM standard was especially discontinuous in this respect, since it marked a clear break in technological developments and regulatory regimes. GSM set the stage for Nokia's global breakthrough, and thereby provides an important snapshot of how the Finnish ICT industry managed to enter mobile telephony, master the technologies and regulatory challenges, and transform itself into a global leader.

In the software communities of the 1980s, the GSM acronym was translated into the "Global Software Monster" due to the technological challenges involved in living up to the demanding specifications of the standard. The standard was based on many years of European collaboration within the Groupe Spécial Mobile, founded in 1983 under the Conférence Européenne des Administrations des Postes et des Télécommunications (CEPT) and subsequently transferred to the European Telecommunications Standardisation Institute (ETSI). Initially, this collaboration included the major European PTOs—this was the regulatory regime that had been a successful one in the NMT era. However, due to increasing technological complexity and IPR clashes, collaboration was subsequently opened to the equipment suppliers as well. This was largely facilitated through political coordination at the European level, whereby the "basket model" of standardization was introduced.

In the basket model the interfaces between the subsystems of the cellular network were standardized, while the detailed choice of the internal component technologies was left to the equipment suppliers. Accordingly, competition was enhanced because equipment suppliers could contribute to the standard with their own technological solutions. This also invited the formation of constellations of R&D alliances around competing component technologies. One such alliance was the ECR900, which provided Nokia and Finland with an entry ticket through the back door into the large firms' oligopoly alongside such players as Ericsson, Alcatel, and Siemens.

The technological challenges of the GSM were foremost related to the digitalization of radio transmissions, and the exponential increase in the complexity of the signalling and control software. In Finland, meeting these challenges involved the interplay of various developments, some of which were based on bold managerial choices, others of which were highly coincidental.

A key precondition for the timely entry into GSM markets was the accumulated competencies that Nokia had developed in the field of digital software processing and transmissions in the 1970s and 1980s. A peculiarity was that Nokia had gained a very significant market position in the data modem business in the 1980s, based on interactions with an advanced banking sector in the Nordic countries as the key customer. Data modems and early personal computers made Nokia a leading user of digitalized integrated circuits (ICs) in collaboration with such giants as AT&T and Texas Instruments in the United States. Likewise, Nokia was an early mover in the field of digital transmission systems with such global industry firsts as the delivery of a 30-channel transmission system to the Finnish PTO in the late 1960s. Later on, further collaboration with the PTO, various local telecom operators, the State Railways, and advanced customers in the Soviet Union gave way to voluminous orders for the DX200, a digital switching system. In the early 1980s, following the strong market position of Mobira in NMT, a clear vision of the future potential of mobile telephony became evident throughout Nokia. These competencies found unintentional applications in the digital cellular environment of the GSM.

Apart from being an "accidental incumbent" in digital signal processing, transmission, and switching, Nokia also managed to coordinate scarce resources and combine various technologies very efficiently and at the right time. The first step towards Nokia's consolidation of competencies in Finland was its outsourcing of some R&D to the Oulu region. As a result of regional initiatives to proliferate Oulu as an important ICT center in Finland, a vibrant software community was emerging there. This outsourcing was subsequently internalized through the founding of Nokia's R&D centers in the Helsinki and Tampere regions, in close collaboration with technical universities.

At the same time, Nokia reorganized its telecom divisions through the founding of Nokia Cellular Systems. Instituted in 1988, Nokia Cellular Systems was designed to cater solely to the envisioned GSM-based growth in the cellular systems business. This reorganization was meant to contribute to the goal of making the deadline for the inauguration of the GSM service in Europe in 1991. The tight deadline was met in Finland through the world's first GSM call in June of 1991, even though the pan-European inauguration of the service was delayed due to technical problems.

However, Nokia was also lucky in many respects. In hindsight the decentralized microprocessor architecture of the DX200 digital switching platform was optimal for the GSM software extensions, although this decision was made primarily due to limited resources in the 1970s. Moreover, the fact that Nokia had collaborated and provided technological solutions to a range of different local operators, PTO, and other state agencies in Finland as well as the Soviets, meant that a whole arsenal of technological solutions were readily available also for the extensions to the global GSM markets. The collapse of the Soviet markets in the late 1980s was a further "lucky" coincidence. It struck the digital DX200 switching business hard but at the same time, enabled the transfer of resources from fixed to mobile telephony at a time when these resources were needed the most. Likewise, the GSM standardization process took many turns favorable to Nokia, one of which was the basket-model compromise that facilitated the formation of competing R&D alliances.

Presently, standardization is increasingly open and primarily in the domain of large multi-technology firms due to the further increase in technological complexity, number of participants, and the importance of multiple patents. This trend is best illustrated through the growth in the number of patents deemed as essential to the GSM and to the UMTS standard (see Table). As a consequence, the competitive landscape is changing once again.

Firms and Their Share Essential Patents in the GSM and UMTS Standard

	Number of essential patents	Number of firms holding essential patents	Key players' shares of the essential patents							
			Nokia	Ericsson	Philips	Motorola	Alcatel	Siemens	Qualcomm	Others
GSM	2,024	24	41%	18%	9%	4%	4%	2%	–	22%
UMTS	3,499	30	27%	8%	–	12%	3%	1%	45%	4%

Source: ETSI (2002).

The GSM has defined one technological and regulatory path towards next generations of mobile telephony, through the GRPS, EDGE, and UMTS standards. The future will tell to which degree this present stronghold of Finland in GSM technologies and markets will also support further advances and standardization paths in the rapidly changing and increasingly multi-layered and competitive landscape of the ICT industry.

Source: Kindly provided by Christopher Palmberg on the basis of Palmberg and Martikainen (2003).

The development of the *Nordisk Mobil Telefon* (NMT, Nordic Mobile Telephone) standard in the 1970s was a highly valuable outcome of the traditional cooperation of Nordic authorities and industry. It aimed at creating a Nordic market for mobile telephony and inducing competition. The standard was open to third-country suppliers as well. Openness promoted competition in network equipment and handsets. Advanced features such as roaming were included, and fortunately, the diffusion-promoting "caller pays" practice was also adopted.

In the early 1980s, the Nordic countries formed the largest mobile communication market worldwide in terms of the number of subscribers. Mobira, a joint venture of Nokia and Salora, supplied the first NMT handsets.[5] In contrast, Finnish companies were neither ready nor willing to supply network technology at the starting phase of the NMT project. Eventually, under pressure from PTO, and motivated by the need to curb Swedish Ericsson's market power and equipment prices in general, Mobira, and later Tele-Nokia, started to manufacture network equipment (Palmberg 2002).

In 1988, the telecommunication authorities of the European Community published the *Groupe Spécial Mobile* (GSM, Digital Global System for Mobile Communication) standard. Nokia and Ericsson were among the first to adopt GSM, which eventually became almost universally accepted—with the major exceptions of the United States, Canada, and leading Latin American countries. Recently GSM has also gained ground in these markets.

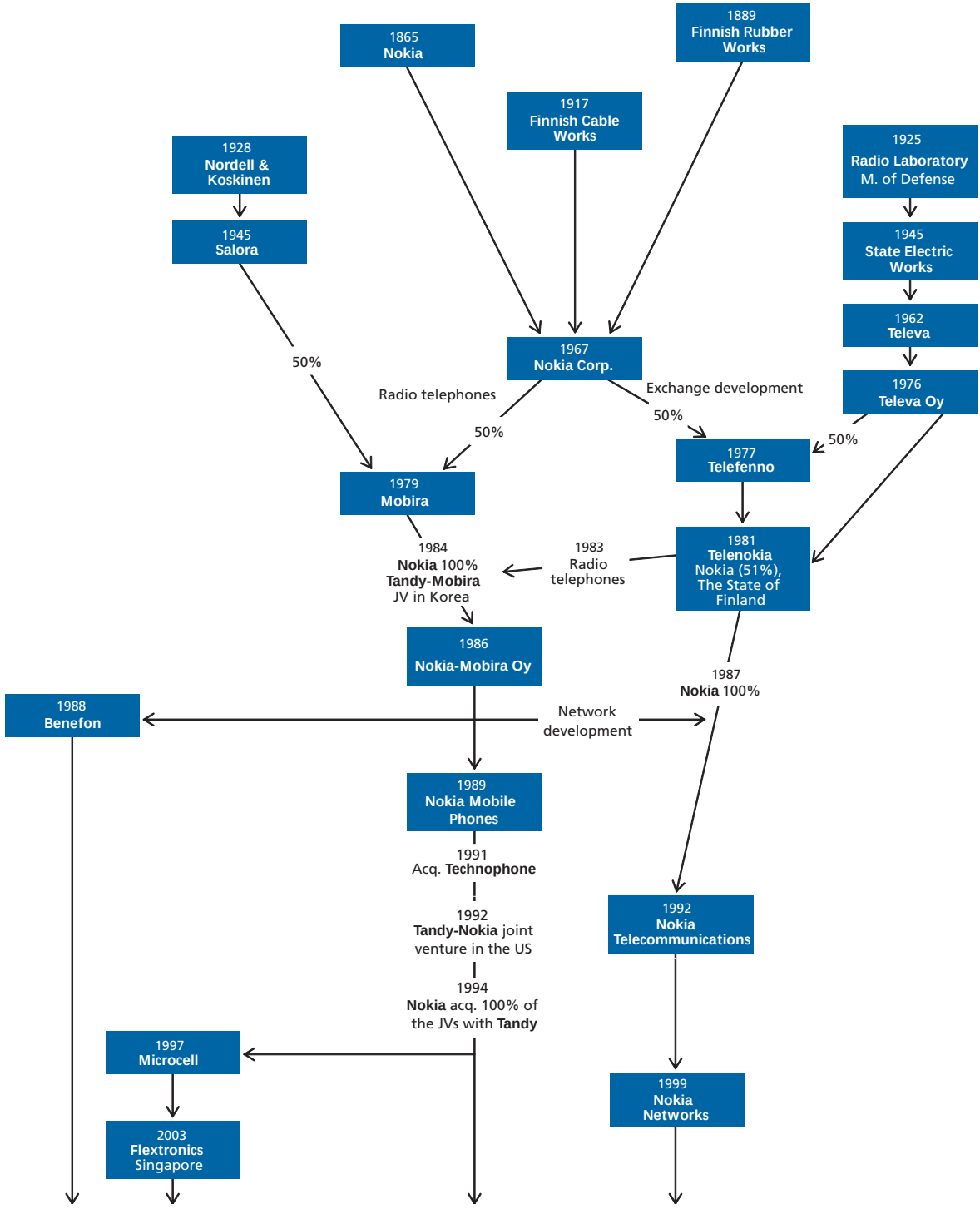
PTO was the sole NMT operator in Finland. The liberalization of the wireless operation culminated in the granting of a GSM license to Radiolinja (a private operator). In 1991, PTO and Radiolinja were among the few who opened their GSM networks in accordance with the original schedule set up by the GSM development group's memorandum of understanding. Nokia made its global GSM premiere by providing Radiolinja's network.

Although the foundations of domestic equipment manufacturing were laid in the 1920s, up until the1980s, foreign manufacturers dominated the market. During the 1970s and 1980s, Finland was advancing rapidly in digital and mobile technologies. Nokia participated in these developments and since the 1970s, it has become a central force in the consolidation of the industry. By the late 1980s, the bulk of the Finnish telecommunications equipment industry had merged into Nokia.

Nokia's Transformation into a Global Mobile Communications Giant

The merger of Suomen Kaapelitehdas (Finnish Cable Works), Suomen Gummitehdas (Finnish Rubber Works) and Nokia in 1967 may be seen as the birth of the current Nokia Corporation. Although the wood-grinding mill lent the name, the cable company provided the core knowledge base to the new entity: in 1960 it had established an electronics department reselling computers, providing computing services, and also manufacturing some its own

Figure 7. **The Evolution of the Finnish Mobile Communications Industry**

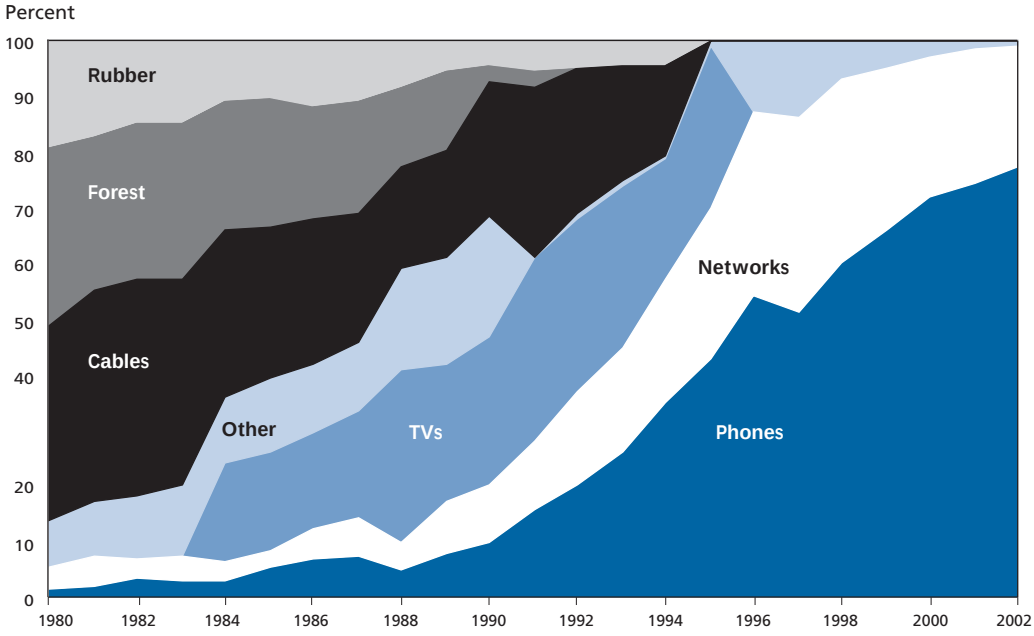


Source: Derived by the authors from an earlier version by Paija (2001, p. 25).

electronic devices. It also assumed an important role in educating its own staff—and Finns more generally—on digital technologies.

Nokia was still pursuing a conglomerate strategy in the 1980s and made several sizable acquisitions in consumer electronics (i.e., televisions such as Swedish Luxor in 1984 and German Standard Elektrik Lorenz in 1987), information systems (e.g., Swedish Ericsson Information Systems in 1988), and other fields not directly related to telecommunications.[6] This conglomerate strategy, together with managerial and ownership problems, caused—along with the early 1990s recession—a deep crisis. Jorma Ollila became the CEO in 1992. Under his leadership, activities outside mobile communications were divested. The process was completed by the late 1990s.

Figure 8. **From a Multi-Branch Conglomerate to a Mobile Handset Company in a Decade: Nokia's Sales by Industry**[7]



Sources: Derived by the authors from an earlier version by Paija (2001, p. 27) with additional data from Häikiö (2001b) and Nokia's annual reports.

With the exception of UK-based Technophone in 1991,[8] Nokia has not made major foreign acquisitions in its current core businesses. In fact, it retreated from its acquisition strategy almost completely after the early 1990s. But alliances were important from early on: in handsets, Nokia established joint ventures with American Tandy, and did private labeling with Tandy-owned Radio Shack, AT&T, and others; on the network side, it initially partnered with Alcatel (France) and AEG (Germany) to provide GSM solutions.[9]

With a nearly 40 percent market share, Nokia is currently a clear market leader in mobile handsets, and is one of the dominant players in mobile network infrastructure equipment. It has been riding the wave of exploding global mobile telecommunication markets, fueled by worldwide deregulation in telecommunications. Thanks to its narrowly defined and globally orientated strategy, it has been able to meet the market challenge somewhat better than its closest competitors. Furthermore, the management has been able to build an innovation-driven culture and supporting organizational structure, flexibly exploiting both internal and external networking.

Nokia has had its share of problems and challenges as well. It was nearly bankrupted in the early 1990s, primarily as a consequence of its overly ambitious and costly acquisition and internationalization strategy.[10] The mid 1990s logistics crisis and the mismatch of product mix and market demand led to a major revision in organizational structure. What seems to set Nokia apart from many other gigantic corporations is its ability to react quickly and improvise in a moment of crisis.

There Is More to the Finnish ICT Cluster than Nokia

Koski, Rouvinen, and Ylä-Anttila (2002) show that international ICT manufacturing exhibited an intensifying concentration tendency in the 1990s, and that laggards rarely catch up, let alone leapfrog, the leaders. Thus, originally ICT-specialized countries tend to become more so. Finland is a rare exception to this rule. During the 1990s, it went from being one of the least ICT-specialized industrialized countries to becoming the single most specialized one.

The broadly understood Finnish ICT sector (or cluster) —from digital content provision and packing via network infrastructure equipment manufacturing and operation to end-user terminals and portals—is comprised of 6,000 firms (Paija and Rouvinen 2003), including 300 first-tier subcontractors of Nokia (Ali-Yrkkö 2003).

The impact of the ICT cluster on the Finnish economy can hardly be exaggerated. In the 1990s its GDP share rose from 4 to 10 percent.[12] Nokia's share is an estimated 3 percent. ICT has indeed become the country's third industrial pillar at the expense of the traditional metal and engineering as well as forest-based sectors. Nokia alone accounts for an estimated one-fifth of Finnish exports.

Finland is quite dependent on Nokia, but at least now the Finnish economy has a second major pillar alongside the traditional forest-related industries. Should anything go wrong, the country has a proven ability to adapt. As compared to a dependence on natural resources such as oil, it seems

Table 3. **Siemens Remains the Biggest Communications Equipment Providing Corporation: Some ICT-Related Companies in Fortune Global 500**

Communications Equipment Providers						
Firm	Country	Revenues (US$ billion in 2002)	Profit margin (profits/revenues, % in 2002)	Employees (thousands in 2002)	R&D intensity (expenditure/ revenue, % in 2001)	Worldwide market share in mobile phones (% in 2002)
Siemens	Germany	77	3	426	10	8
Samsung Electronics	Korea	48	12	80	6	10
NEC	Japan	39	-1	146	7	
Fujitsu	Japan	38	-3	157	7	
Nokia	Finland	28	11	52	10	36
Motorola	United States	27	-9	97	14	15
Cisco	United States	19	10	36	18	
LG Electronics	Korea	18	2	55	5	
Alcatel	France	16	-29	76	11	
Ericsson	Sweden	15	-13	65	20	6
Lucent	United States	14	-86	47	17	
Nortel	Canada	11	-34	37	19	

Major Operators						
Firm	Country	Revenues (US$ billion in 2002)	Profit margin (profits/revenues, % in 2002)	Employees (thousands in 2002)	R&D intensity (expenditure/ revenue, % in 2001)	Worldwide market share in mobile phones (% in 2002)
NTT	Japan	90	2	207	3	
Verizon Communications	United States	68	6	229		
Deutsche Telekom	Germany	51	-46	256	2	
AT&T	United States	47	-28	71	1	
France Telecom	France	44	-44	244	1	
SBC Communications	United States	43	13	176		
Olivetti	Italy	30	-2	107		
BT	UK	29	14	105	2	

Other ICT Firms						
Firm	Country	Revenues (US$ billion in 2002)	Profit margin (profits/revenues, % in 2002)	Employees (thousands in 2002)	R&D intensity (expenditure/ revenue, % in 2001)	Worldwide market share in mobile phones (% in 2002)
IBM	United States	83	4	316		
Hitachi	Japan	67	0	340		
Sony	Japan	61	2	161		
HP	United States	57	-2	141		
Vivendi	France	55	-40	284		
AOL Time Warner	United States	42	-237	91		
Microsoft	United States	28	28	51		
Intel	United States	21	2	79		

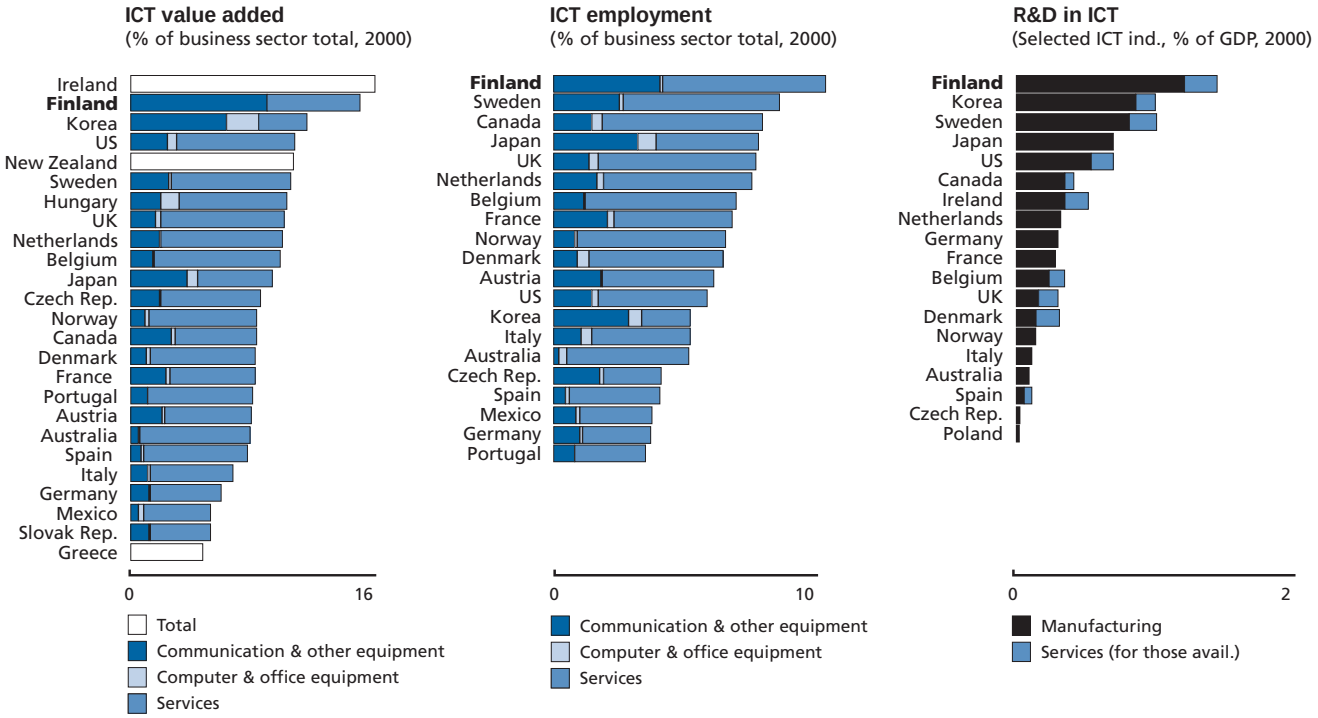
Sources: Fortune (2003), R&D figures for communications companies and some operators from OECD (2003, pp. 80–81), mobile phone market shares of major suppliers from *Gartner Dataquest's* website (*www.gartner.com*, Ericsson refers to SonyEricsson).

plausible to argue that the knowledge accumulated in ICT-related activities could be more easily applied elsewhere. Obviously, such a small country can probably never hold a well-diversified portfolio of internationally competitive business activities.

Although other Finnish ICT companies are gaining ground in global markets, there have not been major breakthroughs in broader ICT market segments. In recent years Finland has nevertheless been able to attract R&D activities of such firms as Ericsson, Fujitsu, IBM, HP, and Siemens, which may be interpreted as a sign of the viability of its ICT cluster.

Jalava and Pohjola (2002) show that the absolute macroeconomic effects of ICT in the late 1990s were quite similar in Finland and in the United States (see, for example, Jorgenson 2001). As distinct from the situation of the United States, however, the effects in Finland are mostly mediated via

Figure 9. **Heavy Specialization in ICT and Communications Equipment Manufacturing**[11]



Source: OECD (2002b).

Table 4. **Some ICT Companies on the Main List of the Helsinki Stock Exchange**

Company	Self description	Net sales in 2002 (€ millions)	Profit margin in 2002 (%, net sales per operating profit)	Personnel in 2002
Nokia Oyj	The world leader in mobile communications	30,016	15.9	52,700
TeliaSonera AB (Sweden, figures for Sonera)	The leading telecommunications group in the Nordic and Baltic regions	2,241	2.9	8,170
Elisa Oyj	One of the leading European operators in applying new technology	1,563	-4.5	8,120
Tietoenator Oyj	One of leading suppliers of high value-added IT services in Europe	1,271	7.5	11,600
Perlos Oyj	The world's largest supplier of mobile phone precision components, powder inhalers for pharmaceuticals	365	0.4	3,640
Novo Group Oyj	One of the largest providers of business-to-business IT services in the Nordic countries	309	3.0	2,260
Eimo Oyj	A leading manufacturer of precision plastic components for communications, automotive, and healthcare	252	1.2	1,940
Aspocomp Group Oyj	A high-tech circuits and mechanics manufacturer for communications, automotive, and other industries	183	-12.8	3,080
Teleste Oyj	A technology-leading provider of video and broadband cable networks	67	-6.4	506
Aldata Solution Oyj	A leading European retail software company	66	6.4	448
Yomi Oyj	A significant provider of software for communications networks and terminals	58	6.7	621
Comptel Oyj	The global market leader in mediation software for operators and service providers	49	-13.4	595
Tecnomen Oyj	A worldwide supplier of messaging and intelligent network systems for operators and service providers	40	-35.4	457
F-Secure	The leading provider of centrally managed security solutions for the mobile enterprise	39	-4.5	306
Stonesoft Oyj	A global supplier of security platform software	30	-75.3	336
Sysopen Oyj	One of the leading independent integrated e-Business solution providers	29	10.0	323
TJ Group Oyj	A European provider of Extended CRM solutions	28	-57.6	321
SSH Communications Security	A world-leading supplier of managed security middleware (cryptography and authentication)	17	-83.9	147

Sources: Helsinki Stock Exhange (www.hex.com), Top 500 database by Talouselämä business periodical, companies' websites.

Box 2. **Nokia—A Big Company in a Small Country**

Nokia and Finland

Nokia is by far the biggest company in Finland. It accounts for one-fifth of the country's total exports and close to 3 percent of its GDP. But its role is even more important in strategically important activities like R&D and internationalization of business. Nokia's share in total business sector R&D is 50 percent, and of total national research and development some one third. Hence, as a performer of R&D, Nokia is bigger than the whole Finnish university sector. More than 60 percent of Nokia's R&D (€3 billion in 2002) is conducted in Finland. Nokia employs 20,000 people in Finland, of which more than half are in R&D.

Nokia in the Finnish Economy

Nokia's 2002 Share in	
GDP	2.7%
R&D (GERD)	35%
Exports	21%
Employment	1%
Employment, manufacturing	5%
Market valuation of Helsinki Stock Exhange	60%

Source: ETLA estimates.

ICT provision. ICT penetration rates are nevertheless quite high and the country is a leader in certain types of ICT usage, for example, online banking and mobile payments.

Maliranta and Rouvinen (2003) use firm-level data to study the effects of ICT usage. The average effect in Finland is almost exactly the same as the mean estimate calculated across tens of similar international studies. There is, however, huge variation across firms. Although in most respects Finland is also an advanced user of ICT, it nevertheless seems that as a user it is not as exceptional as it is as a producer. This is somewhat alarming, as the long-run economic effects of ICT are mostly mediated via its use.

Can We Explain It?

New Markets, Reduced Financial Constraints

The liberalization of global markets for goods, services, capital, and technology, initiated by developments in the United Kingdom and the United States in the late 1970s, led to a globalization boom in the mid 1980s. Finnish companies gained access to new markets, dependency on domestic banks for finance was reduced, and capital constraints were relaxed. Larger Finnish companies gained direct access to foreign investors. There was a huge influx of capital to Finland in the mid 1990s, and for a couple of years the Helsinki Stock Exchange was the most internationalized one in the world, as measured by market value owned by foreigners. Contrary to the Israeli case, for example, smaller Finnish companies have not made initial public offerings in NASDAQ or other foreign markets. They have nevertheless benefited from the rapidly increasing availability of venture capital finance since the early 1990s (Hyytinen and Pajarinen 2002).[13]

Creative Destruction

Clearly, a country's historical developments and macroeconomic environment provide the general conditions for its economic development and microeconomic restructuring. For Finland, World War II and the recession of the early 1990s provided clear breaks from the past. These events, together with the country's natural environment and lack of natural resources, fostered pragmatism and a straightforward culture in both politics and business. The relatively poor Finns simply could not afford inflexibility or bureaucracy—they had to adapt to the challenges imposed by the internationalizing world. Even in the deepest crisis, political and economic institutions remained functional, and thus the necessary adjustments took place in an orderly manner.

Vast unemployment in the 1990s gave the ICT cluster the large recruitment pool necessary for its expansion. The public educational system also responded to the content and volume needs in ICT-related education. Furthermore, the collapse of the eastern trade relaxed resource constraints within firms, which could then be targeted to the development of ICT (including GSM) and the expansion that followed.

Role of Public Policies

The institutionalization and strengthening of science and technology policies began in the early 1960s. Important changes that contributed to the knowledge-driven growth and expansion of the ICT sector took place throughout the following decades. The main target of these policies was to strengthen the science and technology base of industry (Lemola 2002).

In the beginning of the 1980s, technology policy became increasingly target-oriented and systematic. The National Technology Agency (Tekes) was established in 1982 to coordinate public R&D support and related efforts, such as national technology programs. Technology transfer and commercialization of research results were emphasized. Tekes and its programs became important instruments for implementing policies. The focus of the new agency's operations was information technology. In fact, two extensive information technology programs had already been initiated before Tekes was established.

Towards the end of the 1980s, a more systemic view on policymaking was adopted. In the 1990s, the Science and Technology Policy Council, a high-level body advising

the Cabinet and the President on science and technology matters, introduced the national innovation system as a basic framework for policymaking. Innovation was seen as having a systemic character, contrary to the traditional linear innovation model. This enhanced cooperation between various policy agencies and improved possibilities for making use of emerging complex ICT. The systemic view also emphasized the role of education in adopting, diffusing, and utilizing new technologies (see Georghiou, Smith, Toivanen, and Ylä-Anttila 2003).

Booming Demand

During and prior to the cold war era, telecommunications operation was considered a natural monopoly and equipment manufacturing was largely kept national for strategic reasons. Since then, both operation and equipment markets have been almost completely deregulated and liberalized. Finnish ICT firms had ample experience operating in a competitive environment with diverse customer needs, unlike many of their international competitors. Besides having a history of telecommunications competition that dated back over a hundred years, Finland was also some three years ahead of other industrialized countries in taking the final steps towards completely deregulated communications markets.

In mobile telecommunications in particular, deregulation brought about eager "second-tier" operators and service providers that wanted to deploy new networks rapidly and with a minimum of technical problems. Former monopoly operators were forced to respond by upgrading their networks. Competition, and resulting lower prices, fueled demand, which in turn led to further investments. Thus, the industry was indeed in a virtuous cycle in the 1990s.

The non-telecom ICT market was also booming. The geographically dispersed multinational enterprises had new demands for ICT-related equipment and services. Rapidly falling equipment prices boosted both business and consumer use. The Internet went mainstream in the mid 1990s; the mobile phone became a mass-market product around the same time, although initially these two developments were not directly related.

Technological Opportunity

Digitalization was a major technological breakthrough in voice and data storage, processing, and transmission. It was important for Finland, as it provided an opportunity for new players with no experience or vested interests in computing or communication. Finland had sufficient expertise in digital technologies at large and in telecommunications in particular, both of which were absolutely vital for the big GSM breakthrough.[14]

Radio technology, in addition to a profound understanding of telecommunications, was one of the prerequisites for building a mobile telephone system. University-level education in radio technology had started in the early 1920s. As suggested above, it "lurked in the shadows" in many Finnish firms well before it had commercial applications. This was driven by the fact that amateur radio was a popular hobby in Finland.

NMT and GSM—Winning Standards

Telecommunications standardization in the Nordic and European contexts may be the single biggest explanatory factor in the Finnish ICT success. Finland was an early adopter of first NMT and then GSM, both of which eventually proved to be the "winning technologies" in their eras.

Early on, NMT provided critical mass and relatively high penetration rates, which led to early recovery of development costs as well as accumulation of hands-on knowledge and scale benefits. Network benefits of both production and consumption also accumulated quickly.

Upon the transition to digital technologies, Nokia bet heavily on GSM as the second-generation (2G) standard, which eventually commanded three-quarters of the worldwide user base. Nokia managed to capitalize on its early lead in both GSM networks and handsets.

The fact that mobile telecommunications standards were agreed beforehand rather than being completely or in part determined by market forces, clearly aided entrants and market creation. The settlement of these and subsequent standards was in part based on demonstrations, where the benefits of a given technological solution could be shown in an open competition. Nokia has been quite successful in these competitions, and thus it has considerably influenced the formation of these standards.

Advanced Users

Scandinavians seem to be accustomed, and therefore quite willing, to test new technologies. In the early years of mobile telecommunications, new generations of phones always caused quite a stir and "forced" many users to shop for an upgrade. Fortunately, customer needs in these markets preceded those elsewhere, thus giving somewhat of a first-mover advantage to the Scandinavian firms. Thus, the Scandinavian market was a rather happy marriage of technological competence in both production and use.

As shown above, all of the Scandinavian countries were present in the early NMT markets, but only Nokia and Ericsson stood the test of time. One of the reasons for this may be the fact that these two also had a strong presence on the network side, giving them a thorough understanding of the whole system.

Nokia's expertise in networks was considerably enhanced by technologically advanced domestic operators who were interested in the latest gadgets but at the same time quite

Box 3. **Nokia Success Factors**

Nokia's sales were €30 billion (31 billion USD) in 2002, thus exceeding the annual budget of the state of Finland. At the end of 2002 it had three business groups: Mobile Phones (77 percent of net sales), Networks (22 percent of net sales), and Ventures Organization. It employed over 50,000 people in 2002, of which more than 40 percent were in Finland. Ninety percent of its shares were held abroad. At the end of 2002 it had production centers in nine and R&D centers in 15 countries.

In a decade, Nokia's (nominal) sales have grown 10-fold and its share price has grown over 70-fold. How did Nokia do it? The underlying market trends and general factors are considered in the text; in this box we look for explanations inside the company.

Nokia—Key Figures

	1992	2002
Market value (€ billions, end of year)	1,028	72,300
Net sales (€ billions) of which abroad (%)	3,056 80.0	30,016 98.8
Profit margin (%, operating profit per net sales)	1.7	19.0
Employment of which abroad (%)	26,770 48.6	52,700 57.1
R&D (%, R&D expenditure per net sales) of which abroad (%, authors' estimates)	6.1 30.0	10.2 35.0

Sources: Top 500 database by Talouselämä business periodical, Nokia's annual reports, ETLA estimates.

SUCCESS FACTORS

The Foundations—Technology

Technology at Nokia consists of many things, including, first and foremost, its own R&D. Also important have been efforts to promote prevailing and new industry standards, a broad patenting strategy, as well as technology at production, including its "platform thinking" and logistics to and from the factory.

The initial impetus for much of Nokia's R&D effort has been direct or indirect (e.g., standards) customer needs. Oftentimes the work was conducted with outside partners or in joint ventures. In the late 1980s Nokia Research Center was established to coordinate and support R&D efforts in various business groups. Currently the center primarily serves the business units. The business units also have their own R&D centers.

NMT, GSM, and UMTS standards—all vitally important for Nokia—are discussed in the text. The company's latest efforts in promoting standards go beyond telecommunications protocols. In a combined effort with other manufacturers, Symbia is being promoted as a standard handset operating system. In Open Mobile Alliance, more than 300 companies promote open standard solutions for interoperable mobile services.

Jacques Noels, a Frenchman leading Nokia Consumer Electronics from 1988 to 1992, drew the attention of Nokia's management to the important role of a solid patenting strategy (Häikiö 2001, pp. 21–22, 153). He noted that in the late 1980s, Japanese, Korean, and Taiwanese ICT companies were preyed upon by some US manufacturers with strong patent portfolios. In 1988, after reaching a 10 percent market share in the United States, Nokia was predictably sued by Motorola for alleged patent violations. The case was settled out of court. After the incident, Nokia started to take determined actions to expand its patent portfolio.

"Platform thinking" is one of the cornerstones of Nokia Mobile Phone's R&D and production strategy. Its aim is to develop a manageable set of standard subsystems or platforms, a combination of which then forms a specific handset. A platform includes necessary design, technical, and commercial specifications. The number of specialized, as opposed to industry standard, components is kept to a minimum. As a consequence of this strategy, Nokia has been able to outsource most of its component production and assembly, while focusing itself primarily on brand management, logistics, and key software components (SEC 2001).

Focus—From Technology to Lifestyle-Driven Consumption

Nokia has carefully attended to customer needs and has valued long-term customer relationships. In practice this has shown in the company's close cooperation with operators in the business side, and in offering desirable features, design, and branding on the consumer side.

In handsets Nokia was among the first to offer curvy "pocket-fitting" designs with integrated antennas, screens with sufficient contrast and size for comfortable reading, end-user customization such as exchangeable covers, and downloadable ring tones and logos, as well as entertainment such as off- and online games. While all of these seem obvious now, it took surprisingly long before they became part of the standard setup.

Surprisingly enough, Nokia's head designer is not a Finn. Since 1987, American Frank Nuovo (at first as a consultant, and since 1995 as the head of the Nokia Design Center in Los Angeles) has led handset designing.

The name Nokia became the centerpiece of the company's branding strategy in 1991. Relatively early, "lifestyle consumption," as opposed to, for example, technological excellence, became the focal point in branding. A decade later, Nokia had become the strongest brand in the mobile market and one of the ten most valuable brands in the world.

Approach—Internal and External Networking

Day et al. (2001) argue that achieving a fine balance between separation and integration has been one of Nokia's key strengths. Various units have sufficient independence but they nevertheless have shared values, goals, strategies, and vision. Through team work, internal recruiting, job rotation, and informal personal networks across hierarchical levels, the company attempts to exploit the already available resources to the fullest. In Finnish culture, informal contracts and trust have been the norm—even in industrial relations. However, with progressing globalization, formal agreements have become a necessity. In external networking, Nokia has been active in outsourcing, partnerships, and alliances, while keeping its core activities such as branding and R&D mostly in-house.

Organization—No-Nonsense Management

Last but not least is management. Upon becoming the CEO, Jorma Ollila defined a relatively narrow focus for the company that it has followed ever since. Even during the heyday of the new economy, Nokia remained lean and focused. Maintaining this focus was undoubtedly aided by its increasingly international ownership structure.

In the 1990s Nokia's managerial challenge was to manage rapid organic growth; in the new millenium the challenge has been to manage the ending of the growth. Nokia's growth was clearly aided by its agility and lack of bureaucracy. Although the company has Finnish roots and its executive board is populated by Finns, Nokia's orientation has been distinctively global.

price conscious and always benchmarking domestic offerings against foreign competition.

Cooperation and Visionary Management

Competition brings about efficient and lean organization. Somewhat paradoxically, cooperation has been equally important for the success of ICT in Finland. Indeed, international comparisons (EU 2000; OECD 1999) suggest that intense inter-organizational cooperation is one of the essential features of the Finnish national innovation system.

As shown above, a diverse set of Finnish communications expertise was eventually merged into Nokia. In the 1980s it was relatively similar to some other Finnish conglomerates, but in the 1990s it transformed itself to something exceptional. Despite its roots, Nokia was able to give up its forest-related activities and seems to have realized quite early that the Soviet trade was best treated as a "cash cow" used to finance developments elsewhere. Focusing on mobile communications was a rather bold move on Nokia's behalf in the early 1990s, but it has paid off handsomely.

Although Finns are often accused of being too engineer-oriented, Nokia has been less so than its closest competitors, Swedish Ericsson and US Motorola. This may be due to its historically somewhat broader customer interface in both the operator and end-user side, Nokia's early lead in the handset market, and early industry developments. Nokia started to emphasize design and branding before the competitors—it anticipated that the mobile phone was going to become a mass-market consumer product. It seems that from early on Ericsson has envisioned itself as a system company, while Nokia always identified itself as a handset company, although at times the network side commanded a large share of the turnover. As compared to Ericsson and Motorola with long traditions in the field, Nokia was clearly the challenger, and thus it had to be humble.

What's Ahead?

All-IP World

One of the key challenges of the Finnish ICT cluster is the on-going convergence of voice and data communications, information systems, consumer electronics, and digital content that is being tailored for these various channels and devices. Mobile Internet or perhaps more appropriately "whatever, wherever, and however desired," will introduce a new playing field with diverse and seemingly different players. Indeed, participants in the respective industries are already competing in both handsets and networks, and this tendency will only strengthen as Internet protocols (IP) increasingly form the basis for *all* electronic communication. Over time the focus on equipment weakens as it becomes more diffused, and shifts to applications and content.

Finland has two major weaknesses in the all-IP future. First, it has little clout outside mobile telecommunication equipment. Thus, at least domestically, it cannot leverage market power in other domains as the industry is being transformed. Second, the all-IP world is not likely to favor the integrated and closed architectures and business models of the telecommunications world. The first problem has been addressed by acquiring a broader set of competencies and forming alliances with the leaders of the respective industries. The second problem can only be addressed by actually competing in the ever more open and fragmented operating environment.[15]

Next Generation Networks

In the mid 1980s, the International Telecommunications Union (ITU) assumed an active role in the introduction of the next generation (third, 3G) standards. Although ITU pushed for one worldwide standard, eventually three became accepted in International Mobile Telecommunications (IMT-2000)

guidelines: W-CDMA (better known as UMTS, Universal Mobile Telecommunication System), CDMA2000 (promoted in particular by American Qualcomm) and the Chinese TD-SCDMA. Originally ITU's decision was considered a win for the Nokia-Ericsson camp promoting UMTS, but early market developments seem to suggest that CDMA2000 is progressing faster than expected.

Europe attempted to maintain its lead in mobile telecommunications by pushing for rapid deployment of UMTS. In many European countries radio spectrums for 3G operations were auctioned for over €100 billion in total. It soon became clear that deployment and diffusion would be slower, network building costs higher, and expected revenue per user lower than the licensees had anticipated. While the auctions were designed to maximize the immediate pay-off for the public good (radio spectrum), the long-term effects were unanticipated. The rules of the auction explicitly prohibited secondary trading and defined how, when, by whom, and with what standard the 3G networks were to be set up. Thus, the operators were not making a technology or even a business decision—they were deciding whether or not they wanted to be in the (mobile) telecommunications business; this was a question of their very existence. Currently the operators' indebtedness due to auctions, combined with the bearish financial market, is holding back the deployment of 3G networks.

With the 3G auctions, Europe effectively did the exact opposite of what was intended; in effect, it taxed the UMTS standard over its rivals. In any case, by making a public decision favoring one technology over another, the auctions did away with technology neutrality, which is often considered one of the golden rules in technology policymaking. The regulatory failure in the 3G rollout has recently sparked requests for public actions "reversing" the damage.

The main benefit of the first generation digital (as compared to analog) system was improved voice quality. The key promise of 3G is improved data communication. So far voice has been the key driver of mobile communication, although data is gaining ground. Upon bidding for a spectrum, the operators seem to have assumed a rapid and large shift from voice to data. This shift is indeed taking place, but from the European point of view, somewhat differently than they had expected.

Whereas Europeans seem to have assumed that the mobile Internet would be an extension of mobile telecommunications, the American route of extending wire-line data communications architectures to wireless local area networks (WLANs, also known as Wi-Fi or 802.11*x*, where *x* refers to the incarnation) seems to have an early market lead.

Arguably, a combination of WLAN and an intermediate generation (2.5G, e.g., GPRS, general packet radio service) mobile telecommunications system having the "always on" feature could be used to reach the goals of 3G. WLAN nevertheless has a number of unsolved problems such as control for log-in and access rights, payment, and coverage, which have already been solved in 3G. It is too early to say how the market will unfold, but most likely 3G and WLAN will coexist with in-between roaming as desired.

Industry Turbulence

There was an over-investment in virtually all ICT-related activities in the late 1990s. In part these were driven by one-time events, such as deregulation and liberalization in major markets, the Y2K computer glitch, the introduction of the euro, and commercialization of the Internet—not to mention the new economy bubble. In hindsight it is easy to say that the market participants should have anticipated some leveling-off in demand. But nobody could have anticipated the collapse of the ICT market that has taken place. The current market situation has taken a heavy toll on the companies involved. The underlying factors of the recent boom are nevertheless still there: real prices of digital computing power and communications drop at double-digit annual rates, new applications of ICT that are discovered every day and continue to boost productivity in business and to improve our daily lives. Thus, while the medium-term prospects of the industry are gloomy, the longer-term prospects are considerably brighter. However, only some of the current businesses will live to see the dawn of these prospects.

What Kind of Mobile Culture?

In a sense, the discussion of 3G vs. WLAN is also about how the culture of using the technology evolves. Will a typical user eventually require broadband access at all times and locations for streaming video and similar applications, or is s/he going to be happy having hotspots in areas of peak demand and limited communication ability elsewhere? And perhaps more importantly, for what and how much is s/he willing to pay?

For the majority of us, the office or home desktop computer remains the most important means for storing the flow of our lives. A number of small electronic appliances, mobile phones, along with personal digital assistants, electronic organizers as well as lap- and palmtops, are trying to take over the personal computer in this respect and to become all-encompassing "personal trusted devices," perhaps even replacing our wallets and passports.

Depending on the actual configuration, Finland may stay on the cutting edge and continue to serve as a useful testing ground for new applications, or it may have to play catch-up with respect to some other lead-user concentrations such as Japan or some US regions. Individuals, both as consumers and business representatives, will ultimately decide who wins in the market place.

Conclusion

Viability of the Finnish Model

Upon its birth as an independent nation, Finland had a somewhat disadvantageous starting point. But as Porter (1990), among others, has noted, in the long run selective disadvantages can be turned to sources of national competitiveness. Decades of a relatively stable political and economic environment, as well as a shared national vision on how to build the country, have been important factors in Finland's success.

Finland was lagging behind the rest of Europe in industrial development after World War II. It consciously upgraded its skills and competencies and in half a century caught up with the leaders. The most recent push in the country's development nevertheless involves many coincidental factors and good timing. Thus, Finland has been fortunate, but the fact that it was well-positioned when the opportunity arose had nothing to do with luck. Historically Finland has played catch-up; now it is slowly learning that it is considerably harder to be one of the leaders.

As shown above, the confluence of several factors led to the ICT boom in Finland. The country itself provided particularly fertile framework conditions and had accumulated a great deal of ICT-related expertise. Due to unfavorable macroeconomic shocks, it had resources available and a desperate need for something new. Digitalization presented a technological opportunity. Furthermore, the country had early exposure to two successive generations of winning standards. Finnish firms had already "laboratory tested" competition when deregulation created a wide open world market. On top of this, there was a company that had the vision and a strategy to make it happen. These factors, combined with quite a few lucky breaks, served to put Finland out in front of the pack.

Although the scope of the Finnish ICT cluster has broadened in recent years, it remains highly specialized in mobile communications. The cluster has benefited greatly from having a powerful locomotive and system integrator, Nokia. Although smaller Finnish companies have made efforts to decrease their dependency on their key customer, in many cases their fortunes are still tied to it. Nokia has been able to maintain and even strengthen its position in global competition, and to a limited extent can influence developments in the market place. However, the fact remains that the whole sector is in turbulence.

Major future challenges for the Finnish economy include an aging population and increasing needs for flexibility in the labor market. The working population will inevitably start to decline in only a couple of years. This will weaken one of the economy's most important competitive advantages as the growth of a highly educated labor force slows down.

Changing Policy Priorities

The performance of the Finnish economy in the 1990s was remarkable. It looked as though the economy had found a unique way to combine high social security, dynamism, and growth. Successful policies contributing to the Finnish success story were equated with a new economic model for the information society (see Castells and Himanen 2002).

While in hindsight the Finnish public policies of the 1990s were successful, the "Finnish miracle" can only be partially explained by public policies pursued in the 1990s. The necessary policy changes had already been made in the 1980s, with some having come as early as the 1970s. Building competitive advantages takes time. There was no master plan to restructure the Finnish economy and industry; rather, an array of policy measures were working to the same end over an extended period of time (see Georghiou et al. 2003).

However, policies pursued since the early 1990s have had their role as well. There was a major shift in priorities as a consequence of European integration and changes in comparative advantages of the economy; focus shifted from short-term macroeconomic to long-term microeconomic policies. It is nevertheless true that sound but stringent macroeconomic policies contributed to the recovery. By the end of 1990s the high double-deficit of the current account and public sector finances vanished and unemployment had started to fall. While joining the EU and EMU narrowed the scope of macroeconomic policies, it also brought new stability with moderate inflation, low real interest rates, and increasing predictability of fiscal policies.

Under these circumstances, the increased emphasis on microeconomic and especially innovation policies has been a successful choice. These new policies are based on indirect measures aimed at influencing firm behavior. Policies concentrate on rectifying market failures, promoting competition, and improving framework conditions. These types of enabling policies fit well to the economic environment of the 21st century. The key priorities today are innovation policies and policies for enhancing the functioning of capital markets.

Although the high-road strategy of innovation and technology has been emphasized only recently, it was initiated in the 1970s and 1980s. In the 1980s, long before the rise and fall of the "new economy," Finnish technology policy began to give high priority to ICT. These policies were continued in the following decade and they undoubtedly contributed to the success story of the 1990s. Finnish R&D investment and networking between public and private actors rose to new heights.

What Is to Be Learned?

The Finnish experience suggests that a deep crisis often precedes considerable and lasting shifts in economic and social structures. In general, people seldom have a desire to take great leaps forward into the unknown, but a crisis may bring about a willingness to accept the inevitable. Major adjustments in "mental models" may also make one better able to adapt to further changes.

Moreover, it appears that small countries with greater homogeneity and closer interaction (networking) among economic agents may well have an advantage in adjusting to new technologies and, hence, in generating economic growth. This is a kind of a small country paradox, since most of the economic literature (including new growth theories) suggests that larger countries grow faster than smaller ones, and should thus achieve higher levels of income (see Lundvall 1999).

The Finnish response to the most recent crisis was to open up the economy, modernize social structures, strengthen public finance, and shift policies from direct business involvement to building framework conditions for private business.

The rapid turnaround of the Finnish economy would not have been possible without the rise of the ICT cluster, which in turn was facilitated by the convergence of a number of factors. Unfortunately we cannot perform real world experiments to see what would have happened in a different environment, but it is our belief that even slight changes in events or their timing would have made a big difference. For instance, had the remaining bits and pieces of the Finnish communications sector, deregulated and liberalized from 1988 to 1994, been opened up a few years earlier, later, or even in a different order, the situation would have been quite different. If, for example, Radiolinja had built an analog NMT network or, along with PTO, postponed its GSM introduction a few years, Nokia's international GSM premiere and a progressive market as a homebase would have been endangered. Had Finland not experienced the recession, there would have been fewer resources targeted to the at-the-time uncertain ICT business. Other aspects of recent developments provoke similar thought exercises and conclusions.

Although the history of Finnish ICT-related policymaking is full of right decisions at the right time, they have mostly been made for the wrong reasons. For instance, the political wrangling over GSM licenses did not even touch upon the economic and social benefits that would be gained by competition in and early adoption of digital mobile telephony.

Because there are no universally applicable policies that every country should adopt, the Finnish model cannot be replicated as such. There are nevertheless some general principles of sound policymaking that can and should be imitated. Policies should adapt to changes in operating environment and should take into account lessons learned from experiences elsewhere. At the same time, they should build on national strengths and not be swayed by wishful thinking. Innovation policy must have a long-term strategic perspective. Hence, policies must be consistent over the long term and not dictated by short-term cyclical or political considerations. Constant benchmarking of performance is necessary for the assessment of policies.

The case of Finland is a good example of the interaction of several growth-generating factors. Favorable factor conditions and a high level of investment are not sufficient. In order to achieve sustained growth, more emphasis has to be put on adoption of innovations, learning, and increasing specialization. Growth that is not based on constantly rising productivity is unsustainable.

Reading Guide

Pajarinen, Rouvinen, and Ylä-Anttila (1998) consider Finnish competitiveness in the globalizing world. Hernesniemi, Lammi, and Ylä-Anttila (1996) discuss the micro-foundations of Finnish competitiveness and provide an overview of the Finnish industrial clusters. Some of this work has been summarized by Rouvinen and Ylä-Anttila (1999). Castells and Himanen (2002) discuss the "Finnish model" (reviewed in Ylä-Anttila 2003).

The *National Industrial Strategy* by the Ministry of Trade and Industry of Finland (Pietarinen and Ranki 1993) may be seen as the starting point and original documentation of the country's current industrial policy. In their evaluation of the Finnish national innovation system, Georghiou, Smith, Toivanen, and Ylä-Anttila (2003) summarize recent developments in policymaking and consider future prospects.

Paija (2001) provides a comprehensive overview of the Finnish ICT cluster. This work has partly been updated in Paija and Rouvinen (2003). Koski, Rouvinen, and Ylä-Anttila (2002) have a comparative perspective on ICT in the EU countries, but they also touch upon the Finnish case. Steinbock (2002) has a global perspective, but he also discusses Finnish experiences.

The three volume *magnum opus* by Häikiö (2001a; 2001b; 2001c) is the most authoritative piece of writing on the history of Nokia. With unrestricted access to the company's internal archives and personnel, he provides an unmatched level of detail. An abbreviated version is also available in English (Häikiö 2002). Ali-Yrkkö, Paija, Reilly, and Ylä-Anttila (2000) discuss the role of Nokia in the Finnish economy. Ali-Yrkkö (2003) discusses the role of Nokia in the Finnish national innovation system. Ali-Yrkkö (2001) takes a detailed look at the company's partner network in Finland. Ali-Yrkkö,

Paija, Rouvinen, and Ylä-Anttila (2003) look at the company from a global management perspective.

Palmberg (2002) examines the cases of DX200 and NMT from a public procurement perspective. Palmberg and Martikainen (2003) discuss the role of GSM and related technologies in Finland.

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Notes

1 Recall that from the 13th century until 1809 Finland was under Swedish reign, after which it was a semi-autonomous grand duchy of Imperial Russia until it gained independence in 1917. Due to its strategic importance, the Tsar had established a telegraph monopoly in the country shortly after Morse's original patent in 1837. Fortunately, the Tsar's reaction to Bell's 1876 patent for telephone was somewhat different, perhaps because the telephone was considered "an instrument of entertainment." Interestingly, at the time that Finnish telephony was being established, nearby Stockholm had more telephones than any other city in the world (Holst 2003).

2 Coincidently, in the very same year, Eric Tigerstedt, a Finnish inventor who was well ahead of his time, attempted to patent a "pocketsize folding telephone with a very thin carbon microphone."

3 There are also three or more significant operators in each of the following: long distance, international telecommunication services, and mobile telephony.

4 Mobira was the fourth in the global handset market after Motorola, NEC, and OKI.

5 Weighing approximately five kilograms, the original NMT terminals were not quite the handsets of today.

6 Indeed, in the late 1980s Nokia was the biggest manufacturer of personal computers and color television sets in the Nordic countries and was among the top 10 in Europe. In 1986 Nokia had 10 divisions, 45 business units, and 180 lines of business.

7 The area in the middle of the figure indicates Nokia's disastrous attempt to buy its way into television manufacturing; cumulative losses amounted to €1.3 billion in year 2000 prices (Häikiö 2001b, p. 126). Although it seems plausible to argue the experiences gained aided Nokia in its mobile communications businesses, there is no evidence to support the argument (see, e.g., Häikiö 2001b, pp. 115, 254). There was little exchange of personnel between the units. The communications business separately built its production facilities, logistics, and distribution channels. There is also no evidence of sharing ideas in branding, design, or management between the two lines of business. The failures in television nevertheless had the indirect effect of making Nokia very cautious in its acquisitions, emphasizing cost-efficiency and profitability and the importance of maintaining a narrow business focus.

8 At the time, Technophone was the second largest mobile phone manufacturer in Europe.

9 According to a Nokia director Kari-Pekka Wilska, the Tandy cooperation considerably enhanced the company's customer orientation. In the leading Finnish daily newspaper *Helsingin Sanomat* (7 April 2002, p. E3—in Finnish, translated by the authors), he notes: "We had a Finnish engineer's mindset. As a major distributor of consumer products, Tandy's view was totally different. . . . We learned that even though the product can command a high price in the market place, it does not have to be expensive to produce."

10 There was even an attempt to sell the company to Ericsson, which in hindsight unwisely showed no interest, although it had made a proposal for a joint venture in the mid 1980s; Siemens showed interest in the company but negotiations were discontinued.

11 ICT sectors as defined at the source. The reference year may vary. See the original source for further notes.

12 We approximate the ICT cluster with the following NACE industries: 30 office, accounting and computing machinery, 32 radio, Television and communications equipment, 64 post and telecommunications, 72 computer and related activities. This is considerably narrower than Paija's (2001) "original" ICT cluster definition.

13 The recruitment of Mr. Jorma Ollila (Nokia's current CEO) from the London office of American Citibank in 1985 was motivated by the increasing role of international finance. The following year he took the first steps towards implementing Nokia's current ownership structure by managing a directed share issue to one of George Soros' funds (Häikiö 2001c, pp. 75, 78). After Finland removed the remaining restrictions on foreign ownership in 1993, Nokia started sizable equity issues in international markets. In 1994 it was listed to the New York Stock Exchange. According to Häikiö (2001b, p. 195), Nokia is the least domestically-owned company among the hundred biggest companies in the world.

14 Nokia electronics, established in 1960, resold computers, provided computing services, and also manufactured some of its own electronic devices. Sales were modest, but the 1960s may be seen as an era of competence building in digital technologies. The real breakthrough and expansion came in the 1970s. In 1972 Nokia signed a contract to deliver a large computer system for the Loviisa nuclear plant. In 1973 Nokia decided to start its own computer manufacturing after a major order from a local bank (Kansallis Banking Group). In order to capitalize on accumulated computer expertise and to leverage its phone cable business, Nokia became involved in fixed-line digital telecommunications by acquiring a license for a central telephone exchange from CIT-Alcatel in 1976. Its own (in part developed at Televa) digital exchange, the now legendary DX200, was introduced in 1982. It was based on a standard Intel microprocessor and was thus easily programmable and upgradeable. With its distributed processing power, all-digital silicon architecture, and industry-standard components and programming language, it went against prevailing beliefs about telecommunications. DX200 was amazingly profitable in fixed networks and later formed the foundations of Nokia's wireless network systems. With altogether 2 thousand person-years of R&D effort spanning over 10 years (Keijo Olkkola, as cited in Häikiö 2001a, p. 275), it may be the biggest single R&D project in Finnish history (see also Palmberg 2002).

15 The management of Nokia understood opportunities and threats in the all-IP world quite clearly in the mid 1990s. Internally its business impact was likened to that of digitalization some years earlier. Partly as a response, a corporate venturing unit New Ventures Organization was established in 1998.

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