Nordic ICT Spaces

A policy-oriented overview of regional ICT

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Preface

This Working Paper was initiated and financed by the Committee of Senior Official for Regional Policy at the Nordic Council of Ministers. The paper provides a policy-oriented overview of the literature reflecting the regional aspects of the development of new information and communication technologies (ICT).

It includes the outcome of:

- A literature survey of current knowledge on regional ICT development, made by Trond Einar Pedersen, Step Group, Oslo.
- A statistical analysis of Nordic ICT agglomerations based on 1999 employment statistics (NACE 4) at the municipal level, by Åge Mariussen and Jörg Neubauer.

The synthesis of these separate elements was made by Åge Mariussen, who was also responsible for the project as a whole.

Stockholm, June 2004

Contents

Summary and policy implications

The point of departure for this study is the OECD definition of 'new information and communications technology', and the important question of where (in which sub-national regions) this new and – until now – fast growing industry will locate.

The statistical data used here is the employment statistics of Nordic municipalities from the period 1998-1999, following the NACE code index. In the debate on the geographical pattern of the 'new' ICT industries, several theories have been launched.

The 'old' ICT industries, with approximately 616 000 employees in Norway, Sweden, Finland and Denmark in 1999 were still, despite evidence to the contrary, substantially larger than the 'new' ones, which employed some 270 000 people that year, from a total Nordic employment role of roughly 10.8 million. The 'old' industries here include newspapers, printing and book publishing, journals, telephone communications office equipment, industrial purpose electronics, consumer electronics, optical instruments, photography, motion picture production and distribution, video technology, advertising, libraries, radio and TV. We often find such industries located in the centres of the capital regions, as well as in centres in most large and medium sized cities. Some of these industries, such as motion picture production, radio, and TV, developed during the early phases of the modernization of the 20th century. They were often located outside – but in close proximity to – capital city centres, where they formed clusters with related industries and sub-contractors in the neighbourhood. Such clusters, together with the advertising industry, formed the backbone of the media industry, thus providing one of the core industrial sectors for most Nordic capital cities.

The 'new' ICT industry – following the by now standard OECD definition, includes (1) *sales* (wholesale and retail related to new ICT products), (2) *software development and consultancy,* (3) *hardware* (manufacturing) and (4) *telecommunications*. This definition is indicative of a rather complex phenomenon, as is the location pattern.

Whereas national telecommunication institutions, later privatized, were often located within the industrial areas *surrounding* the capital city centre, electronic manufacturing to various degrees, evolved further out so to say, in other industrial cities where for example in Sweden and Finland they provided the industrial backbone of the 'new ICT revolution' of the 1990s.

For the purpose of the present discussion, two major theoretical topics may be addressed.

- Space. The debate on the significance of agglomeration, proximity and regional clustering among economists, geographers and sociologists.
- Institutions. The debate on national institutional explanations for innovation in the global economy among historians and industrial sociologists.

By looking at spatial and institutional factors, it is possible to discuss the regional pattern of the new ICT industries, as well as the distinction between 'haves' and 'have – nots'. Based on this discussion, a typology of Nordic ICT spaces is outlined, including:

(1) Industrial City Regions
(2) University-based Regions
(3) Small, peripheral agglomerations
(4) Capital city regions
(5) 'Have not' areas

This typology is discussed, using employment statistics from 1999.

The evolution of the new ICT industry in the Nordic countries has been determined by spatial, institutional and national conditions.

- *Institutions*. Historical and institutional factors explain different national paths to development, with, on one hand, the Swedish-Finnish success story of the 1990s, and a stronger linkage to electronic manufacturing in these countries, and Norway and Denmark on the other, where ICT development was to a greater extent driven by universities and small businesses.
- *National path dependencies*. An important point to emerge from the literature survey was the uniqueness of the historical character and the preconditions of the Swedish-Finnish success story of the 1990s. As such, this development cannot be copied by others. Nevertheless, even these Swedish and Finnish success stories subsequently experienced the effects of the recession and other disappointments, while the once significant 'trickle down' effect of ICT into industrial regions is now fading. What is left then is locally embedded clusters, with innovative entrepreneurs looking for new solutions.
- *National systems*. Capital city clusters are important in all countries, with diversified and large agglomerations of new ICT industries, determined by global as well as national links.
- *Spatial diversification within city regions*. Within capital city regions we find industrial areas outside the centre, sales and software consultancy in the centres, and suburban municipalities with software production facilities.
- *Industrial and university regions*. Within all countries, regional dynamics explain new university based and industrially based ICT clusters. At this level, proximity, interactivity and regional development coalitions are the important factors.

To Nordic regional policy makers today, enhancing the conditions of entrepreneurship within new the ICT sector is crucial. Three points deserve future attention:

- Enhancing knowledge. A plentiful supply of skilled labour is a critical precondition in forming the basis for ICT entrepreneurship. In this respect, universities can certainly play a crucial role, but the supply of skills may come from other sources, including large incumbent old-economy firms and foreign-educated people. Relevant skills here include not only the scientific and technical, but also the managerial and financial ones. The supply of these relevant skills, through educational institutions and regional policy programmes is obviously a part of the regional policy domain.
- A system of innovation support. An emerging cluster seems to involve the ability to take advantage of technological and market opportunities not yet

exploited. For many of the rapidly growing clusters studied in the literature, the establishment of co-operative connections with leading centres of technology represents the most important mechanism for sparking off entrepreneurial opportunities in existing and new ICT niches and segments, along with the supply of venture capital – sponsored by policy actors. As regards innovation support, Nordic countries apply widely differing strategies. In this context, the Finnish Centres of Expertise programme is an interesting 'best case' in providing innovation support in science parks.

- *Diffusion into old industries*. This opens up a focus on future hitherto unexploited ways in which new ICT technology may be diffused into the existing 'old' industries. The major 'digital divide' problem to be solved in the Nordic countries today however relates to a lack of proximity enabling interactive learning to take place between ICT suppliers of sales and services and their future 'advanced' customers in the old industries who are often located outside national capital centres.

Experience of new entrepreneurial achievements, particularly in promoting new ICT diffusion into new 'old industries' seems to be an area where the exchange of Nordic experience is crucial. In policy terms, this field opens up discussion of several topics:

- Development of the national system of innovation, to promote the supply of relevant knowledge, through education and research policies.
- Policies promoting regional innovation systems, regional clusters and local science parks.

In the Nordic context, there are several areas where comparative analysis and benchmarking will be useful. They include:

Case	Policy
Science parks	Entrepreneurial support systems
Capital city regions	Urban innovation strategies
Regional clusters	Innovation & regional development policies
Emerging clusters	Innovation policies
National innovation systems	National innovation policies

1. Regions

The typical 1980s assessment of the then fledgling ICT industry went something like this: As, *technically* speaking, these new technological developments seemed to render physical distance unimportant, and as the new industries also seemed to be evolving independently of pre-existing industrial structures, then, it was argued that these new ICT industries had the ability to provide new possibilities for industrial development *in the periphery*. Of course, things would not prove to be so simple.

The weakness of this theory was that it assumed that proximity was worthless. It was quickly realised however that there were a number of important factors contributing to the geographical concentration of the new industry rather than to its decentralisation. As such, one of the most important discussions in the literature concerns the significance of proximity, agglomeration and 'clustering'.

The opposite theory was that the 'new' ICT industry would flourish *only in larger cities, and primarily in the Nordic capital cities*. Here, it was claimed, agglomeration and clustering economics would provide a basis for inward investment and entrepreneurial dynamics fuelled by easily available venture capital. Agglomeration theories were developed by economists pointing out that externalities created within an agglomeration initiate positive feedback loops. In part, agglomeration theory also draws on geographical theories of industrial districts, and theories of the cluster dynamics. Nevertheless, the geographical pattern followed by the ICT sector was not to be determined by size alone. ICT prospered in some cities but not in others. Within the cities in which it did prosper it created new industrial spaces, often in small municipalities beyond the city centre.

A significant finding from the data analysis presented in this Working Paper is thus that *size* matters, but that there is too much variation in the relation between the size of the *municipality* and new ICT employment to reduce the question to this factor *alone*. The correlation between the size of the municipality and the strength of ICT employment cannot be assumed to be different from 0. At a more aggregated level, making a distinction between capital city regions, other major city regions and other areas, shows that ICT employment does increase with increasing centrality. But the point remains, new ICT employment cannot simply be explained by size alone.

A further question then emerges in this context, namely, is ICT now moving away from the city centres? Is this a 'trickle down' phenomenon? The growth of ICT-activities beyond the capital regions and other major cities has also been explained by the ability of ICT corporations and networks to reduce the 'friction of distance'. Thus, ICT firms seem to promote the decentralisation of some activities (such as routine and mobile production and service activity) away from the large cities. However, during the 1990s, it did not stop there, rather we saw a completely different phenomenon, the expansion of regional ICT clusters, including innovative, 'higher level' functions, such as R&D and new product development. This took place in several industrial and university cities, and at several levels.

At the global level, the major US corporate actors moved innovative functions into Nordic capital cities into close proximity with the national champions of the increasingly successful mobile phone technology, namely, Ericsson and Nokia. In looking at cluster development in the capital regions in the 1990s, both the development of the clusters of ICT firms in Kista and Espoo may be seen as outputs of global corporate actors and national industrial champions playing such 'global games'. The outcome of these games then was the emergence of the global clusters in Espoo, Kista, and other regions in Nordic countries.

This trickle down process was also important at a lower level, with the Oulo success story being a typical example of cluster development *outside Helsinki*. Moreover, both Karlskrona and Oulo come very close to the 'Triple Helix' model of regional development, where alliances between local planning authorities, local universities, national ICT *corporations* and local firms were crucial. The willingness of such corporations to relocate not only standardised functions, but also moved *development projects and software research* out of the major national cities, at the time this phenomena appeared largely to depend upon one major advantage held by these cities, namely, the ready supply of locally situated young people with an ICT-based University level education. Even so, the evolution of Oulo and Karlskrona was to some extent also dependent upon the policies of the national industrial champions such as Ericsson and Nokia. In Denmark, we had North Jutland, and in Norway, the 'Electronic Coast' along the western shore of the Oslo Fjord as other examples of the development of this general phenomenon. Thus, in looking more closely at the industrial city development of the 1990s, it becomes obvious that both the investment decisions of global corporate actors and the construction of local development alliances were important. As such, ongoing developments in these new ICT centres were both the beneficiaries of 'trickle down' policies as indicated previously, as well as being the initiators of important 'bottom up' factors which together congealed to produce something greater that a mere sum of the parts involved.

Theories of 'bottom up' development emphasise the fact that new ICT employment was emerging as a result of talented micro level entrepreneurs, operating through a new version of Schumpeterian logic, often referred to as 'the new economy'. One was its obvious dependency upon skilled labour coming directly from the universities, as the 'new economy' concept was 'knowledge based'. The *other* aspect of the new economy theory was its insistence upon new forms of innovative logic. Innovation was interactive. This idea of interactivity, again, drew on the innovation research that had emerged during the latter part of the 1990s, emphasising interactive learning. This perspective opened up a focus on new economy micro level heroes, or, gifted entrepreneurs, capable of reaping the technological fruits of the new economy harvest.

It was however often pointed out that in certain success cases these 'heroes' did the right thing at the right moment through the establishment of, (or where entrepreneurs built on an already pre-existing), regional innovation systems or 'triple helix' alliances between universities, ICT corporations and regional planning authorities, which enabled rapid regionally based growth. These coalitions, it was claimed, were instrumental in unleashing the knowledge based growth dynamics of a new economy.

The 'new knowledge' (often interpreted as university based, analytical knowledge) argument, combined with the idea of increasing innovation through interactive learning, explained the diversities of development in several Nordic new ICT clusters during the 1990s. While a number of the new regional clusters were initiated through national level university and innovation policies, and were influenced by the decisions made by national and global corporate actors, the later phases of development were to a large extent dominated by local entrepreneurial achievements.

A source of ambiguity concerning industrial agglomerations and the more expansive version of the agglomeration – the 'cluster' – is the question of the criteria for identification. Certain indicators have what appears to be a level of precedence when so-called high-tech agglomerations are to be identified. Typical indicators used to measure the relative concentration of ICT are of an aggregate kind, e.g. productivity (GDP/population), technological density (number of patents/population), scientific density (number of scientific publications/population) (Barré, Laville and Zitt, 1998). Identification of industrial agglomerations by means of these indicators is in principle based on the simple expectation that significant industrial concentrations can be found by looking to geographical areas where performance within patenting, scientific publication and production is high, relative to the population of the area.

Maps of ICT agglomerations based on these criteria tend to show metropolitan areas, geographical areas with large well-diversified services and so-called 'knowledge based cities' or specialist research university campus cities or towns (Keeble and Wilkinson, (eds.) 2000). This method of identification of ICT agglomerations often fails however to give any qualitative information about the characteristics of the industrial concentration[1]. Other methods of identifying agglomerations or clusters have however also emerged in recent years. The OECD publication *Boosting Innovation, The Cluster Approach* (OECD, 1999), presents a set of methods for the identification and description of clusters. The methods include compiling innovative interaction matrices from survey information (DeBresson and Hu, chapter 2 in OECD, 1999), the analysis of I/O (input-output) numbers (Hauknes, chapter 3 in OECD, 1999), and the mapping of innovative clusters in national innovation systems (Spielkamp and Vopel, chapter in 4 OECD, 1999). The latter study applies a range of variables, though R&D versus non-R&D performance is used as the main indicator. The OECD publication is not however dedicated solely to ICT or to the so-called high-tech industries alone.

The book 'High Technology Clusters, Networking and Collective Learning in Europe' (Keeble and Wilkinson, (eds.) 2000) provides a synthesis of research contributions that measure ICT agglomerations in an international context. Although the book includes all the so-called high technology industries, it remains one of the single-most useful contributions in the field when the aim is to construct a picture of how the ICT industry evolved in Europe. From the theoretical concepts of industrial concentration, clustering, and agglomeration it emerges that the so-called 'new economy clusters' are highly skewed in geographical terms. The book's argument is general and departs from the structural phenomenon of the increased importance of SMEs (Longhi and Keeble, 2000). A geographically universal shift can be observed in European and North American countries over the last 30 years, from a larger share of SMEs in economic activity compared to the share of larger firms (e.g. Acs and Audretsch, 1993; Audretsch, 1995; Birch, 1981; Keeble and Wever, 1986).

[1] Publication and patent citation analysis can say something about the extent to which actors interact with each other in an agglomeration. See for example Maurseth P.B., 2001, *Essay on the Nature, the Scope and the Consequences of Knowledge Spillovers*, Dissertation for the dr.polit.-degree at the Department of Economics, University of Oslo.

In the contribution by Longhi and Keeble (2000) the growth of SME-based industrial regions (agglomerations) is seen in the light of trends such as globalisation (both of markets and of management philosophies) and localised (culturally based spatially specific) innovation processes. Norton (2000) moreover argues that the new economy is entrepreneurially formed in the meeting of scientists and engineers with venture capitalists and 'business angels'. The bulk of empirical studies focusing on specific and successful cases of ICT agglomerations and clusters (typically Silicon Valley and the Cambridge Phenomenon) give vigorous attention to the cultural dimension as a dynamic catalyst.

The working paper presents a taxonomy of regional Nordic ICT clusters based on a data analysis of Nordic municipalities, which broadly relates to the work undertaken by Longhi and Keeble (2000).

Through the statistical analysis, available case studies, and other available sources of knowledge, four classes of Nordic ICT regions may be defined:

(1) *Industrial City Regions:* These regions all have an industrial history within electronic manufacturing. ICT agglomeration is postulated as the additional result of proximity to higher education and research and the intense need for the existing industries to invest in, and acquire, ICT and to ensure a network of high-tech suppliers. Proximity to advanced education and research is also seen as crucial. The typical cases are Swedish and Finnish success stories from the 1990s.
(2) *University-based Regions*: These regions may be regarded as local innovation systems whose high-technology industrial dynamics have originated from the knowledge base of their universities. They are found in all major university cities in the Nordic countries. However, they dominate more in Denmark and Norway.
(3) *Peripheral Regions:* In certain peripheral areas, primarily in Norway, but partly also Sweden, government regional and defence policies have resulted in institutions creating small, local agglomerations (small universities, public institutions, military bases.
(4) *Capital City Regions:* Nordic capital city regions emerge as the locus of global networks of innovation. Metropolitan areas are characterised by numerous skills in diversified high qualifications, specialised professional and business services, financial services and training, and in technical research institutes.

At a lower geographical level, within the capital city regions, as well as within some of the more sophisticated industrial/ university regions, we find a spatial division of labour, primarily between, on one hand, manufacturing and software development (in Greenfield locations outside the city centre) and sales, concentrated in the very heart of the centres.

The Nordic statistical comparison undertaken for this paper illustrates the significance of medium-sized industrial and university cities as the backbone of the Finnish-Swedish success – as opposed to the Norwegian concentration of new ICT development in Oslo.

These national level differences are indicative of a complex picture of ICT with several explanatory factors:

1. Size *does* matter, as sales of ICT consumer goods are located in the same way as other sales, i.e. as a function of population in the region.
2. Size also matters when it comes to software consultancy services, which has a spatial pattern comparable to that of other business consultancies, today better known as Knowledge Intensive Businesses (KIBS).
3. Trickle down matters when it comes to electronic manufacturing, which during the 1990s boosted traditional electronic manufacturing cities in Sweden and Finland, though we are now seeing a relocation to the Baltic countries and to parts of Asia.
4. Finally, trickle down – or the decisions made by corporate actors on the need to move out of the centres – also does matter when it comes to exploiting the advantages of local supplies of skilled software experts from universities.

The other side of this story of corporate decision making triggering growth in industrial and university cities outside the capital is the new found significance of regional actors, who use local opportunities provided by national and global actors. These regional actors were important at two levels:

- Regional development coalitions were instrumental in enabling inward investments.
- Entrepreneurs. The local cluster environments created by inward investors and regional development coalitions enabled the development of local entrepreneurs.

The stories of 'local heroes' explain why certain clusters but not others were able to exploit these new options, and why and how they were able to make sustained contributions to the development of the industry.

At this point, we also need to consider the global level, which explains why these options were widely different in Finland and Sweden, as opposed to Norway and Denmark.

2. The level of innovative action: Regional, national, or global?

Following Nelson's debate on national innovation systems, Michael Porter's analysis of national competitive advantages, and Richard Whitley's discussion of national business systems, a rich literature has emerged emphasising national path dependencies, the significance of national level institutions of research and education, labour relations, and welfare state systems, as well as the peculiarities of national industrial clusters.

Seen in a global context, the evolution of the ICT industry follows a particular pattern, which began in the US. Here, the technological backbone of the Internet industry was created, through military and space research. The entrepreneurial achievements of the 1970s and 1980s, made it possible for the founders of the new companies such as Microsoft and Oracle to out-compete and subsequently dominate the old 'dinosaurs' of the field such as IBM. In the second round, the Internet economy players skilfully tapped US military and space technologies for their own economic purposes. Thus, the first of the major regional clusters such as Silicon Valley emerged in USA. The core firms of the ICT industry in the USA soon established an unbreakable early-adopter advantage over the rest of the world. This *main* global pattern is based on US technological hegemony, when it comes to the core technology areas. This was, however, to be combined with a US *corporate* logic of moving production in the direction of clusters beyond the USA, which providing cheaper locations (Breschi & Malerba, 2001). The US corporations not only moved hardware manufacturing, but also, and more importantly, modularised components of software production into the new expanding clusters. Thus, they were able to tap into the rich human capital resources of bright young people pouring out of universities in Asia, Israel, and a number of other low cost countries.

The Swedish-Finnish success story of the 1990s, namely, the development of mobile telephone *production* in the two Nordic countries, itself, generally perceived to be a high cost area, is an historical *exception* to this predominant global pattern. This exception, again, was possible because of several factors:

- *Path dependency*. Unique historical conditions in the evolution of telecommunications in Sweden and Finland, such as the deregulated evolution of the mobile telephone industry in these two countries, the existence of local advanced users (the Finnish army, local Swedish transportation industries), thus providing institutional preconditions for important local actors.
- *Local actors*. Local industrial actors, skilfully combining US and local technologies in a *new area of ICT*, mobile telephones, an area where actors in the core global clusters had yet to develop anything comparable (Bresnan, Gasmbardello & Saxenian, 2001). Thus, Nokia and Ericsson were able to by-pass the early-adopter defences put up in other areas – and create a new technological field of their own.
- *Institutions shaping dynamic innovation systems.* The local actors were capable of defining optimal institutional preconditions and networks of innovation (Ali-Yrkkö, 2001). An important factor in this respect was the early *modularization* of the Swedish mobile phone technology system, made possible through the early and deep interpenetration between local wire-based digital operators and providers of US ICT knowledge (Glimstedt 2002). This modularisation enabled the evolution of project-based networks, which was the technological precondition for the corporate exploitation of the human capital of the different university cities in the Nordic countries.

What should be emphasised here is the unique and historically specific character of this process. The current situation is characterised by the new ICT crisis that emerged during the spring of 2000. One aspect of this crisis is the adaptations made by global actors, including the national champions, in moving out of high cost Nordic manufacturing. The question remains however just how much software development will be retained in Sweden and Finland, or indeed is this the end of their 'success stories'?

It seems as though Swedish and Finnish ICT development may in the future be converging in the direction of that in Denmark and Norway, where the core focus has always been the application of new ICT in old industries, other than telecommunications. Moreover, the current crises may actually prove to be a fertile breeding ground for new entrepreneurship and radical new innovations.

3. The 'haves' and 'have nots'

The concept of the Digital Divide is strongly related to ICT agglomerations by pointing to the distinction between areas where the new ICT sector is concentrated – and thus also to areas excluded from the growth of new ICT jobs. This question of whether countries or regions '*have or do not have ICT'*, has turned out to be very important from a policy perspective. In the context of innovation and technology policy-making, it is important to be defined positively in this regard. National policy initiatives in general, and regional policy development in particular almost universally aim at promoting new ICT development. There is a strong media-related and symbolic value in being prosperous within the ICT realm. Such notions are predicated upon the belief that industrial development in advanced countries depends on the emergence of these new economic activities. Being on the right side of the Digital Divide is therefore considered to be of the utmost importance for economic prosperity. Being on the wrong side of the Digital Divide is at least considered to be negative, even though it is not a universal observation that countries with a weak ICT industry perform badly overall in economic terms[2].

Smith (1999) stressed the significance of the traditional industries' contribution to growth in the advanced economies while not discarding the significance of ICT. He does however make the point that industrial development occurs in the transformation of traditional industries, e.g. they are intense users of ICT.

4. Nordic ICT spaces, a typology

In the four Nordic countries of Sweden, Finland, Norway and Denmark, we have 1455 municipalities. They differ, both in terms of spatial size, and in the number of inhabitants. In looking for agglomerations, we have also to include adjacent municipalities, and the larger, functional city regions, which may then be disaggregated into several municipalities. Swedish municipalities in particular can be extremely large. With these important exceptions, the municipal level is a rough approximation of what is usually referred to as 'proximity'. As an operational definition, we will consider municipalities with 'new ICT agglomeration' as municipalities where more than 500 people are employed in the 'new ICT industry', and/ or more than 5 % of the workforce is employed in new ICT industry. In this way, we are including both larger cities with substantial ICT agglomerations that are dwarfed by other industries in the region, as well as small municipalities with a relatively large part of the workforce in the new ICT sector. This definition results in 99 Nordic municipalities being regarded as 'new ICT agglomerations'.

[2] This is at least the case within the context of the advanced world.

The table below illustrates the distribution of employment in the new ICT area, following the standard OECD definition (Appendix 1) on Nordic regions and nations, 1998-99.

		Total	**Denmark**	**Finland**	**Sweden**	**Norway**
Capital city region	ICT jobs	136.116	26.664	23.992	58.676	26.784
	Share of ICT	50.3	49.1	55.8	45.0	62.3
	ICT as share of employment	4.8	3.8	3.8	6.5	4.8
	Total employment	2.827.223	726.413	639.316	901.764	559.730
Major ICT agglomerations (University and industrial)	ICT jobs	98.610	18.599	12.012	59.592	8.407
	Share of ICT	36.4	31.2	30.0	45.6	19.5
	ICT as share of employment	3.6	3.5	2.9	4.1	2.4
	Total employment	2.763.774	529.342	418.367	1.470.665	345.400
Micro ICT agglomerations	ICT jobs	26.027	7.313	5.166	8.278	5.270
	Share of ICT	9.6	13.4	12.0	6.3	12.3
	ICT as Share of employment	1.4	1.2	1.5	1.5	1.4
	Total employment	1.909.141	625.015	340.607	566.079	377.422
Have not areas	ICT jobs	10.002	1.815	1.777	3.864	2.546
	Share of ICT	3.7	3.4	4.1	3.0	5.9
	ICT as share of employment	0.3	0.2	0.2	0.5	0.3
	Total employment	3.222.434	858.400	734.414	832.834	796.786
TOTAL	Total ICT	270.755	54.391	42.947	130.410	43.007
	Share of employment	2.5	2.0	2.0	3.5	2.1
	Total employment	10.722.563	2.739.170	2.132.704	3.771.360	2.079.338

Some 3.2 million people in the Nordic countries work in 'areas outside', with a new ICT density between 0.2 and 0.5 % of the workforce. Another 1.9 million work in areas characterised by 'micro ICT agglomerations', where new ICT employment approximates to 1.4 % of the workforce on average. 5.7 million work in areas with 'high new ICT density', with an overall average of 3.6% of employees working in 'new ICT'. In looking closer at the spatial distribution, it is useful to make a distinction between:

- Sales of ICT. One might expect sales to have a 'Christellerian' distribution, with concentrations in big cities, as well as in regions with industrial customers, and a thinner network of suppliers in more peripheral areas.
- Telecommunications may be expected to have concentrations in the capital cities, with the national telecommunication centres, though we could also

expect it to be found in the operative centres of telecommunication systems, as well as in regional innovation systems developing new telecommunication technologies, enjoying proximity to universities.

- Software. Software production, seen as a ‘white collar’ activity, may partly be seen as related to regional labour markets, with clustering in cities with Universities, clustering in office buildings located in attractive suburban areas, as well as in the major city centres, close to industrial customers.
- Hardware. Standardised hardware production has now been diffused away from high cost city areas, in the direction of more remote areas with lower costs, and available regional labour markets with knowledge of the electronics industry. Increasingly, hardware production is also outsourced to low-cost countries, on a global scale. During the early stages of product development however one might expect advantages from the co-location of software and hardware industries.

5. Capital city regions

National capitals have the largest regional agglomerations of the new ICT industry in all of the Nordic countries. This is due to the significance of the capital cities as national centres of telecommunications, as well as to the fact that the capital is the centre of the research, finance and industrial communities. Capitals have easy access to ICT university education, and, due to their position in the national innovation systems, are centres of software consultancy and sales. In capital cities, Venture Capital is more easily available. In capital city regions, and in other major agglomerations outside the capital cities, we also find suburban municipalities with concentrations of software.

The typical spatial pattern within the capital cities is as follows:

- City centre municipalities, with software, sales and telecommunication functions, and the important links between major suppliers of ICT technologies and their industrial customers.
- ‘Green’ suburban municipalities, with software industries. This is the case with ‘white collar’ software consultancy and development, located in nice surroundings with good housing conditions.
- Large clusters beyond, but in close proximity to, the city centre, typically with a mixture of software, hardware and telecommunications. This is the case with Espoo in Finland and Kista in Sweden, where we find the agglomerations surrounding Nokia and Ericsson’s headquarters, combined with other global corporations, as well as industrial park institutions. These clusters reflect the node function of the capital, within the context of the global networks of ICT.

The Stockholm region is clearly the largest and most differentiated of the capital city regions. Most importantly, it has more hardware manufacturing, not only in specialised industrial areas outside the city, but also in the city centre. The city centre, the municipality of Stockholm, and the adjacent municipality of Sundbyberg, integrate all four functions, and thus emerge as a highly diversified agglomeration. South of the city centre, we find locations with specialised concentrations of hardware production and telecommunications, whereas in the north, we find the Kista cluster, that may itself be divided into a software section (Northern soft) – and some municipalities that also have some hardware industry firms (Northern industrial).

In Kista, Nokia, Microsoft, Intel, IBM, Sun, Adobe, Siemens, Oracle, and HP are joined by some 400 academic spinouts (Cooke, 2001). Several academic research institutions are also present. However, as pointed out by Cooke, Kista is not a 'fully fledged cluster', because it is substantially networked into Ericsson's mobile telephone *value chain*. Within the larger Stockholm region, a strong software industry evolved, with consulting as an important element in this context. The typical cases being firms with the relationship of sub-contractor *vis-a-vis* Ericsson, who then tried to expand from their regional market into the national Swedish market and beyond, into export markets, promoting software solutions within *e*-commerce and B-to-B etc. Within the city region, most of the employment is concentrated in the city centre, and 9 other municipalities north of the city centre, in the direction of Arlanda international airport. In practice, this cluster is within 15 minutes driving distance by car from Kista.

6. Industrial and university-based regions

We find three subcategories here:

- Major University cites are highly diversified, when it comes to ICT, and they include not only software production and sales and telecommunication industries, but sometimes also electronic hardware manufacturing. Typical examples being Århus, Aalborg, Roskilde, Tampere and Turku.
- University based cities are more focused on software and sales, without complimentary manufacturing functions. A typical example here being Trondheim.
- Industrial cities are specialised in hardware manufacturing and sometimes also in the production of telecommunications hardware. Typical examples here being Struer and Pandrup.

At this level, differences between the national systems also emerge.

- Denmark has a capital city dominated by sales, services and telecommunications, combined with relatively small, specialised industrial cities (Struer and Pandrup) and major university cities with substantial software industries, such as Århus, Aalborg and Roskilde.
- Norway, like Denmark, has a capital city dominated by sales, services and telecommunications, and small and medium sized university and industrial towns and cities. In addition, Norway has micro-agglomerations in the periphery (military facilities, and public-service institutions).

Unlike Denmark and Norway, Sweden and Finland have substantial manufacturing functions in most major ICT agglomerations.

- The capital cities have large, highly diversified agglomerations, which are nodes in global networks, including several global corporations.
- Several Swedish and Finnish cities are both industrial and university-based.

The ‘have nots’ are characterised by a low level of ICT employment (between 0.2 and 0.5% of total employment, broadly reflecting areas where ICT employment is only to be found in sales and services. 3.2 of the 10.7 million people employed in the Nordic countries lived in these areas in 1999.

7. Looking beyond mobile telephones: New ‘old’ industrial customers

In looking at the new Norwegian ICT industry, it is quite obvious that the unique technological core of this industry is to be found in the suppliers of new ICT technology to ‘old’ national clusters, such as for instance in the marine industries, the maritime industries, and in petroleum. If this is indeed the case, an interesting question thus emerges, namely, how is diffusion enhanced? To a certain extent, this question basically reopens the regional proximity debate, as interactive implementation may seem to demand proximity in industrial clusters where sophisticated new ICT suppliers (software and sales) are located close to advanced ‘old industry’ customers. Other examples of this are the Swedish automobile – IT clustering efforts undertaken in the Gothenburg region, and the developing links between ICT and the standard consumer electronics industries.

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Appendix: Tables

	Denmark	Finland	Sweden	Norway
Total employment	2733170	2132 704	3918 678	2079 338
Total Information Technology	216517	170744	349556	145944
New Information Technology	54391	42957	130 410	43007
2221(V24) Printing of newspapers	865	1937	2005	1077
2222(V25) Printing	11443	11569	18498	8015
2223(V26) Bookbinding and finishing	1549	323	2481	572
2224(V27) Composition and plate making (printing)	2413	1388	2394	667
2225(V28) Other activities related to printing	219	160	2899	1307
2231(V29) Reproduction of sound recording	265	86	30	63
2232(V30) Reproduction of video recording	237	104	80	106
2233(V31) Reproduction of computer media	145	12	140	288
3001(V32) Manufacture of office machinery	520	20	1579	39
3002(V33) Manufacture of computers and other information processing equipment	1627	2672	2144	827
3220(V34) Manufacture of television, radio transmitters, apparatus for line telephony	3236	24049	31790	2033
3230(V35) Manufacture of television and radio receivers, sound and video recording and reproducing app.	6290	1341	4207	756
3320(V36) Manufacture of instruments for measuring, checking, testing, navigating	5550	3426	11029	2864
3330(V37) Manufacture of industrial control equipment	386	1845	4770	1110
3130(V38) Manufacture of insulated wire and cable	1962	1889	5144	1570
3210(V39) Manufacture of electronic valves, tubes and other el. Components	3497	4793	8164	1336
3340(V40) Manufacture of optical instruments and photographic equipment	1560	283	2109	78
2211(V41) Publishing of books	3836	2283	5015	2693
2212(V42) Publishing of news-	18266	10239	16822	13939

	Denmark	Finland	Sweden	Norway
papers				
2213(V43) Publishing of journals and periodicals	8046	3172	5137	2144
2214(V44) Publishing of sound recording	334	461	1339	255
2215(V45) Other publishing	1377	468	1142	772
5143(V46) Wholesale of el. Household appl., radio and TV	4130	1508	11045	2909
5164(V47) Wholesale of office machinery and equipment	20820	8495	24569	15264
5165(V48) Wholesale of other machinery for use in industry, trade and navigation	20726	16080	27575	15240
5245(V49) Retail sale of el. Household appl., radio, TV	7586	3173	7912	6881
5247(V50) Retail sale of books, newspapers and stationery	3424	3 225	3 887	3989
5272(V51) Repair of el. House-hold goods	1640	1557	3539	1319
6420(V52) Telecommunications	19023	16264	30748	12433
7133(V53) Renting of office ma-chinery and equipment, including computers	258	68	258	317
7210(V54) Hardware consul-tancy	1 241	296	1 559	827
7220(V55) Software consultancy and supply	20732	14485	53702	18698
7230(V56) Data processing	5737	7051	6254	3593
7240(V57) Data base activities	488	781	1116	2532
7250(V58) Maintenance and re-pair of office, accounting and computing machinery	766	1321	2087	767
7260(V59) Other computer re-lated activities	1138	7	612	692
7440(V60) Advertising	14300	7024	21878	6850
9211(V61) Motion picture and video production	2373	1209	2834	1008
9212(V62) Motion picture and video distribution	308	203	704	208
9213(V63) Motion picture pro-jection	1398	424	1092	976
9220(V64) Radio and television activities	6775	7596	9617	5114
9240(V65) News agency activi-ties	680	413	1169	495
9251(V66) Library and archives activities	9319	7044	8481	3321

Appendix: The OECD definition of the ICT sector

OECD (2000) has provided a definition of the new economy as the ICT sector. In the manufacturing sector the products 'Must be intended to fulfil the function of information processing and communication including transmission and display' and 'Must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process' (OECD, 2000: 7). In ISIC codes this includes:

- 3000 – Office, accounting and computing machinery.
- 3130 – Insulated wire and cable.
- 3210 – Electronic valves and tubes and other electronic components.
- 3320 – Television and radio transmitters and apparatus for line telephony and line telegraphy.
- 3230 – Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods.
- 3312 – Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment.
- 3313 – Industrial process control equipment.

For the services the products "Must be intended to enable the function of information processing and communication by electronic means." (OECD, 2000: 7).

In ISIC codes this includes:

- 5150 – Wholesaling of machinery, equipment and supplies.
- 6420 – Telecommunications.
- 7123 – Renting of office machinery and equipment (including computers).
- 7200 – Computer and related activities.

Appendix: Capital city regions

The Copenhagen Region

Software
Three municipalities in the Copenhagen city region are within the 'software and sales' position, specialising on software:

Lyngby-Taarb	32.050.000	4.017	95.700
Herlev	18.725.000	21.531	93.050
Ballerup	36.766.000	26.482	78.627

Software, sales, and telecommunications
Similarly, 5 municipalities are within the software, sales, and telecommunication position. These are the core municipalities in

Hvidovre	26.752.000	7.788	74.529
Frederiksberg	40.494.000	9.717	69.570
Glostrup	22.007.000	1.037	65.309
Høje Taast	31.593.000	16.649	58.895
København	320.500.000	19.979	58.273

Software, sales, and hardware
4 municipalities combine software, and sales, with some additional hardware

Albertsun	22.198.000	47.048	83.022
Gladsaxe	34.480.000	53.580	89.699
Brøndby	23.764.000	51.705	97.239
Søllerød	14.912.000	48.990	97.944

The Helsinki region
In the Helsinki region, we find two different structures:

Software, sales, and hardware

Espoo	93.746.000	59.674	94.301
Vantaa-Vanda	82.148.000	57.943	91.370

Software, sales, and telecommunications

Helsinki-H 344.939.000 23.701 58.623

The Stockholm region

Southern industrial

In the industrial agglomerations in the south, we find both telecommunications, in Nacka-Haninge, and manufacturing, in Nynäshamn.

Nacka	25.585.000	60.832	27.334
Haninge	20.625.000	64.970	26.262
Nynäshamn	7.426.000	95.335	44.712

Northern industrial

Huddinge	33.506.000	89.768	95.073
Järfälla	20.083.000	74.286	99.342
Täby	20.785.000	57.276	98.696

Diversified centre

Sundbyberg	15.323.000	33.242	61.538
Stockholm	49.9043.000	43.153	72.938

Northern, soft

Danderyd	15.283.000	33.359	87.423
Sollentuna	20.788.000	26.687	94.388
Upplands-V	13.906.000	16.318	99.371
Södertälje	37.237.000	12.445	91.026
Solna	52.216.000	8.940	88.117

The Oslo region

Software and hardware

Asker 20.833.000 37.384 99.219

Software

Oppegård 8.522.000 0.502 98.782

Software, hardware, and telecommunications

Bærum	52.397.000	7.563	77.252
Oslo	366.456.000	12.795	67.206

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