The Mobile Telephone Cluster in the Nordic Countries: Policies to Foster Innovation and Success through Provider Competition and Knowledge Alliance Development

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Abstract

The Nordic countries, and most especially Finland and Sweden, have been very successful in the development of international leadership in both mobile telephone penetration and mobile terminal and infrastructure manufacturing. Nokia and Ericsson are often discussed as world leaders in product design and innovation for both terminal and network infrastructure. Their success is the product of many years' government focus in developing the mobile telecommunications industry as a whole, with a key policy aim of having a innovative manufacturing sector anchored within an advanced and demanding regional mobile telecommunications market.

We examine here the policy and market environment in these countries that has supported the development of this highly vertically integrated and successful industry. Some attention has been given to the development of science parks, support of collaborative research that has supported both research and development and the development of a skilled labor market to assist firms' growth. Less attention has been given to the success of government policies that have promoted the firms' core technological competencies in supranational fora (most notably the promotion of firm competencies in the GSM standard) and the positive impact of the deregulated competitive telecommunications market, especially in Finland.

The Nordic industry is also quite vertically integrated in that a number of Small and Medium Enterprises contribute to its success. Two of these are examined in this paper.

We draw conclusions from the policy environment of Finland and Sweden and develop recommendations for governments seeking to develop innovative and integrated national telecommunications industries. Further recommendations are drawn from successful firms in the Nordic countries regarding the need for management to be responsive to a range of policy and market factors in their home markets should they wish to develop leading hardware and information services.

Introduction

The recent focus on the convergence between information technology and telecommunications illustrates the centrality and interconnectedness of telecommunications in modern society and economies. The development of services in national economies at the expense of traditional manufacturing and primary industries, the growing importance of electronic commerce and information content-based industries and the growing importance of globalisation all presuppose a central location for telecommunications policies at national and international levels.

This case study analysis takes in international, regional (European and Nordic) and national policy elements, where appropriate, in presenting a clear illustration of the policy environment within which Ericsson of Sweden and Nokia of Finland have emerged as leaders in the manufacture of mobile telecommunications network equipment and terminals (handsets). Elements examined here include the role of governments in liberalising market arrangements, their role in the establishment of technological standards and their role (in an industry policy or interventionist framework) of industry coordination and assistance.

The supranational context of Europe is examined first. The two nations are relatively recent though enthusiastic entrants to the European Union, and EU level policies with regards to telecommunications in general, and mobile telephony in particular, have been highly important in the success of the two nation's mobile phone industry.

European Context

Like all aspects of post-war Europe, an understanding of mobile telecommunications policies develops only from an understanding of the various national policies, systems and rivalries and a further understanding of generally recent attempts at regional integration. At a European level, until the late 1970s the regulation of telecommunications services tended to be viewed as an appropriate responsibility of national governments.

The larger of the European states; France, Germany and Britain, all had somewhat similar telecommunications systems and histories in the late 1970s. They had a common tradition of state owned monopolists that dominated national telecommunications systems and indeed this was more often than not the model elsewhere in Europe. The only exceptions were the Nordic nations where competition in various forms was allowed. In Finland, for example, there had been a strong tradition of independent, regional local access providers. In Sweden while there was *de juré* competition, *de facto* monopoly existed through the dominance of Televerket.

Throughout Europe the Public Telecommunications and Telegraph Organisations (PTTs) were often little more than notionally independent of national governments and were generally quite staid and conservative in their management. As late as the early 1980s, for example, cross border calls were more expensive than network economics would dictate. Further, where users sought to develop cross-border networks for data transmission they encountered numerous technical and organisational incompatibilities that were illustrative of a disjointed European telecommunications system as a whole (Gannon, 1997, 295).

From the perspective of the European Commission, such a situation was a cause for concern. The future success of economic and social integration in Europe required the ability for the citizens, businesses and governments to effectively communicate with one another. The increasing importance of data services required more complex systems, with a concomitant need for interconnectedness to extend beyond voice to data services through standardisation of communications protocols.

Prior to the early 1980s, most of the matters of national PTT interconnection were managed by the European Conference of Postal and Telecommunications Administrations (CEPT), an organisation that had as members most of the Western European PTTs. The accelerating processes of technological change in telecommunications forced a broadening of CEPTs brief from the basic regulation of interconnection to a more comprehensive focus on technological compatibility between national systems. While CEPT was reluctant to become too prescriptive to its members regarding technologies and commercial matters relating to basic service and network infrastructure, the relatively young mobile services sector tended to be viewed as a peripheral though promising area by national

governments and their PTTs.

In 1982 CEPT established the "Groupe Spéciale Mobile" (hereafter GSM or Global System for Mobile Communications) working group to develop a second generation digital standard for use throughout Europe, a set of common standards for a common cellular network in Europe. The Nordic countries, along with the Dutch PTT, were instrumental in proposing both the establishment of the working party and the reservation of spectrum throughout Europe that would be suitable for digital services.

Arguments in favour of a unified approach were convincing. They included the potential commercial and market benefits of a harmonised approach to the development of the next generation of mobile telephony. Soon policy makers, PTTs and equipment manufacturers became involved with and committed to the pan-European model.

An early decision related to the reservation of radio spectrum throughout the European region suitable for future rollout. In first generation analogue systems, various standards had used various frequencies in different European nations and a pan-European approach to frequency allocation was viewed as imperative for future roaming and effective spectrum management. The 900 Mhz frequency was decided upon. This frequency was already being utilised in the UK and the Nordic region for analogue mobile telephony and it provided a fair balance of clarity and cell size for the majority of European urban terrain (the initial area of focus for the rollout for the new networks).

The future provision of pan-European roaming was viewed as an important and commercially attractive aspect of a unified approach, though as events transpired the most positive commercial benefit to be found were the economies of scale available in the research and development for and manufacture of network and terminal equipment.

Easy consensus was achieved among the various players regarding the undesirability of a future repetition of the melange of analogue standards in place throughout Europe (Titch, 1985, 24). The UK, France, Germany, Italy and the Nordic all employed different first generation mobile standards. In the event, the diverse analogue standards that had been present throughout Europe prior to the adoption of GSM gave way to the universal and early adoption of GSM in the key markets of Scandinavia, Great Britain, Italy, Germany and France (Funk, 1998: 422). The development and European regulators saw an opportunity for a precedent to be set that showed how regional cooperation among commercial operators, manufacturers and governments could work together to achieve common goals (Garrard, 1997, 130).

The EU and CEPT also both had their eye on a broader goal. The move in the telecommunications industry more generally towards complex electronic equipment provided the potential for either a balcanisation of European operators into incompatible network approaches or the development of a functional, regional network. Further, policy makers began to note that "the fact that, from a technological point of view, the Community was lagging behind its main competitors (particularly the United States) began to become apparent" (EU, 1998).

The EU's *Green Paper on the Development of the Common Market for Telecommunications Services and Equipment*, published in 1987, extended both the need for liberalisation in national telecommunications systems and also standards harmonisation throughout the Union (Just and Latzer, 2000). Structurally it was seen to be important that an effective separation be developed between ownership and regulation – dual roles often internalised within state-owned PTT monopolies (Muller et al., 1993, 628).

From an industry point of view, the long-term desire of member states and the Union as a whole was the development of a competitive and interconnected telecommunications industry that developed innovative hardware and provided

competitively priced and novel service (Bernier, 1996). Illustrative of moves at the European level to build up electronics industry competencies was the EUREKA programme (European Research Coordination Agency). Launched by France's Francois Mitterrand in 1985, the programme sought to fund cooperative research between industry, academia and public sector institutions (Kreiner and Sevon, 1998, 8).

Through the economies of scale created through the larger, liberalised markets, a flourishing of the European telecommunications industry developed. Further, the requirement for the European firms to work cooperatively in the development of new functionality within the GSM standard and elsewhere created a cooperative environment that supported knowledge sharing and networking.

While the intrusion of the Brussels bureaucracy into the core markets of the state owned PTTs created some angst among certain national governments, the Union's efforts to harmonise technologies used in mobile telephony met little resistance. Mobile telephony was, at the time, a relatively small market segment in comparison to the traditional PTT operative areas.

GSM thus became the pan-European digital standard in 1987 and was progressively introduced into operation throughout Europe from 1991 onwards. The impetus for GSM development can be seen as the result of a happy confluence of a variety of technological and political factors.

The GSM group began work in earnest in late 1982 with a view of formalising the myriad issues required for the development of the new standard. A fundamental problem that soon emerged related to the use of patented technologies or intellectual property rights (IPRs) in the new standard. GSM, like all electronic applications, built upon existing knowledge and utilises existing protocols and patents in the development of a new system. Many firms in Europe and elsewhere had established patent protection over technologies that were vital components of a functional system. In the final analysis, the spirit of cooperation won out, to a degree. The GSM group established a principle that all European vendors, operators and manufacturers could use the various GSM IPRs freely in the manufacture of GSM terminals and network equipment (Garrard, 1997, 141).

The sole dissenting voice in the GSM group came from Motorola, the Illinois based multinational. US based firms had traditionally been far more protective of IPRs than their European peers, with firms like Qualcomm of San Diego emerging as industry giants based, to a large degree, solely on their control of key technologies relating to CDMA technology. CDMA is a key component of the IS-95 standard that has been broadly adopted in the United States (Funk, 1998). Understandably, Motorola was uncomfortable with the prospect of freely disseminating its patented technologies to European firms with little promised in return. In the final analysis, a set of principles emerged that allowed Motorola to cross-license its share of vital GSM patents with the European firms and produce equipment for GSM systems without the requirement of royalty payments.

The Nordic duo of Nokia and Ericsson benefited greatly from these arrangements. Patents and competencies that the firms had developed for NMT systems were vital for GSM manufacture and both firms found themselves able to launch competitive products for the European market when commercial services were introduced in1992.

In 1988 CEPT established the European Telecommunications Standards Institute (ETSI). This agency was given the role of moving forward the technical process of developing the GSM standard and its successors. Its establishment had at its heart the acknowledgement that the technical development of the GSM standard belonged with a group that was not so clearly aligned with the national PTTs. Kano (2000, 313) also posits that its establishment by

European governments illustrated their desire that emerging European technologies not disseminate to Japan and the United States too early in their development phase.

The GSM standard was created with a commitment to standards openness. Paetsch (1994: 287) notes:

> The GSM standard itself is an open nonproprietary-standard, which means that not just the air interface is specified but all interconnections between the base station and network subsystems. It is, therefore, possible that cellular systems components are supplied by different vendors. Also the (European Union) strongly encouraged this development, since it allows smaller companies to participate in the market with certain niche products.

From an industry-policy perspective, the rationale that drove standards openness flowed from a broad set of shared commitments. It was a view broadly held across member states that the encouragement of the development of a vertically integrated European technology industry with a functional mix of innovative and entrepreneurial SMEs with a degree of industrial leadership provided by the larger conglomerates was desirable.

The Nokia CEO, Jorma Ollila (1998, 143), commented in 1998 that:

> GSM is a good example of excellent cooperation in standardisation work. Manufacturers, operators and regulators shared a common vision of digital mobile communications in an open standardisation process.

Thus the spirit of cooperation and openness that had played a part in the success of an effective Nordic model of mobile telephony became the model for emerging European digital mobile. Pulkkinen (1997: 155) notes the dynamic situation that was created in Europe to support the development and diffusion of the GSM standard:

> The process of CMT standardisation and standard diffusion resulted from a mix of technological, political and economical forces. In the phase of ferment, political forces played an important role especially in Europe, where several nations promoted national standards in cooperation with national manufacturers.

The GSM standard, like the NMT standard before it, was conceived as an open and non-proprietary one, allowing competition and innovation to flourish both within the manufacture of network equipment and personal equipment. The success of Nordic roaming and the economies of scale achieved within the limits of the NMT market (Cornwell, 1984) saw the entire Nordic model emulated at the European level. As few member states had much to lose from the unified approach, most went along with the processes and the disparate first generation analogue models of mobile telephony that had been such a bane for European travellers gave way to European wide adoption of GSM by the mid-1990s.

This unified system of GSM adoption accelerated the takeup of mobile services throughout Europe and the OECD. The success of mobile telephony in Europe, and specifically the GSM standard, has not been remarkable by any measure with regards to scale and scope of market success.

The Finnish Experience

As has been mentioned earlier, telecommunications policy in the Nordic region differed somewhat from that found elsewhere in Europe. Finland's telecommunications is, like its language and history, characteristically unique.

At the time of the invention of the telephone, Finland was a province of Czarist Russia and, perhaps lacking an understanding of telephony's potential, Russia allowed the formation of regional cooperatives to provide local access in many areas. When Finland achieved independence in 1917 there were a large number of local and independent providers of local telephony in place (850 by the 1930s). While the new national government-owned PTT adopted a monopoly role in the provision of long distance telephony, local access was provided by local providers spread

throughout the country (Noam, 1992, 215).

When Finland passed new telecommunications laws in 1987 to further enhance competition in long-distance services, it was one of the few small nations where true and effective competition developed quickly. The local telephone companies had a long tradition for innovation and responsiveness, in contrast to some of the more staid European PTTs. When long-distance telephony was fully deregulated in 1992, a number of local providers invested to form the Finnet group to provide competition for the former state monopolist in the provision of long-distance services. Finland has thus often been called one of the most competitive telecommunications markets in the world (McLelland, 1991; Siponen, 1999).

Mobile telephony in Finland is also characterised by strong competition and innovation. Local firms established in the service provision arena in 2000 are the state-controlled operator Sonera, rival Helsinki Telecom's subsidiary Radiolinja and Telia, wholly owned by the Swedish Telia. In 1999 the Suomen Kolmegee alliance of regional operators and Swedish Tele2 (Sweden's second operator after Telia) was granted a third generation license to complement these previously mentioned firms in the provision of 3G services. Further, a number of local firms, like the Vaasa Telephone Company, are building new local networks at the 1800 Mhz frequency band in regional areas.

Throughout the history of GSM, the Nordic nations played a concerted and vital role in developing both the vision for an open, pan-European standard and in overcoming the technological challenges that the development of mobile telecommunications on a mass-market scale required.

There is a great deal of conviviality among the Nordic neighbours. Their recent decision to build a complex of embassies together in the readopted German capital of Berlin is a strong statement of shared regional interests. A key attraction of the Øresund bridge project was the development of a regional industrial and academic community between southern Sweden's Malmö-Lund region and the Danish capital of Copenhagen. In the context of this research, this regional identification provided the impetus for another important and far-sighted policy, namely the development of a shared standard for analogue mobile telephony – the Nordic Mobile Telecommunications (NMT) standard. The Nordic countries had accepted the idea of developing a mobile telephone system at a conference in Norway in 1969 (Lindmark and Granstrand, 1995). Their shared early acceptance of, and commitment to, mobile services was influenced by, among other factors, the peculiarities of the Nordic climate and terrain and the need for an effective communications system for the military. Their success was marked: by 1979 there were 75,000 mobile telephone subscribers in the Nordic countries as compared with 40,000 in the US Bell system and less than 10,000 each in Britain, Germany and France (Pulkinnen, 1997: 89).

Pulkkinen notes the importance of early standards promotion in Nokia's success:

> We argue here that the specific nature of the development of industry standards facilitated Nokia's growth in the early 1980s. The first mover position of the Nordic CMT (cellular mobile telephone) manufacturers to develop CMT technology and to gain a knowledge of the markets on a par with other manufacturers.

The strong market penetration of mobile telephony in the Nordic countries further afforded Nokia in Finland and Ericsson in Sweden with a heightened ability to build deep knowledge about the manufacture of mobile telephones and allowed them to become innovative world leaders in a strongly growing industry. This knowledge in the Nordic analogue standard placed the firms in a strong position to develop further knowledge as GSM was promoted and adopted throughout Europe.

By the early 1980s, Nokia began to view the emerging mobile telephony market as worthy of a focused strategy. Perhaps drawing on the success of Ericsson in building synergies between the Ericsson AXE digital switch and mobile network switches, Nokia developed a joint-venture with Salora (the national PTT) in 1979 to create Mobira, the predecessor of the current mobile telephone manufacturing unit.

Salora was the main service provider for mobile telephony in Finland at the time. Nokia had entered into a number of supply arrangements with Salora for fixed line exchange equipment during the 1970s (Salora was one of the first purchasers of Nokia exchange equipment in 1973), and an extension of this cooperation for the supply of mobile network equipment was a natural progression for the firms (Ekberg, 1985, 113).

The mobile telecommunications industry was attractive to Nokia for a number of reasons. Unlike most nations, Finland had always maintained a competitive market environment with multiple telephone companies. There were thus multiple potential purchasers for Nokia switching equipment, many of whom had traditionally purchased Ericsson and Siemens equipment. Many of these firms proved equally happy (indeed perhaps a little happier) in purchasing a local product if it were available. The "winner take all" situation common elsewhere where a single PTT authority purchased products only from the large suppliers was never present in Finland, thus starting small in telecommunications was a viable niche strategy for the young Nokia division. Nokia developed a range of customer relationships among the Finnish local telephone companies, illustrated by the supply of exchange equipment to both the Helsinki and Tampere Telephone Companies in 1979.

Nokia was also in a position of being able to develop new products for mobile telephony. Their radiotelephone competencies were relevant for the new NMT 450 standard that began operation in Finland in 1981. The firm quickly developed products for their home market. NMT equipment (terminals and network) in time also became a valuable export earner for Nokia and Ericsson as the standard was adopted in markets in the former Soviet Union, Spain and Asia. In Russia the military had traditionally operated equipment at the 900 Mhz thus NMT-450's life was extended far beyond its use elsewhere as installation of GSM 900 equipment, the European standard, was not possible.

As the firms both came from small home markets, these early forays into export markets were important in developing an external focus for firm technology and market strategies. The close feedback loop that existed between the firm and the sizeable domestic and regional (Nordic) markets helped to ensure that the firm tended to be successful in providing innovative products closely aligned with customer expectations. The potential to leverage these new products into export opportunities provided the "big picture" for the firms. Bernier (1996, 34) noted that "unlike other European companies, which have large home markets, the two Scandinavian telecom companies have been forced to focus on external expansion".

As the firms expanded into export markets for their terminals and network equipment they made known their desire for transparent trade arrangements in equipment. This was due to the fact that the small nature of home markets made them relatively insignificant in the scope of total firm sales. Further, the firms themselves would have difficulty gaining open access to markets in Asia and the Americas if their own home markets were closed to external competition (Muller et al., 1993).

Nokia and Ericsson thus worked to develop leading products and solutions for international markets and their home markets became test-beds of innovative technologies and open, accessible markets. As penetration increased, costs

declined at a rate not experienced elsewhere. Their investment programs were guided by the knowledge that an integrated European market with a single standard was developing. This surety allowed the firms to concentrate on research and development to produce new and innovative products to service the pan-European market and markets in Asia and elsewhere.

Industry and Macroeconomic Policy Issues

The Nordic region's common post-war adoption of a managerialist approach to national industry policy were clearly at odds with the more liberal approaches adopted in the United States and elsewhere. The role of government as an agent of cooperative coordination spurred the development of "national champions" of economic development (Parker, 1999) that suited large industrial conglomerates like Ericsson and Nokia.

Approaches based upon cooperative managerialism at the national industry policy level were internally consistent with corporatist decision making elsewhere in society and the presence of elaborate social democratic welfare systems. Forces of global economic change made the maintenance of all such structures difficult in the 1990s. The collapse of the Soviet Union served to exacerbate the pressure on the Nordic nations to liberalise their economies.

Penttilä (2000) notes the "quiet revolution" that reformed Finland's foreign policy and economy in a strategic and eventually successful manner at the time. The collapse of the Soviet Union in 1989 was a harbinger of massive economic dislocation throughout the region, though it was especially felt in Finland – so much so that between 1990 and 1993 Finnish real GDP fell by 10%, unemployment reached 18% and the public sector deficit reached 7% of GDP.

In 1991 Finland devalued its currency in the face of speculative activity from international hedge funds and a traditional reliance on forestry products for export receipts – an industry that was notoriously volatile in the early 1990s. Large Finnish firms and government, both of whom had borrowed to fund investment in the nation's capital intensive primary industries, felt the brunt of escalating repayments.

In establishing a national response to these economic problems, the government was mindful that the nation's geographical location ensured that any future success needed to utilise national opportunities presented by its location at the north of Europe while minimising the costs associated with its unstable eastern neighbour. Thus European integration assumed a central position in Finnish industry and economic policy.

Explicit government policies in both Sweden, and more especially Finland, also sought to develop strong links between the manufacturers and academic researchers. An example has been the support by government to establish technology parks in areas like Spinno, near Helsinki (Autio and Kloftsen, 1998). These parks, anchored by large tenants like Nokia or Ericsson saw the development of a range of small support firms with strong links to the University sector, government funding agencies and Nokia to develop in a cooperative manner innovative components for mobile telephony.

The Finnish government's espoused commitment to develop the economy in Finland through the development of high-technology manufacturing, assisted by bodies such as the Finnish Ministry of Trade and Industry, the Technology Development Center of Finland and the National SME Foundation, created remarkable and positive results. Both Finland and Sweden saw rapid success in the development of mobile telephony competencies and manufacturing with a large number of smaller support firms who have themselves provided much impetus for incremental and modular innovations.

The Government's and indeed the nation's response was a managed Schumpeterian revolution of creative economic destruction. For a long period Finnish industry policy had been focused on the dual objectives of economic deepening (developing a value added focus for the nation's primary products) and economic broadening (developing high-technology industries in a sustainable manner). In the period after 1995, the fruits of this policy approach became evident as the cyclical paper industries moved into positive growth and the high-technology industries, anchored by Nokia, entered a period of remarkable success.

The Finnish Government has taken a lead role in encouraging these developments through direct and indirect mechanisms. It has, for example, augmented its research budget for 1997-1999 by one-quarter and the private sector has also kept pace. The research budget for 1999 (60:40 private to government sources) was around 3% of GDP, higher than any other OECD nation.

Further, key competencies developed in the Nordic market afforded Nokia a valuable technological leadership position to service the rapidly growing North American market. Nokia entered into a joint-venture with Tandy Corporation, an electronics retail chain, in the US in May 1984. This alliance was to provide the firm with a valuable entry point into the US market, and between 1984 and 1988 Nokia entered 20 new international markets (Pulkkinen, 1997: 129). Nokia, throughout this period, leveraged their technical knowledge of production of NMT compatible equipment to the broader industry, producing equipment for the rapidly expanding US analogue AMPS standard.

In 1988 the firm's brilliant through troubled CEO, Kari Kairamo, committed suicide. Kairamo, who had been CEO since 1977, had developed the technology side of Nokia through the acquisition of (among other assets) a German TV maker, Ericsson's computer business and a U.S. paging company (Fox, 2000, 160).

His replacement, Simo Vuorilehto found Nokia as unfocused as ever and began streamling the unwieldy firm. Nokia at the time was dealing with broader troubles – its traditional businesses were struggling in the face of a Finnish recession. The crisis is illustrated by the fact that in 1991 Nokia's biggest shareholder tried to sell its stake to Ericsson – though Ericsson was not interested (Fox, 2000, 162). In 1992, when Jorma Ollila took the helm, the process of concentrating the firm from a producer of tyres, boots, televisions and a variety of other products into a world leader in the production of mobile telephones was well advanced.

GSM Era

The most recent and broadly based success of Nokia has come during the international expansion of the GSM standard. The introduction of GSM, which occurred in parallel with the liberalisation of European mobile markets, created a raft of opportunities for the firm. Jorma Ollila, the CEO, was quoted in 1996 as saying "Nokia has widely benefited from the liberalization trend sweeping across Europe" (Bernier, 1996, 33). The introduction of competition for GSM services in Europe also allowed Nokia to develop new markets for its network equipment. The firm established early relationships with second tier firms like Orange in Britain and E-Plus in Germany for the supply of network equipment and base stations. As the market has matured and these firms have expanded their networks, Nokia has found its growth leveraged in both terminal and network equipment manufacture.

As the GSM standard gained broad acceptance throughout Europe (and was also accepted in a more limited fashion in the United States, the Asia-Pacific) the firm found exponential growth for their innovative and market-leading products.

The development of digital equipment for the GSM standard that became operational in Europe in late 1991 marked a technological discontinuity for the industry and Nokia took advantage of this opportunity for a marketing and design-led change. Prior to 1991 Nokia's phones had been branded a variety of different names, though after 1991 the 1991 name appeared on all phones and equipment. Nokia's new equipment was also deliberately "un-brickish", with smooth corners. A small issue perhaps, but a feature that marked Nokia's equipment apart from its competitors in style and design (Pulkinnen, 1998; Fox, 2000).

In designing products that would function in Japan, Europe and the United States (albeit operating with different standards and network protocols), Nokia also developed a menu-based operating system for phones that allowed extensive features and functionality without making the phone un-usable for normal consumers. The larger screen also facilitated use of SMS messaging, a GSM standard feature that was originally envisaged as a means of operators passing short messages to users. This technology became a feature that was highly popular in the Nordic among young users, becoming a trendy and inexpensive means of communication.

The 2100 series, launched in early 1993, has been fundamental in developing Nokia as a world leader in terminal design and manufacture. Nokia has sold more than 20 million of these terminals (Nokia, 2000) and their reliability and functionality played a large role in cementing Nokia's reputation for quality in the minds of international consumers. The 2110 GSM terminal was very popular in Europe, winning a number of industry plaudits for quality, reliability and functionality.

Nokia adopted the 2110 GSM version of the terminal for the United States market and the variety of network standards operating there. The firm released the 2120 for the digital US S-54b (TDMA) standard in 1994, soon after the release of the 2110 in Europe. The 2160 was released for the US market in March 1996. This was the first dual mode terminal (a phone able to utilise different networks) able to utilise both analog (AMPS) digital (IS-136 TDMA) networks (Nokia, 1996).

The Swedish Experience

Reflecting Nokia's success in Finland, McKelvey et al. (1998, 3) note that "the history of mobile telecommunications in Sweden is, to a large extent, the history of the firm Ericsson and its relationship to the Swedish PTTs as well as to other small firms". The close relationship between producer and user of the new technology also played a part in supporting the growth of Ericsson's telecommunications competencies. Ericsson's and Televerket's relationship had traditionally been a strong one. Granstrand and Sigursdon (1985a, 149) noted that collaborative links between the two firms originated in contracts in the 1880s, continuing until today through a range of collaborative research and production arrangements.

As in Finland, early contracts between the Swedish military and domestic firms created the impetus for the development of radiocommunications competencies. Swedish Radio AB (SRA) was created as a joint venture between ASEA, AGA and Ericsson in 1919 with a role of producing radio equipment for both the Swedish navy and the Swedish PTT, Televerket (McKelvey, 1998, 20).

The nascent industry in Sweden in the mid-1960s served a predominantly urban clientele. The approximately 450 Swedish subscribers to the system in 1967 tended to be travelling professionals or senior managers of large firms. Molleryd (1999, 85) notes that the vision held by senior engineers within SRA at the time was for a truly national industry and system, serving a broad market. Such a view was uniquely held in the Nordic region, with few other

areas globally seeing the technology as more than a peripheral and high-value addition to existing fixed line networks.

Such foresight, shared by the PTT, SRA and national policy makers, drove innovations aimed at extending and economising the use of spectrum with a view to extending the potential user base. The MTB standard, first implemented in 1967, had as a technical focus the more effective use of radio frequency. This drive was illustrative of the desire of the participants view that mobile telephony needed to grow in usage for it to be profitable to develop and implement.

Moves towards a national system were aimed at developing strong economies of scale and further positive externalities for travelling users. Both of these outcomes could also be facilitated by a move to an international focus for the technology. Such reasoning was behind the development of the Nordic Mobile Telecommunications (NMT) group in 1969.

It is fair to reason that the participants at the 1969 meeting of PTT representatives from the Nordic nations of Iceland, Norway, Sweden, Finland and Denmark to establish the NMT standard could not have imagined the future significance of the decisions that they were to take. The meeting formalised a shared understanding that mobile telephony technology should be harmonised among the participants to allow roaming and the development of economies of scale in research, development and manufacturing. The group established committees that moved rapidly to develop these protocols, and the group agreed on protocols for an analogue system that was launched throughout the region in 1971. The NMT system that began operation in Nordic nations from 1981 was not the world's first cellular system, though the choices made regarding spectrum (at the 450 Mhz band) meant that a combination of excellent coverage and low usage prices could be developed.

Growth in the relatively prosperous Swedish market was exponential early in the release of the new technology, and growing pains in the form of network congestion were soon felt. The analogue technology employed at the time used relatively simple and manual switching processes that required operators within exchanges to connect every call to and from the wireline network. As the subscriber base swelled, the use of manual switching come under increasing pressure. Manual systems required the operators to select the appropriate radio-tower for each call. As the within the subscriber base reached 20,000 in Sweden alone, more than 400 operators were required – a significant proportion of Televerket's employees (Molleryd, 1998).

Technological change from outside wireless was soon to provide answers to these problems. The growth of electronic exchange equipment was being pioneered in the Nordic through Ericsson's other divisions. In 1973 the NMT group formalised the specifications for an extension of automated switching to mobile telephony (Meurling and Jeans, 1994).

The choice to focus on emerging electronic and soon digital technologies and turn away from simple analogue radio technologies marked a technological cleavage for the industry. The pursuit and development tended to be more expensive than the use of existing technologies, though it seems that the organisational culture within Ericsson and the broader national and regional culture supported such an approach. Following the expansive and creative paths offered by innovation became a hallmark of the Nordic industry, a characteristic that was to serve it well in the future.

The NMT standard matured towards another significant iteration in the development of the NMT 450 standard that became operational throughout the region in 1981. This again marked a technological discontinuity in that it employed

AXE switching within the exchange, the first fully digital switches developed. AXE research and development had been carried out for fixed line services within Ericsson between 1969 and 1976 (Granstrand and Sigurson, 1985a, 165).

The synergies within Ericsson's radio communications and core fixed-line businesses were important as the rollout of the new system as the firm was able to bring together leading-edge technology from a range of areas to develop fully integrated mobile systems. The development of such systems was always to factor strongly in Ericsson's technology marketing strategy and key buyers of the new AXE technology for fixed line communications soon purchased the mobile variant with a view to minimising training and maintenance investment and ensuring network compatibility (McKelvey et al., 1997, 56).

The NMT 450 was first implemented not in the Nordic region but in Saudi Arabia. The Saudis had approached Ericsson to upgrade their national fixed line network and Ericsson convinced them to install the latest mobile technology as well (Meurling and Jeans, 1994, 55). The deal assisted in the funding of necessary research and development within the firm and created a sense of urgency that was to serve the firm well in ensuring it had a leadership position in NMT terminals and network equipment when the rollout in the Nordic area began in 1981.

By creating the nexus between mobile telephony and digital switching, NMT 450 required a large amount of work on software development aimed at effectively managing call usage. Paetch (1993, 28) notes that a product of this research was the development of true mobility that allowed users to transfer between cells while on a call. Such technology had not been available in earlier technological iterations and was made possible by the introduction of new approaches to call management.

Ericsson bought the 50% of SRA it had not owned from British interests in 1983. Perhaps realising the potential of the industry and importance of creating synergistic links between existing wireless technologies like the AXE switch and mobile telephony, the firm began a focus on developing vertically integrated systems for customers. The strategy met with marked success as the firms emerged as the sole supplier of digital switching equipment in the core national markets of Sweden, Denmark, Norway and Finland as these nations upgraded to the new technology in 1981 and 1982 (McKelvey et al., 1997, 26).

GSM Era

Ericsson's success as a global industry leader today has been built on its mobile and fixed line businesses and, perhaps most importantly, the synergies that it has been able to develop between the two.

European liberalisation of mobile telephony began to be felt in the early 1990s. Early contracts in Germany and the United Kingdom with competitors to the existing PTTs were secured by Ericsson. To a great degree these relied upon Ericsson's ability to deliver full network solutions for the emerging, competitive operators.

Within the highly consumer-oriented terminal market, Ericsson and Nokia both met with marked success. A strong feedback loop within the domestic and regional environment, where demanding domestic consumers expected new innovations regularly, saw the two Nordic firms lead in the release of new products. For example, Nordic consumers have lead the world in the takeup of new technologies like SMS messaging. Penetration rates in Sweden and Finland throughout the era of GSM has remained the highest experienced in the world.

The Role of SMEs

In this supportive, though competitive, environment, a number of small and medium enterprises have emerged as central to the industry's development. The growth of the large multinationals created significant niche opportunities in peripheral though important areas of manufacturing and services. To illustrate this, two cases are presented of Finnish firms that cooperate with both Nokia and Ericsson.

Elcoteq was established in 1984 as a specialist producer of flat panel displays for television and computers. While headway in this chosen industry was difficult to achieve, the firm's broad competencies in electronics assembly allowed a move towards contract assembly services for the regional mobile telephone manufacturers.

With the benefit of hindsight, Elcoteq made good use of a challenging set of environmental factors. While the collapse of the government and economy of the Soviet Union in the late 1980s and early 1990s was the harbinger of great economic difficulties for Finland generally it created a unique set of opportunities for Elcoteq.

The first of the former Soviet republics to secede from the union in 1991 was Estonia, and by the early 1990s a series of privatisations were being undertaken to disburse government assets to the private sector. Elcoteq purchased a bankrupt television factory near Tallinn, the Estonian capital, in early 1992, and converted the assembly systems for the manufacture of mobile telephony. Estonia provided a combination of close geographical proximity to Finland, Sweden and other European markets along with a low cost though well educated workforce. The Estonian government, through the Estonia Investment Agency, also assisted Elcoteq in increasing the size of the Tallinn plant and in 1995 the firm tripled the plant's capacity, increasing the number of employees on site from 880 to over 2,000 (Tukiainen, 1996).

A refocus on core competencies by Nokia management was being undertaken in the early part of the 1990s as a response to a desire for cost cutting and the potential of firms like Elcoteq to undertake contract assembly services for the firm. Elcoteq's CEO noted in 1998 that "traditional hierarchical leadership and production is history. There is no need for the Motorolas and Nokias of this world to do everything themselves" (Romantschuk, 1998).

The peculiar knowledge infrastructure and rapid technological change in mobile telephony also worked in Elcoteq'' favour. Elcoteq focus on an area of the market that was percieved as low value added and was thus not viewed as a threat to either Nokia or Ericsson. The firm's position late in the technology cycle (at the assembly and final manufacture stage) ensured that the firms were able to both contract subassembly services at the same time. There was little concern of industrial espionage at this period of the product development cycle as technology at the manufacturing end of the technology cycle tends to be well known to all industry participants. This situation allowed Elcoteq to successfully bid for subcontracting for both Ericsson and Nokia at the same Tallinn factory for many years.

Elcoteq later expanded into other low cost labour countries with ready proximity to major consumer markets like Hungary, China and Mexico (Merita, 1999) and has seen sales and profitability grow rapidly in recent years.

Elcoteq's business strategy has leveraged the firm's success to the success of its regional partners, Nokia and Ericsson. Its technology strategies tended to offer less of the potential for lucrative profitability that has been evident in some industry players who control intellectual property rights through patents (for example, Qualcomm and Ericsson). Having said this, the riskiness of the firm's business strategy is also reduced. Elcoteq is relatively

unconcerned about technological directions taken at the beginning of the technology chain – its competencies and profits are both located at the low end of this chain where volatility tends to be lessened by a constantly growing demand for terminals from a range of producers by consumers.

Another Finnish firm, JOT Automation, has grown strongly in cooperation with both Nokia and Ericsson. This firm has provided advanced assembly equipment (like board handlers, necessary in the integration of advanced terminal componentry and test handlers, necessary for quality control) on a "turnkey" basis to both firms.

JOT Automation's intriguing name comes from the phrase "Just-On-Time", a typically Finnish allusion to "JIT", the managerial approach that had been development in Japan and elsewhere to reduce warehousing requirements needed during the manufacturing process.

The firm's competencies are broad - across the manufacturing technology industry. Its products are demanded by firms who have sought to increase the level of automation in assembly processes, a vital aspect of quality control in the manufacture of precision interests like internal communications and information technology in mobile terminals and other consumer electronics. Their equipment combines both robotics technology and manufacturing automation to produce automated lines that can handle most aspects of the manufacturing process, from assembly to packaging.

JOT Automation's sales growth has been less spectacular that that of its peer, Elcoteq, though it does occupy a strong niche position and a broad customer base within and beyond mobile telephony. It has developed a strong alliance with Hewlett-Packard to increase the knowledge and software component of its test products and is seeking to develop broader presence in the information technology and telecommunications manufacturing industries.

Key contracts are still generated in home markets, however. Between September 1998 and June 1999, FIM300 (approx. 50 million Euros) worth of contracts for production automation and packing equipment were signed between Nokia and the firm.

The relationship with Nokia has also been a catalyst for further expansion of the firm beyond Finland and Europe. Nokia's US operations are based in the Dallas-Fort Worth area of Texas, and JOT Automation chose neighbouring Irving as the base of its US operations in 1995. The firm's presence in Irving has been profitable, being responsible for one third of firm sales in 1998 (Carbo, 1998).

The strategy adopted by JOT Automation has been somewhat different to Elcoteq's. While Elcoteq has developed a strong relationship based upon mutual dependency, the growth of firms like Nokia, Ericsson and indeed Elcoteq itself has provided a munificent environment within which demand for manufacturing automation equipment provided by JOT Automation has naturally increased.

The collaborative network relationship in the case of JOT Automation is somewhat more at arm's length than is the case with Elcoteq, though the firms still work closely together at early stages of the production cycle in the development of technological solautions required for precise assembly tasks. JOT Automation works with Nokia earlier in the production process and thus tends to lock-in support as part of its involvement with the design and production process. This tends to limit its ability to work with competitors to Nokia, though there are ample opportunities for diversification available to JOT Automation in the related consumer electronic industries.

The growth of both of these former SMEs has indeed been leveraged to the growth of the larger firms as they have grown from a very small base to provide a range of necessary non-core operational services for their larger partners.

As will be seen in the next case, this core strategy is not the only one available to SMEs in industries with large, multinational peers.

Conclusions

There are a number of relevant lessons for interested policy makers be drawn from the success of the Nordic duo for industrial and policy participants in mobile telephony.

- The cooperation between industry, government and academia in both Finland and Sweden created an environment within which technological innovations flourished. Governments in the two countries led the way in facilitating this environment through a range of direct and indirect mechanisms relating to the coordination and funding of research and development, training at a tertiary level and negotiating access to overseas markets.
- The competitive environment of the Nordic region drives the local industry to be world class. Few such small markets as Finland's support such advanced services and such high penetration rates. The competitive environment also provides numerous opportunities for both terminals and network infrastructure for competing players.
- The final point relates to standards choices. Nordic policy makers were active in ensuring that regional standards were adopted elsewhere or incorporated in new standards where appropriate. In European fora, policy makers have been active in ensuring the competencies of the leading Nordic firms has been reflected in choices made regarding technology adoption. The small size of the Nordic markets has ensured that the exclusionary stances of Japanese standards bodies was not replicated in the Nordic region. The success the flowed from economies of scale in NMT also ensured that the proliferation of incompatible standards evident in the US was not allowed by European policy makers.

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