NUPI

[641] Paper

Industrial heterogeneity of the ICT industry

An exploratory survey on Norwegian firms

Arne Melchior

Nr. 641 Desember – 2002

Norsk Utenrikspolitisk Institutt

Norwegian Institute of International Affairs

Utgiver: NUPI

ISSN: 0800 - 0018

Besøksadresse: Grønlandsleiret 25
Addresse: Postboks 8159 Dep.
0033 Oslo
Internett: www.nupi.no
E-post: pub@nupi.no
Fax: [+ 47] 22 17 70 15
Tel: [+ 47] 22 05 65 00

Industrial heterogeneity of the ICT industry

An exploratory survey on Norwegian firms

Arne Melchior

[Abstract] The paper presents evidence from a limited survey undertaken among Norwegian ICT firms in 2001, supplemented with other statistical evidence. Corresponding to the limited production of ICT hardware in Norway, the hardware firms covered by the survey were dominated by sales outlets of foreign firms. While these firms are on average small and with a modest skill requirement, some of them are larger and more skill-intensive due to the provision of related software and services. Within-firm learning, higher education as well as sector- and industry-wide knowledge externalities generally matter to IT firms. Education is ranked third, and is more important for software and services than for hardware. Knowledge externalities are less important for foreign-owned firms. 2/3 of the firms surveyed produce various combinations of hardware, software and services, with software+services as the most frequent combination, composed by firms that are on average clearly larger than the sample average. Such firms rely more on learning within the firms and less on sector-wide knowledge externalities than other IT firms. Adaptation of products to individual customers is important for many IT goods, and implies that e.g. imported software frequently generates substantial domestic employment in related services. The survey tentatively suggests that such complementarities in production may be an important aspect of IT production. Norwegian IT exports are generally small, but pure software producers in the sample had larger exports.

Correspondence: Arne Melchior, P.O.Box 8159 Dep., N-0033 Oslo, Norway.
Phone 47+22056520, e-mail arne.melchior@nupi.no.

Preface

During 2001-2, NUPI carried out a survey on Norwegian information technology firms, with extensive data for 110 firms. The results are published in Melchior and Øi (2003, forthcoming). As a preparation for this study, we carried out a less systematic and more limited survey among Norwegian firms in April 2001. This paper provides documentation on the preparatory study. Given that the survey only covers 37 firms, limited statistically based conclusions may be drawn from the material. The aim was mainly to derive hypotheses, to get acquainted with the problems involved in a survey of this kind, and to learn about the ICT sector. Nevertheless, the prekliminary survey contains some evidence of interest, in addition to being helpful for the design of the later study. We therefore publish the results here.

The exploratory survey in April 2001 was jointly planned and undertaken by the author and Leo Andreas Grünfeld at the Norwegian Institute of International Affairs. I thank Grünfeld for his contribution to the study. Financial support from the Norwegian Research Council, project no. 137515/510 under the SKIKT (Social and Cultural Preconditions for ICT) programme, is gratefully acknowledged. As usual, the responsibility for the conclusions as well as the errors remain with the author.

Oslo, December 2002.
Arne Melchior
Head, Department for International Economics

1. Introduction

Research has taken time to catch up with the rapidly evolving phenomenon of ICT. During recent years, however, our knowledge on the ICT sectors has improved considerably. This is partly due to better data provided by national governments, private consultancy firms and international organisations such as the OECD. Within the field of economics, research has shed light on important issues such as

- the ICT contribution to growth and productivity, both at the micro and macro level
- the development of new products and the need for quality-adjusted measures of output
- the market structure and competition in industries with network externalities, such as the telecom sector and parts of the software industry
- the pace of technological change in various segments of the ICT industry.

In spite of these advances, there are still huge gaps in our knowledge about ICT. One of these gaps is due to the fact that the ICT business is very heterogeneous, while available statistics are still rather crude. In particular, software and ITC services production largely constitutes a black box with limited statistics, and with unclear boundaries between its sub-components as well as towards wholesale activity. Since software and services constitute a large share of ICT production, particularly in small countries like Norway, better knowledge on such activity is of crucial importance for assessing comparative advantage, growth prospects and industrial policies in the ICT area. This is especially true with respect to exports: According to public statistics, most international trade in ITC products relates to hardware While it is true that services are mainly supplied domestically, there are segments within the software+services part of ICT where exports are significant. By investing abroad, services firms may also sell internationally. For a country like Norway, with limited hardware production, it is important to trace the characteristics of these segments.

The purpose of this paper is hence to shed some light on the heterogeneity of the ICT, and particularly the IT, sector, and to obtain tentative assessments of the distinctions between sub-sectors in terms of industrial characteristics. For this purpose, a survey among Norwegian IT firms will be undertaken. As a preparatory exercise, a more limited survey was undertaken among participants at IT Expo 2001, a trade fair held in Oslo in April 2001. Responses were obtained from 37 firms, with information on their activity, product type, skill profile, employment, ownership, exports and imports. Details on the questions included are described in the Appendix. While this survey was too limited in order to obtain hard-core statistical evidence, it provided a useful basis for developing hypotheses and questions to be addressed in later research. In the following, the results are presented, and also put into a broader perspective by referring to some relevant other sources of information. Before presenting the results from the survey, a brief overview of the ICT sector will be given, focusing on the composition of the industry and the particular situation in Norway.

2. Background: Segments of the ICT industry

According to OECD (2000a, 59), the OECD markets for ICT may be subdivided into telecom (41% in 1997), IT (information technology) (41%) and internal IT spending within firms (18%). Within the IT sector, software and services constituted more than half, with a share that has grown over time. Table 1 shows the shares for the main components of the IT markets in the OECD, in 1990 and 1997, as well as their average growth rates 1990-97.

Table 1: Segments of the OECD information technology (IT) markets, 1990 and 1997

Sub-sector within IT:	Share of OECD IT market (%) in:		Average annual growth rate (%) 1990-97
	1990	1997	
Hardware: Single-user systems	22.2	27.9	11.6
Other hardware	22.6	12.3	-1.0
Data communication equipment	2.6	5.0	18.6
"Prepackaged" software	13.4	16.4	11.2
Services	39.3	38.4	7.6
Total IT market in OECD-27	100	100	8.0

Source: OECD 2000a, Chapter 2.

Hence the combined share for hardware has declined, but with a strong shift towards single-user systems. Data communication equipment has grown most rapidly, but still represents a small share. Services have grown at a pace close to the IT average, while software has expanded its share.

The services sector in Table 1 includes wholesales and renting of hardware, as well as other IT services. Out of the total ICT employment of 71 300 in Norway in 1998, "other ITC services" represented 37%, while ICT manufacturing, ITC wholesale and telecommunication services hade shares of 15, 31 and 16 per cent, respectively (Statistics Denmark et al. 2000, 65). Wholesale activity hence represented a substantial share of ICT services. As will be demonstrated, these shares vary across countries.

In spite of the importance of software, current statistics only give a partial account of software activities. "Prepackaged software", shown in Table 1, only includes a limited part of overall software production. According to OECD (1998, 7), more than half of overall software spending by IT customers was accounted for by internally developed software. The remaining part was more or less evenly split between prepackaged software and purchases from outside contractors, with some variation in shares across countries. In public statistics on IT services production (excluding software production within non-ICT firms), the distinction between prepackaged and other software is not maintained. Table 2 shows the composition of other IT

services production in Norway in 1998, based on the classification scheme most commonly used.[1]

Table 2: Composition of other IT services production in Norway, 1998				
NACE cat.	Category	Firms	Employ-ment (persons)	Turnover (mill. NOK)
72	Computer and related activities	4317	26225	29467
	Sub-categories	Shares for sub-categories (percentages)		
72.1	Hardware consultancy	2.2	2.5	2.5
72.2	Software consultancy and supply	70.9	66.0	76.4
72.3	Data processing	13.3	16.8	4.9
72.4	Data base activity	9.1	9.1	9.0
72.5	Maintenance/ repair of hardware	3.2	2.8	4.5
72.6	Other computer related activities	1.3	2.8	2.7
Source: Statistics Norway (2001), Real estate, renting and business activities 1998, NOS C 637.				

Hence software consultancy and supply is the dominating sub-group, representing 66-76% of the total.[2] This subgroup comprises activities spanning from the sales of standard software to customer services related to the use of software. It is evident that the characteristics of the former may be very different from those applying to the latter. For example, the export potential for standard software may be considerable. Services are mainly supplied locally and thus cannot be supplied by cross-border trade, but may be sold internationally by means of foreign direct investment. In order to trace the export potential for ICT products, it is necessary to distinguish between market segments to a greater extent than Table 2 does.

3. The Norwegian ICT sector

The survey only covered a small number of Norwegian firms. When interpreting the results, it should therefore be observed that (i) the Norwegian ICT sector is different from the ICT sector in other countries, and (ii) the sample of firms covered by the survey may not be representative for the whole Norwegian ICT sector. Concerning the latter, it is evident that a trade fair such as IT Expo 2001 is directed towards sales in Norway. Export-oriented firms may therefore be under-represented. Furthermore, firms participate in a fair of this kind if they consider this type of marketing to be useful. Firms focusing on consumer "mass markets", or firms directed at narrow segments of business customers, may hence be under-represented. When the results are presented below, other available statistics will also be

[1] See OECD (1998) or Statistics Denmark et al. (2000) for an overview of classification systems and definitions.

[2] This category should be distinguished from "prepackaged software", a term sometimes used in OECD statistics (e.g. in Table 1 above). The latter mainly comprises standard software, with data from IDC (International Data Corporation, a consultancy firm). It is not entirely clear how OECD avoids a possible problem of double counting between this category and "services" in Table 1.

referred to, when available, in order to check whether a selection bias may be present.

Concerning the Norwegian ICT sector, Table 3 provides some selected indicators that indicate the main differences between Norway and the OECD as well as Sweden, Denmark and Finland in the field of ICT. The main characteristics of ICT in Norway are, in brief:

- Market growth has been rapid but below the OECD average. Fast diffusion of PCs and mobile phone contribute to fast market growth, while a small ITC manufacturing sector limits the demand for intermediate ICT goods.
- In terms of employment, Norway's ICT sector is larger than the OECD average but smaller than in Sweden and Finland. Production is heavily skewed towards services, and manufacturing ICT is limited. Value added per employee is relatively low.
- Norway is clearly a net importer of ICT goods. According to the OECD figures, even imports are in relative terms far below the OECD average. A possible explanation is that small hardware production limits the imports of intermediate goods.[3]

[3] The import share for Norway reported by OECD (2000b) is surprisingly low, given the high consumption and low domestic production of hardware in Norway. According to Statistics Denmark et al. (2000, 70), the ITC share of total imports for goods only (not including services) was at 10.5% in 1998.

Table 3: Norway's ICT activity compared to the OECD and the Nordics.
Figures for 1997 unless otherwise stated.

Indicators on:	Variable	Norway	Sweden	Denmark	Finland	OECD	Source
Consumption	ICT market growth 1990-1997	**6.3**	1.6	5.3	0.6	8.0	OECD (2000a)
	Installed PCs per 100 inhabitants	**36**	35	34	29	24	
	Mobile phone subscribers per 100 inhabitants	**48.4**	46.4	33.5	57.8	22.4	
Size of ICT production	ITC employment as percentage of labour force	**3.2**	3.6	3.3	3.4	2.8	OECD (2000b), and calculations based on figures in the "Country profiles" appendix of this publication. Labour force data from World Bank (1999).
	ITC employment, % of business sector	**5.3**	6.3	5.1	5.6	3.6	
	ITC value added, % of business sector	**6.4**	9.3	n.a.	8.3	7.4	
Composition of ITC production	Manufacturing ICT, % of ICT employment	**14.0**	34.0	22.7	41.9	38.0	
	Telecommunications, % of ICT employment	**24.9**	20.8	20.0	19.7	22.8	
	Other ITC services, % of ITC employment	**61.1**	45.2	57.4	38.4	39.2	
Foreign trade (1998)	ICT share in total exports of goods and services	**3.5**	14.9	8.3	19.6	12.5	
	ICT share in total imports of goods/ services	**7.8**	14.2	12.7	16.1	13.2	
	Specialisation index (between –1 and 1)	**-0.36**	0.15	-0.18	0.18	-0.02	

Note: The trade specialisation index for Denmark is based in ICT manufacturing only. Installed PCs per inhabitant for Norway is for 1996. OECD averages are for the countries for which data are available, and the number of countries included varies from 21 to 27.4.

4. Types of producers covered by the survey

Concerning the type of activity undertaken, the main information in the survey is given by three indicator variables on the importance of hardware, software and service provision, respectively. In addition, two out of the 37 firms were network access providers (in combination with other activities). In the following, we focus on the distinction between hardware, software and services. A value of 100 for an indicator implies that this product type is of very high importance to the firm, and a value of 0 indicates that it is of no importance. Table 4 shows the (unweighted) averages for these indicators across firms, and how each of these indicators were correlated with some selected structural characteristics. Correlation coefficients that are significant at the 15% level or better, are bold-typed. Levels up to 15% are included due to the small sample size. Because of the small sample, all the results presented should be considered as tentative evidence.

Table 4: Characteristics of different types of activity

Activity variable	Average score (0-100)	Correlation of activity variable with other variables (Pearson correlation coefficients)			
		Higher education	Product differentiation	Innovation	Import share
Hardware	37	**-0.39** (0.02)	**-0.24** (0.15)	**-0.29** (0.08)	0.22 (0.21)
Software	58	**0.46** (0.01)	0.14 (0.43)	0.20 (0.24)	**-0.43** (0.01)
Services	47	0.35 (0.24)	**0.26** (0.12)	0.18 (0.29)	-0.03 (0.86)

Note: P values (significance levels) in brackets. N=36 or 37.

In the sample, software was the dominating type of activity, followed by services and hardware. This is as we could expect, based on the data shown in tables 2 and 3. Hardware is more strongly represented in the sample than national production data suggest. This is due to the fact that some importing firms were present among the firms. As we shall see, these firms were generally small in terms of employment, while the service-related firms were on average larger, so an employment-weighted average of the activity indicators would come closer to the true distribution in the Norwegian ICT sector.

On average, software production is more high-tech than the others, being positively correlated with the variables on education and innovation. At the other extreme, hardware is significantly low-tech in comparison, being negatively correlated with the variables on education and innovation. This result is surely influenced by the fact that in Norway and in the sample here, hardware production is limited and a considerable part of the activity is

related to imports and the distribution of foreign goods.[4] As seen by the correlations with the import share variable, software contains more domestic production (a lower import share), while hardware is positively (although not significantly) correlated with the import share. The variable on product differentiation indicates that hardware tends to be more standardised, while services is more frequently adapted to individual customers.

5. Complementarity in production?

The results above mask the fact that individual producers are frequently not fully specialised in hardware, software or services. In fact, approximately 2/3 of the firms were producing *combinations* of these activities. An issue is whether such combinations may be more than the sum of their component parts; or whether the industrial characteristics of such combinations may be qualitatively different from those of their individual components. Intuitively, one might believe this to be the case: For example, a firm that imports standard software and then adapts it to local customers, and provides related services, supplies a good that is more differentiated, and more sheltered from foreign competition (due to the importance of local presence). While import competition may crowd out local producers of competing software, it may stimulate more domestic production that is directly related or complementary to the imported software. Such "secondary" business may constitute a large fraction of total sales in ICT: A firm importing foreign software for 2000 US$ may sell it together with related services for 10000 US$. A further issue is what knowledge is needed to undertake such "secondary" business: Does it rely on technological knowledge that is internal to the foreign software producer, or may it be undertaken by separate firms?

In order to obtain some information on combined production, we consider a type of activity as important for the firm if the indicator variable is 50 or higher (out of 100), and classify firms in terms of the various possible combinations of hardware, software and services that are possible. In accordance with Table 2, we then find that the most frequent type of combination is software+services (13, or more than 1/3 of the firms). Table 5 presents the various combinations, with the corresponding average values for variables reflecting industrial characteristics.

[4] Ekeland et al. (1999, 29) confirm that the education level is high for consultancy related to software and systems. On the other hand, this study also confirms that parts of the hardware production has a high share of employees with higher (IT) education.

Table 5: Types of firms, and average values of selected indicators

Type of firm specialisation	No. of firms	Product differen-tiation (0-100)	Knowledge base (0-100)				Average number of employees		% Norw. owner-ship	Import share (0-100)	Exports (0-100)	Inno-vation (0-100)
			High educ.	From firm	From sector	From other sectors	In Norway	World-wide				
Hardware only	5	**20**	**30**	95	55	40	21	1191	**20**	**90**	10	**45**
Software only	5	50	63	88	69	50	136	588	60	31	**38**	90
Services only	3	50	42	75	83	50	50	**25672**	33	100	13	75
Hardware+software	2	50	50	88	63	25	20	124	50	38	0	63
Hardware+services	5	60	55	90	60	55	18	27	80	60	0	**100**
Software+services	13	52	**69**	92	62	54	**349**	1063	62	**39**	14	85
All three activities	3	25	67	75	83	42	260	647	67	58	17	75
All firms	37	45	58	88	65	49	172	2882	57	55	13	79

Note: Values in bold for a variable indicate that the relevant subgroup is significantly different from the sample average, based on Pearson correlation coefficients and a significance level of 10% or better. When the values in bold are lower (higher) than the average for all firms, the correlation coefficient is negative (positive).

- Firms focusing on hardware only are mainly foreign-owned firms that sell imported hardware, where products are standardised and where innovation in Norway, as well as higher education, plays a limited role. The subsidiaries of foreign firms undertaking this are relatively small, with 21 Norwegian employees on average.
- When hardware is combined with software or services, the industrial characteristics are considerably changed. In that case, products are less standardised, the share of domestic ownership is much larger, and the importance of higher education and innovation is higher. These firms are still small, and their activity is purely directed towards the domestic market, although they import some of their goods.
- Perhaps surprisingly, firms specialising in services only are partly similar to those selling hardware. They are to a large extent foreign-owned, education is not so important, and they only sell imported goods. These are mainly subsidiaries of large foreign companies supplying business services. Compared to hardware imports, however, products have to a larger extent to be adapted to local customers, so products are less standardised and innovation is more important. The average size of these firms is larger than for the hardware importers.
- Pure software producers, as well as the dominating firm type combining software and services, share several common traits. Products are not very standardised, innovation and higher education is important, the firms are on average larger than the types described above, and a considerable share (60-62%) of the firms are domestically owned. These firms have among the lowest values concerning the import content of their sales. Only the pure software producers, however, have an export share that is significantly above the (low) average for the total sample.

The characteristics described above depend on the pattern of comparative advantage, with Norway as a pure importer in some market segments. It is evident that higher education and innovation are important also in the production of hardware (particularly in the R&D activity), but in Norway, some of the activity is mainly the importation of foreign goods. As shown by Statistics Denmark et al. (2000, Section 5.3), the level of education varies across ICT segments, but with other IT services generally ranked first. The group of hardware firms described above mainly includes foreign-owned importing firms. In ICT manufacturing firms in Norway, the education level is higher than in the wholesale firms (ibid.). Hence the sample covered here may not be representative with respect to hardware in general.

The sub-composition of firms into different groups hence suggests that some *complementarity* links may exist between specific types of hardware, software and services. From Table 5, however, we cannot draw such a conclusion: When e.g. software+services has a significantly higher education level, it may be because software as well as services both rely on higher education. In order to check whether industrial characteristics are different when the activities occur in combination, we include dummy variables for each combination in regressions of industrial characteristics on the activity indicators. Due to the small number of firms in some groups, we only include

dummies for hardware+services and software+services. Table 6 shows the regressions in which these combinations had characteristics that differed from what would be expected from their sub-components. The dummy variables were included only in cases where they contributed to the explanatory power of the regressions.

Table 6: Industrial characteristics of different types of activity. Regressions including dummy variables for combined production.

Dependent variable	Constant	Type of activity, indicator variables			Dummy variables for combined production		Adj. R^2	N
		Hard-ware	Soft-ware	Services	Hardw. +services	Software +services		
Product differentiation	**3.19** (0.00)	**-0.30** (0.07)	-0.02 (0.88)	0.08 (0.58)	**1.29** (0.05)	1.20 (0.20)	0.13	36
Innovation	**4.23** (0.00)	**-0.23** (0.06)	0.13 (0.27)	-0.06 (0.66)	**1.85** (0.00)	-	0.27	36
Higher education	**1.69** (0.04)	0.03 (0.80)	**0.26** (0.03)	**0.23** (0.06)	-	-	0.24	35
Learning in firm	**4.78** (0.00)	0.06 (0.49)	-0.08 (0.37)	-0.14 (0.16)	-	**0.77** (0.04)	0.04	35
Learning from ICT sector	**2.86** (0.02)	-0.09 (0.59)	0.17 (0.37)	0.30 (0.12)	-	**-1.27** (0.08)	0.02	35
Import share	**4.80** (0.00)	-0.07 (0.75)	**-0.45** (0.04)	0.01 (0.95)	-	-	0.11	34
Export share	**2.54** (0.00)	-0.16 (0.12)	0.03 (0.79)	**-0.23** (0.03)	-	-	0.14	34
Learning from other sectors	No significant differences across activities							
Ownership	No significant differences across activities							

Note: P values in brackets. Coefficients that are significantly different from zero at the 10% level or better, are indicated in bold.

- While hardware goods are generally more standard and activity relies less on innovation, the combination of hardware+services is opposite in terms of these characteristics.
- Software+services firms do not rely more on higher education than what should be expected from the subcomponents of their activity, but such firms rely more on learning within the firm, and less from knowledge externalities within the ICT sector.

Table 6 thus suggests that some of the combined activities have characteristics that differ from their sub-components.

The size of our sample is so limited that the results above should be considered as tentative evidence only. In order to obtain more precise evidence, better data are needed. The aspect of complementarity raises important issues for further research in the area, for example:

- Are the complementarities demand-driven (two types of goods are technologically independent but the firms prefer to sell both, due to

demand conditions), or driven by supply conditions (e.g. a software product has to be linked to service provision if it is to work)?

- Are the complementarities permanent or transitional? For example, the domestic adaptation of software may be due to limited standardisation of products. While e.g. word processing technology has approached a dominating standard, more specialised software has frequently not. According to the "product cycle hypothesis", new products run through an initial phase with strong differentiation, and the technology is then gradually maturing and becoming more standardised over time. If standardisation occurs, the product may to a larger extent be imported and there may be less need for complementary domestic activity. To what extent possibilities for standardisation are limited by differentiated demand, is hence important for the future pattern of comparative advantage.
- A third issue relates to foreign investment: If there are complementarities in the supply of ICT goods, cross-border investment may increase: Foreign firms may set up local offices in order to supply e.g. related services. This is more likely if the supply of related services requires technological knowledge that is internal to the firm. The evidence above on the importance of learning within the firm for software+services points in this direction.
- What are the economic implications of complementarity? Some aspects have been mentioned above, but theoretical as well as empirical work could usefully shed light on the impact of international trade and investment in this case.

6. Product differentiation

Product differentiation in ICT can take various forms, including *vertical* (quality) differentiation (e.g. the speed of processors), *national* differentiation (e.g. different language versions of software) and *horizontal* differentiation (e.g. Excel versus Lotus spreadsheets). In ICT services provision, products may even have to be differentiated according to customers, thus giving a second "layer" of horizontal product differentiation. All these forms matter in the ICT sector.

Product differentiation, combined with scale economies in production, is a crucial element in recent theories on international trade and economic geography. When these characteristics are present, a country may not produce all the varieties of a product domestically, and international trade may take the form of "intra-industry trade" (IIT) whereby different varieties of a product are exchanged. Gains from trade are then obtained due to reduced average costs as well as the access to greater variety. If countries are similar in terms of technology, skills and demand, horizontal IIT (whereby similar but differentiated goods are exchanged) occurs, and if countries are different in these respects, vertical IIT (where high-quality goods are exchanged for low-quality goods) may develop.

While this story of two-way trade may have much to say about trade in manufactured goods in general, it may not generally apply to ICT, where trade patterns are heavily dominated by technology competition. Furthermore, network externalities play a crucial role in world ICT markets; hence ICT is not the story about 1000 different operating systems or word processing programs being exchanged across borders. In some major market segments, the extent of product differentiation is fairly limited due to such factors. Challenging Windows or Word is possible (as shown by Linux) but difficult. In other segments of the ICT markets, e.g. software applications, the extent of product differentiation and the scope for introducing new varieties may be considerable.

When there are barriers to trade, large domestic markets may provide a "platform" for developing new product varieties, and hence provide a "home market advantage" for large nations. A producer of business software in the U.S. may be better positioned than a corresponding firm in Norway, due to the larger market. Current trade theory suggests that the extent of such "market size effects" depends partly on the extent of product differentiation, and partly on the magnitude of trading costs. On product differentiation, some theory suggests that small countries should be specialised in relatively standardised goods (see, for example, Melchior 1997). This outcome could, however, easily be reversed if countries differ on other characteristics than market size. This "standard goods hypothesis" does not easily fit into the pattern observed in the data, where e.g. standardised hardware has a high import share in Norway, while e.g. Sweden, Finland and Ireland are net exporters. Nevertheless, the extent of product differentiation is an interesting dimension to be explored with respect to the pattern of comparative advantage in various ICT segments. For example, small countries may have export opportunities in software segments where a homogenous world market is present, and where sales costs are limited.

Due to the limited sample covered by the survey, it was not realistic to obtain reliable knowledge concerning the extent of vertical or horizontal differentiation in general. The high average score on the variable reflecting innovation (79/100) suggests that product innovation is important in the sector. In addition, the survey covered another specific aspect of product differentiation, namely whether products are adapted to individual customers or not. The average score of 45/100 for this product differentiation variable indicates that individual adaptation of products is a second layer of product differentiation that is of importance in parts of the ICT sector. As shown in Table 4, the extent of "individual product differentiation" is low for hardware-related activitity, and high for service provision.

7. The type of customers

The questionnaire also obtained information on whether sales were directed towards private customers, business or the public sector. The results for the sample suggest that business is the most important market segment (an

average score of 87/100), followed by the public sector (53/100) and private customers (18/100). This ranking was similar for all types of firms; however with some variations. Private customers were more important for network access providers and standard hardware, and less important for pure service or software suppliers. For the pure service providers, the public sector was less important. Since there is considerable variation within sub-groups, however, none of these deviations from the average were statistically significant at the 10% level or better. It was statistically confirmed, however, that private customers are more important for standardised goods. In the private "mass markets", there is little room for customer-specific adaptation of products. In the business and public sector markets, both standardised and non-standardised products are sold.

According to Statistics Denmark et al. (2001), the Norwegian business sector is lagging behind its counterparts in Sweden, Finland and Denmark in terms of ICT adaptation. Nevertheless, ICT adaptation is increasing fast also in Norway, and the good side of being last among the Nordics is that there is greater scope for a further increase in Norway. While the services part of the ICT sector is relatively more important in Norway than in Sweden; Denmark and Finland (cf. Table 3), this segment is smaller in Norway when expressed as a share of nationwide service production (Statistics Denmark et al. 2000, 28).

8. The knowledge base of firms

According to the survey, the most important source of knowledge for the firms is learning within the firm, with an average value of 88/100 for the whole sample, followed by learning from the ICT sector (65/100), higher education (58/100) and learning from other sectors (49/100). Observe that all these sources are of importance. Some inaccuracy could be present in the firms' responses to these questions, since they represented subjective judgements rather than hard facts. On education, it would have been better with statistics on the education of the workforce, but this was impossible to obtain in the survey. Within some firms, high education was important in some parts of their activity (e.g. software programming) but not in others (e.g. sales activity). Hence the measures presented here are crude. Nevertheless, the results are of interest by suggesting that

- learning within the firm is more important than education
- there are externalities within the ICT sector (learning from other firms in the sector), as well as – to a somewhat lesser extent but still important – from other sectors.

As seen from Table 5, two sub-sectors were significantly different from the other firms with respect to education. For the variables reflecting learning and externalities, however, there was no statistically significant variation among subgroups of firms.

9. The "nerd" factor

A statement, or possibly a myth, concerning the knowledge base of ICT firms is that in this business with fast innovation and changes, older people are not suited. According to some media stories, ICT is a playground for unmarried young data "nerds", sleeping in the office, working day and night, and going to trendy bars with colleagues in spare moments. In order to check whether this story about the need for youth and flexibility contains some truth, the respondents were asked a provocative question about whether people above 40 were too slow and hence they preferred younger people. In fact, two of the 37 firms fully agreed to this proposition, but 14 completely disagreed, and the average score for this variable was 33/100. According to this, we may therefore conclude that the proposition about the virtue of young age in the ICT sector is only 1/3 true. One of the respondents who disagreed with the proposition e.g. stated that younger people were often efficient when undertaking technical tasks, but that they sometimes lacked the experience and maturity needed in order to take balanced and appropriate business decisions, or to be responsive to the needs of customers. Among the respondents that agreed to the proposition, one e.g. stated that the focus on younger people was partly motivated by concerns for creating a good and homogenous social environment at the workplace.

The role of age in ICT production has been examined in other studies; Statistics Denmark et al. (2000, 49) show that the share of employees below 35 years are a little higher in ICT production than in manufacturing or services in general. This "age factor" is somewhat more pronounced in Finland and Sweden, and particularly in ICT manufacturing. The overall picture is hence that age matters, but not too much.

The age variable was not significantly related to any of the other firm characteristics, with one exception: It was positively and significantly related to the firms' responses regarding innovation. Those who preferred young employees also considered innovation to be more important for the firm's competitiveness.

10. Ownership and firm characteristics

21 of the 37 firms, or 57%, were majority-owned by Norwegians. Table 7 presents some characteristics of these, compared to the foreign-owned firms.

Table 7: Differences between Norwegian-owned and foreign-owned firms in the sample (averages for different variables)			
		Norwegian-owned	Foreign-owned
Number of firms		21	16
Type of activity (0-100)	Hardware	**33**	**42**
	Software	64	50
	Services	53	41
Knowledge base (0-100)	Higher education	59	56
	From firm	90	86
	From ICT sector	**76**	**52**
	From other sectors	**59**	**38**
Innovation (0-100)		80	78
Product standardisation (0-100)		45	44
Average number of employees	In Norway	**283**	**27**
	Worldwide	609	5912
Import share (0-100)		**36**	**84**
Exports (0-100)		11	16
Note: Values for variables where the difference between the two groups were significant at the 10% level, based on Pearson correlation coefficients, are indicated in bold.			

The main differences between domestically owned and foreign-owned firms are, hence:

- Hardware is more important for the foreign-owned firms.
- While education and learning within the firm are equally important in the two cases, externalities within the ICT sector and from other sectors are less important for the foreign-owned firms. This may be due to cultural barriers, or because the foreign-owned firms rely more on technology from their mother companies abroad.
- The Norwegian firms have on average much higher employment in Norway than the foreign firms. The latter are, on the other hand, parts of large firms with much higher employment worldwide.
- The import share of foreign firms is much larger, again indicating that many of these firms are mainly sales outlets of foreign corporations.

In other respects (innovation, product differentiation, exports), the two groups are comparable.

These data confirm the picture that foreign-owned ICT firms in the sample are mainly sales outlets, with a limited size that varies (from 2 to 140), depending on their size and whether local service provision is required to sell their goods. While some hardware firms are pure sales organisations, some foreign firms also supply services and adapt their goods for local customers, and hence need additional staff for this purpose. Foreign firms do not generally come to Norway in order to learn from the Norwegian ICT

sector, in fact such externalities are less important for them than for domestic firms.

From table 7 we also observe that Norwegian firms have significant investment abroad, with more employees abroad than in Norway. This average is strongly affected by a minority of firms, in fact 14 of the 21 Norwegian firms had no investment abroad, and only 4 firms had more employees outside Norway than at home. For the foreign-owned firms, employment in Norway constituted a small fraction of total employment in all cases (a share below 10% in 12 out of 16 cases, and a maximum share of 27% in one case).

11. Exports and imports

According to public statistics, most international trade in ICT goods is related to hardware; in fact 94% of OECD exports of ICT goods is hardware. While almost half the OECD production of hardware is exported, the corresponding shares for telecommunications and other IT services are only in the range of 2-3%.[5] Since Norway's ITC production is biased towards services, little exports are hence to be expected. As already noted, Norway is a net importer of ICT goods, and this is also reflected in the survey. The average values of the indicators for imports (55/100) and exports (13/100), see table 2, are thus in line with what we should expect. As noted before, however, export-oriented firms may be under-represented in our sample, so it is possible that the figure underestimate exports for Norwegian firms.

Regarding imports, we have observed (cf. tables 4 and 6) that software is significantly different from the sample average, with a low import share. Furthermore, foreign-owned firms tend to be importers. Among the foreign firms, it is also the case (and statistically significant) that the larger are these firms in terms of worldwide employment in the firm, the higher are imports.

Customer-specific adaptation of products should generally be expected to provide a trade barrier, since local presence and knowledge of the local market will be important for supply. If customer-specific product differentiation is interpreted as representing high trading costs, we should – according to the new theories of trade and economic geography – expect higher domestic production in segments with high differentiation. Some subgroups of firms fit into this picture; compare e.g. standardised hardware with a high import share, and software+services with high differentiation and a low import share. Other subgroups are, however, not in support of this theory, and on the whole, there is no significant correlation between the product differentiation variable and the variables reflecting imports or exports.

Regarding exports, most subgroups of firms have very low average values for the indicator. The only subgroup that is significantly different from the average, with higher exports, is the group of firms specialised in software.

[5] Source: Calculations based on OECD (2000b).

A closer look at the data reveal that only two out of the 37 firms had scores of 3 or above on the export variable, so most firms had very small exports. Among Norwegian-owned firms, there is a statistically significant positive correlation between foreign investment (measured by worldwide/domestic employment) and exports. This result is, however, driven by very few firms and should not be given too much weight. Our data generally suggest that in important segments of ICT, local market presence is important for sales. This may be an explanation why foreign investment and exports are correlated. Concerning foreign-owned firms: Even if it is true that many of these firms in the sample are mainly importers, it is also true that some of them are exporting from Norway. Unsurprisingly, it is statistically confirmed that the larger ones among the foreign-owned companies are exporting more. On average, foreign-owned firms export more than the domestic ones (see table 6). This difference is, however, not statistically significant.

Concerning exports of software, an important issue for research is to analyse the barriers to trade. The scale of possibilities range from the case when local wizards may invent new software that may be sold more or less frictionless in standardised world markets, to the other extreme where strong local affiliates are needed in every country where a firm wants to sell. If the first story applies, there should be huge export opportunities for firms in small countries, in spite of their small domestic market. If the second story is more common, firms need financial muscle if they are to sell abroad, and firms from large countries may have a "home market advantage". Our limited data set does not give decisive evidence, but suggests that the second story is more frequent or closer to the truth. This does not exclude the possibility that exceptional stories about export success may occur. An implication is, however, that the barriers to exports should be carefully studied as a part of the strategy for a firm that wishes to expand abroad. In most cases, it will be an illusion to believe that ICT exports are frictionless. While the physical shipment of products may indeed be without friction, the "invisible" barriers to trade may be substantial. According to some of the recent theories of international trade and economic geography, the "market size advantage" of large countries should be more pronounced for *intermediate* levels of trade barriers. Hence small countries such as Norway should have a greater chance for export success in segments where trade barriers are either very low or very high. Our survey does not provide evidence on this issue, which may usefully be addressed in further research.

12. Concluding comments

The results obtained from this survey should be considered as tentative evidence only, due to the small size of the sample. In spite of this, the study provides some useful evidence on the characteristics of ICT activity in Norway. In addition to confirming known evidence concerning production structure, innovation, exports and imports, the results show that:

- The adaptation of products to individual customers plays a significant role for many ICT producers, especially but not only related to ITC services.

- Learning within the firm, as well as knowledge externalities from the ICT sector and from other sectors, are important sources for the knowledge of the firm. Externalities were less important for foreign-owned firms than for domestic ones.
- A majority of firms provide combinations of hardware, software and services rather than specialising in one of them. The combination of software and services was the combination most frequently observed. The industrial characteristics of such combinations are in some cases different from those applying to the individual components.
- While exports from the firms were generally small, specialised software producers were exporting more than the others.
- Foreign-owned firms were mainly sales organisations and importers, especially with respect to hardware, but in many cases with an extended staff to provide services together with the imported goods.
- The data suggest that local presence is frequently needed in order to sell ICT goods, and this promotes foreign investment. When imported goods are sold by domestically owned firms, substantial employment related to service provision is frequently generated. The distinction between wholesale and ITC consultancy is therefore not very clear.

The results suggest that work should be undertaken in order to obtain more precise knowledge on the inter-linkages between hardware, software and services in ICT production. To the extent that complementarities exist in production, an appropriate analysis of comparative advantage may not be obtained based on data for the sub-components alone. In the case of Norway, a better understanding of software and IT services provision is important for the assessment of export potential and competitiveness. While service provision to the domestic market is a sheltered activity that will remain a backbone in Norway's ICT activity, the scope for software exports should be examined in more detail.

References

Ekeland, A., T.E. Braadland and A. Wulff, 1999, *Norske IT-kompetansemiljøer*, Oslo: STEP Arbeidsnotat A-06/ 1999.

Melchior, A., 1997, New theory and evidence on the standard good hypothesis, pp. 75-90 in Fagerberg, J., Lundberg, L., Hansson, P. og Melchior, A. (eds.), *Technology and international trade*. Cheltenham UK/Brookfield US: Edward Elgar. ISBN 1 85898 528 5.

Melchior, A., and V. Øi, 2003, *Born Global or Local? Technology, Market Structure and Export Performance in the IT Industries*, Oslo: NUPI, fortcoming as NUPI Report.

OECD, 1998, The software sector: A statistical profile for selected OECD countries, Paris: OECD, DSTI/ICCP/AH(97)4/REV1.

OECD, 2000a, OECD *Information Technology Outlook 2000*. ICTs, E-commerce and the Information Economy, Paris: OECD.

OECD, 2000b, *Measuring the ICT Sector*, Paris: OECD.

Pilskog, G.M. and E. Sverrbo, 2000, *Bruk av informasjons- og kommunikasjonsteknologi i næringslivet 1999*, Oslo: Statistics Norway, Report 2000/24.

Statistics Denmark, Statistics Finland, Statistics Iceland, Statistics Norway and Statistics Sweden, 2000, *The ICT Sector in the Nordic Countries*, Copenhagen: Statistics Denmark.

Statistics Denmark, Statistics Finland, Statistics Norway and Statistics Sweden, 2001, *Use of ICT in Nordic enterprises 1999/2000*, Oslo: Statistics Norway.

Statistics Norway (2001), *Real estate, renting and business activities 1998*, NOS C 637.

World Bank, 1999, *World Development Indicators 1999*, CD-Rom, Washington DC: World Bank.

Appendix: A description of the survey undertaken at IT Expo 2001

For the purpose of the survey, information on the 54 firms included in the catalogue for IT Expo 2001 was collected on the internet sites of these firms, as a preparation. In some cases, such information was used to supplement answers given in the survey.

The firms were asked questions in the following areas:

1. Type of activity: Infrastructure, hardware, software, consultancy, with each field ranked between 1 (no importance) and 5 (very high importance).
2. The kind of market served: Private customers, business, ICT firms, the public sector, with each segment ranked from 1 to 5 according to importance (5=very high).
3. Product differentiation or standardisation with respect to individual customers: Ranked from 1 (fully standardised, with no adaptation) through 5 (tailor-made for each customer).
4. Knowledge base: The importance of higher education, learning in the firm, learning from other firms in the ICT sector, and learning from other sectors (e.g. on the adaptation of ICT to specific purposes), ranked from 1 through 5.
5. Innovation: The importance of fast innovation for the firm's competitiveness, ranked from 1 through 5.
6. Age profile: The firms were asked if they agreed to the proposition that "People above 40 are usually too slow in this business, so we go for the younger ones". Their answers were classified from 1 (complete disagreement) to 5 (full agreement).
7. Key data: The number of employees in Norway, the number of employees worldwide, ownership (Norwegian/ foreign majority) and total sales in Norway in 2000.
8. Exports/ imports: The firms were asked how large share of their total sales in Norway that was imported/ produced in Norway by the firm. The answers were reclassified into an index ranging from 1 (all output produced domestically) and 5 (all goods sold were imported). In addition, the firms were asked to report the share of total sales exported.

In addition, a variable reflecting foreign investment by Norwegian firms was constructed indirectly, as the ratio between worldwide employment of the company and the number of employees in Norway.

For the ease of exposition, the indicators ranging from 1 to 5 were recalculated so that the responses range from 0 (corresponding to 1) to 100 (corresponding to 5).

Among the 54 firms included in the IT Expo catalogue, some firms did not show up. For some others, interviews could not be undertaken, either due to time constraints or because the representatives present did not know the answers. Responses were obtained for 37 firms, with a few missing observations for individual variables. For example, sales in Norway could

only be obtained for 28 firms, and for that reason we rely more on the number of employees (obtained for 37 firms) as an indicator of firm size.