SSH8-CT-2009-225368
INGINEUS
Impact of Networks, Globalisation and their Interaction with EU Strategies

Type of funding scheme: Collaborative Project (large-scale integrating project)
Programme addressed: FP7 Theme 8 "Socio-economic Sciences and the Humanities" (SSH)

Deliverable D9.2
Report summarising the implications per industry for EU countries and emerging economies

Due date of deliverable: Month 36
Actual submission date: Month 36

Start date of project: 1st January 2009 Duration:36 months

Name of lead contractor for this deliverable:
Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP, Participant no.10)

Revision:

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	**PU**
PP	Restricted to other programme participants (including Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CP	Confidential, only for members of the consortium (including the Commission Services)	

TABLE OF CONTENTS

EXECUTIVE SUMMARY ---------- 7

SYNTHESIS REPORTS OF COUNTRY SECTOR REPORTS ---------- 12

1. SYNTHESIS REPORT: ICT ---------- 12

1.1 Introduction ---------- 12

1.2 Regime conditions in the ICT sector ---------- 13

1.3 The context of GIN formation in ICT ---------- 19

1.4 GIN barriers and policy implications ---------- 26

1.5 Conclusion – implications per sector for EU countries (North; Norway, Sweden, Estonia) and emerging economies (South; India, China) ---------- 31

References ---------- 37

Appendix ---------- 39

2. SYNTHESIS REPORT: AGRO-PROCESSING ---------- 42

2.1 Introduction ---------- 42

2.2 Survey comparison ---------- 43

2.3 Survey limitations ---------- 43

2.4 Survey characteristics ---------- 43

2.5 Descriptions of the sectors in each country ---------- 48

2.6 Spatial and sectoral contexts of GIN formation ---------- 49

2.7 Patterns of opportunity/constraints on innovation and types of innovation ---------- 50

2.8 Locations and internationalization (actors and networks) ---------- 52

2.9 Concluding discussion ---------- 54

3. SYNTHESIS REPORT: AUTOMOTIVE ---------- 56

3.1 Introduction ---------- 56

3.2 The auto industry in four country contexts ---------- 57

3.3 Survey comparison ---------- 63

3.4 Survey limitations ---------- 63

3.5 Concluding discussion ---------- 70

3.6 Annex of the specific samples ---------- 73

ANNEX 1- COUNTRY SECTOR REPORT: ICT IN NORWAY ---------- 76

1.1 Introduction ---------- 76

1.2 Methodology ---------- 76

1.3 Subject 1: the present nature of sector activities in your country ---------- 78

1.4 Subject 2: the nature of innovation in the sector ---------- 83
1.5 Subject 3: the nature of knowledge ---------- 87
1.6 Subject 4: locations and internationalization ---------- 89
1.7 Subject 5: sector embeddedness in GINs ---------- 95
1.8 Subject 6: coordinating and communicating in GINs ---------- 103
1.9 Subject 7: prospective, impact from crisis ---------- 106
1.10 Subject 8: looking forward, implications for policy ---------- 106
1.11 Conclusion ---------- 110

ANNEX 2 – COUNTRY SECTOR REPORT: ICT AND AUTOMOTIVE IN SWEDEN ---------- 114

2.1 Introduction ---------- 114
2.2 Method ---------- 115
2.2.1 INGINEUS survey ---------- 115
2.2.2 Cases ---------- 116
2.3 Present nature of sector activities in Sweden ---------- 117
2.4 Nature of knowledge and innovation in the sector ---------- 120
2.4.1 Type of innovation ---------- 120
2.5 Internationalization and location ---------- 124
2.5.1 Global research collaboration ---------- 125
2.5.2 Global generation of innovation ---------- 129
2.6 Embeddedness in GINs ---------- 132
2.7 Barriers for collaboration ---------- 133
2.8 Impact from crisis ---------- 135
2.9 Policy ---------- 136
2.10 Summary of main findings and concluding remarks ---------- 138

ANNEX 3 - COUNTRY SECTOR REPORT: ICT IN ESTONIA ---------- 139

3.1 Introduction ---------- 139
3.2 Subject 1: a (short) history and the present nature of sector activities in Estonia ---------- 141
3.3 Subject 2: the nature of innovation in the sector ---------- 147
3.4 Subject 3: the nature of knowledge – sector activities in your country ---------- 155
3.5 Subject 4: locations and internationalisation ---------- 159
3.6 Subject 5: sector embeddedness in GINs ---------- 163
3.7 Subject 7: prospective impact from the crisis ---------- 164
3.8 Subject 8: looking forward ---------- 165
3.9 Subject 9: policy implications ---------- 165

3.10 Conclusions ---- 167
References ---- 172

ANNEX 4 - COUNTRY SECTOR REPORT: ICT IN CHINA ---- 175

4.1 Introduction ---- 175
4.2 Subject 1: The present nature of sector activities in your country ---- 176
4.3 Subject 2: Locations and internationalization ---- 183
4.4 Subject 3: Sector embeddedness in GINs ---- 187
4.5 Subject 4: Coordinating and communicating in GINs ---- 194
4.6 Subject 5: Prospective, impact from crisis ---- 197
4.7 Subject 6: Looking forward, implications for policy ---- 198
4.8 Conclusion ---- 203

ANNEX 5 - COUNTRY SECTOR REPORT: ICT IN INDIA ---- 204

5.1 Subject 1: the present nature of sector activities in India ---- 204
5.1.1 Background of the sector ---- 204
5.1.2 Contribution to GDP, export and employment ---- 205
5.1.3 From Software to IT Enabled Services (ITES) ---- 206
5.1.4 Home grown success: but ncreasing role of MNCs ---- 207
5.1.5 On survey method for WP9 ---- 211
5.1.6 The present nature of sector activities in India: evidence from INGINEUS survey ---- 212
5.2 Subject 2: The nature of innovation in the sector ---- 216
5.2.1 Results of the Survey ---- 217
5.3 Subject 4: Locations and Internationalizations ---- 224
5.4 Subject 5 Sector Embeddedness in GINs ---- 228
5.4.1 Participation in GINs: Existing evidence ---- 228
5.5 Subject 6: Coordinating and communicating in GINs ---- 235
5.6 Subject 7: Impact from Crisis ---- 237
5.7 Subject 8: Looking Forward –Implications for Policy ---- 238

ANNEX 6: WP 9 REPORT: SECTOR COUNTRY REPORT, AGRO-FOOD IN DENMARK ---- 241

6.1 Introduction ---- 241
6.2 Methodology ---- 242
6.3 Subject 1: the present nature of the agro-food industry in Denmark ---- 244
6.4 Subject 2: the nature of innovation and technology in the sector ---- 251

6.5 Subject 4: locations and internationalisation---254
6.6 Subject 5: sector embeddedness in GINs---259
6.7 Subject 6: co-ordinating and communicating in GINs---263
6.8 Subject 7: prospective, impact from crisis---265
6.9 Subject 8: looking forward, implications for policy---265
6.10 Conclusion---267
References---269

ANNEX 7 - COUNTRY SECTOR REPORT: AGROPROCESSING IN SOUTH AFRICA---270

7.1 Introduction---270
7.2 Methodology---270
7.3 Subject 1: the present nature of sector activities in your country---273
7.4 Subject 2: the nature of innovation in the sector---280
7.5 Subject 3: the nature of knowledge---286
7.6 Subject 4: locations and internationalization---289
7.7 Subject 5: sector embeddedness in GINs---292
7.8 Subject 6: coordinating and communicating in GINs---293
7.9 Subject 7: prospective, impact from crisis---294

ANNEX 8 - COUNTRY SECTOR REPORT: AUTOMOTIVE IN GERMANY ---295

8.1 Introduction---295
8.2 Subject 1. the history and present nature of sector activities---296
8.3 Subject 2. the nature of innovation in the sector---299
8.4 Subject 3. the nature of knowledge---304
8.5 Subject 4. locations and internationalisation---307
8.6 Subject 5. sector embeddedness in GINs---311
8.7 Subject 6. coordinating and communicating in GINs---314
8.8 Subject 7. prospective, impact from crisis---316
8.9 Subject 8. looking forward, implications for policy---317
References---321

ANNEX 9 - COUNTRY SECTOR REPORT: AUTOMOTIVE IN ITALY ---323

9.1 Introduction and methodology---323
9.2 The present nature of sector activities---324
9.3 The nature of innovation and knowledge in the sector---327
9.4 Locations and internationalization---332

9.5 Sector embeddedness in GINs ---- 335
9.6 Impact from the crisis ---- 338
9.7 Looking forward ---- 340
9.8 Concluding remarks ---- 341

ANNEX 10 - COUNTRY SECTOR REPORT: AUTOMOTIVE IN BRAZIL ---- 343

10.1 Introduction ---- 343
10.2 Data sources ---- 344
10.3 The automotive industry in Brazil: a general outline ---- 345
10.3.1 Structural changes in 1990s ---- 346
10.3.2 The 2000s: recovery and new investment cycle ---- 348
10.3.3 Research and development activities ---- 352
10.3.4 The sutomotive industry in Minas Gerais ---- 353
10.4 National Innovation Survey indicators for the automotive sector ---- 355
10.4.1 Expenditure on innovative activities ---- 356
10.4.2 Internal R&D expenditure ---- 359
10.4.3 Funding, educational levels and collaborating ---- 361
10.5 INGINEUS survey results ---- 372
10.5.1 The present nature of sector activities in your country ---- 372
10.5.2 The nature of innovation in the sector ---- 375
10.5.3 Collaborating to innovate ---- 379
10.5.4 Challenges and barriers to innovation ---- 381
10.6 GIN Formation and dynamics in Brazil ---- 382
10.7 INGINEUS survey analysis ---- 384

EXECUTIVE SUMMARY

The main objective of WP9 was to provide insights into inter-sectoral differences in drivers, degree and patterns of global innovation network formation. Three different sectors, each representing their own category in the influential Pavitt (1984) taxonomy, are chosen as cases. Thus, the WP provided insights into GIN formation in each of these sectors on their own and, by way of comparative analysis, lifted the analysis to a more general European level perspective. The main research questions were: What GIN patterns are forming in the selected sectors, and to what extent are these influenced (driven, constrained) by contextual conditions specific to these sectors?

The point of departure for this work package was the recognition that sectors diverge with respect to knowledge, cumulativeness and opportunity conditions. Existing empirical work e.g. show that the "global footprints" of different industries diverge according to the degree of tacitness and complexity of involved knowledge; according to degree of modularity of the product; and with the distribution of actors and environments globally which can be identified and towards which relevant linkages may be formed. Thus, different sectors face different tensions between centrifugal and centripetal forces of internationalization; which result in different patterns of international search, sourcing and collaboration. Understanding these are critical to the formulation of innovation policy in a context of globalization, as the patterns of GINs forming will determine home and host implications. National and EU level innovation policy must simultaneously account for the firm level need to interact and use the most competent and cost-effective partners world-wide; while ensuring that the linkages formed at this level strengthen rather than hollow out innovative capabilities at those same national and EU levels.

This report consists of 3 synthesis reports for Automotive[1], ICT[2] and Agro[3], based on country sector reports provided by partner institutions. The reports summarising the implications per industry for EU countries and emerging economies 8all reports are attached in the Annex), based on a template provided and based on the theoretical paper submitted in D9.1.

The main results of WP9 can be summarized as follows:

- There are modest GIN – and there are sector variations
- Subsector technologies define the types of actor engaged internationally

[1] Eike W. Schamp. «WP 9 Country sector report: Automotive in Germany". INGINEUS interim report. Davide Castellani and Filippo Chiesa. «WP 9 Country sector report: Automotive in Italy". INGINEUS interim report. Gustavo Britto, Eduardo Albuquerque, Otávio Camargo. « WP 9 Country sector report: Automotive in Brazil". INGINEUS interim report. Chaminade, C. (2011). WP 9 Country sector report: ICT and automotive in Sweden. INGINEUS interim report.

[2] Joseph, K. and V. Abraham (2011). "WP 9 Country sector report: ICT in India". INGINEUS interim report. Kalvet, T. and M.Tiits (2011). "WP 9 Country sector report: ICT in Estonia". INGINEUS interim report. Chaminade, C. (2011). WP 9 Country sector report: ICT and automotive in Sweden. INGINEUS interim report. Aslesen, H.W. and S. Herstad, (2011). "WP 9 Country sector report: ICT in Norway". INGINEUS interim report. Lv, P. and X. Liu (2011). "WP 9 Country sector report: ICT in China". INGINEUS interim report.

[3] Stine Jessen Haakonsson, "WP 9 Country sector report: Agrofood in Denmark". Tashmia Ismail and Helena Barnard "WP 9 Country sector report: Agroprocessing in South Africa".

- Based on the survey findings one cannot say that the selected sectors in North have a *global* reach on innovation collaboration:
  - ICT and Agro in the South have a more global reach on innovation collaboration, dominated by MNC presence
  - ICT in the South has North America dominant role as partner. Agro in the South has Europe, Asia, Australia and Africa innovation partners
  - Sectors relate to different knowledge hubs. Sectors in Europe relate to 'regional hubs' compared to 'South'.
- There are sector differences in barriers to international collaboration, and there are differences between North and South in the same sector with regards to type of barriers that are perceived.
- In general sectors in the North emphasise harmonising tools, structures and processes a barrier for international collaboration together with the barriers seen by managing globally dispersed projects. The same sectors in the South especially barriers linked to changing current locations of operations are emphasised, barriers linked to overcoming organisational barriers and gaining management acceptance.
- Propensity of GIN seem to grow out of 1) dense national links (well functioning clusters or RIS) and/or 2) from comparative advantages arising from local resources.
- All sectors are regionally and locally embedded in formal innovation linkages. The knowledge and capacity building aspect of these geographical levels are important – there might be certain linkages/factors that need to be strengthened in sectors at the regional/national level.

Results per sector:

• The automotive sector

In the auto industry the number of mergers of system suppliers and component suppliers are increasing and this may lay the basis for global innovation networks. A shift in the global organization of the industry suggests challenges for different parts of the industry. The relevance of innovation activity for GIN creation seems clear—more efficient actors in the value-chain might be expected to be more involved internationally. Results from the survey are that the Brazilian population is more specialized in manufacturing: while the European firms both small and large are generally more innovative. This may be a factor of the market or other contextual factors that are not observed. The literature however does suggest the danger of 'hollowing-out' of the competencies of the domestic companies. This challenge and the importance of maintaining a certain level of 'absorptive capacity' over time, suggest the importance of promoting RD&I activities in house, as the survey shows a relationship between R&D activity in house and the propensity to engage in international activities.

The immanent reorganization of the industry is raised as a special area of concern in the industry in Europe. On the one hand, this involves the ongoing efforts to adapt and integrate lower carbon technologies into cars; on the other, it involves adapting the market to emerging markets. Several layers of supports (EU, national, and state) target different areas of this wide-ranging sector in Europe, suggesting that a need for policy coordination between the

different levels is important. It also suggests the importance that the policy measures help the industry address emerging challenges. The country reports and the overall study point out that there are GIN patterns that emerge in this sector. However more comparative study into the innovative networks of this sector is needed before more conclusive policy implications can be drawn.

- ## The ICT sector

The study of ICT firms in the North (defined here as Norway, Sweden and Estonia) show that they are small, innovative stand-alone companies heavily embedded in regional or national user-producer relationships – often with lead users in other sectors representing important regional or national clusters. The firms are domestically owned, with high internally oriented innovation activity. The most knowledge intensive activities and the integration and coordination of activities are rooted in dynamic regions of these small open economies.

Certain kinds of transaction intensive services have become commoditized explaining the general rise in offshoring of lower end software services to Southern countries by both small firms and firms that have not internationalised earlier. Nonetheless, very few Northern firms offshore innovation or production, when they do, qualified human capital and specialized knowledge is the motivation, supporting research showing a shift from offshoring being driven by labor costs, to offshoring being a strategy to search for talent. The global search for new talent can be looked upon as signs that more advanced services are being offshored, however, our data do not support that the majority of firms offshore knowledge intensive activities. Many of the ICT firms are small and have limited resources, information systems and web-based collaborative technologies can help in coordinating globally dispersed high-value activities. The challenges of actually identifying relevant knowledge on a global scale are important barriers for small domestically oriented firms. In order to be attractive partners in GIN there is a need for greater specialisation and gradual upgrading of the value chain relationships, process that needs to be carried out at the regional level. The main conclusion is that integration into GINs remains modest among the Northern countries. This is especially so for indigenous firms, suggesting that MNC not only can be gateways for export and import relations, but also for more knowledge intensive linkages leading to potential GIN.

The average ICT company in the South (China and India) is also a small, stand-alone company showing low shares of R&D and innovation. There is a need to develop more innovation oriented expertise in the indigenous ICT firms in the South, as they are the least nationally and internationally embedded in innovation networks. The ICT sectors have emerged as an export industry and the nature of ICT activities first initiated was driven by exogenous factors/demand. The survey results show that North America is twice as important as Western Europe as an export market and as destinations for innovation collaboration. There are examples of firms and sub activities of ICT moving into emerging value adding innovation partnerships – mostly through MNC subsidiaries or MNC headquarters. The ICT sector and services in general shows low capital intensity and electronic form of delivery meaning that services offshoring can grow and relocate faster and as such enter straight into GIN. Both countries show great advances in sub-fields of the ICT sector, and clusters have developed in these countries based on functions. Offshoring knowledge intensive activities to

countries with weak local institutional settings and weak IP regimes comes with a risk, the problem of weak local institutional settings giving weak IP regimes is difficult to remove in short-term in developing countries. Active policy directed towards attracting in and helping firms out, together with the cluster initiatives and building of regionally concentrated hubs, together with educational policy are important for developing these sectors and in order to rise prospective GINs.

- **The agro-processing sector in Denmark and South Africa**

Agro-processing is a sector that span from biopharma, preservation techniques, traditional knowledge, agricultural techniques, production and distribution, sales etc. This suggests potential for GIN across geographical areas with distinct comparative advantages. Based on the reports, we cannot characterize the agro-processing sector as heavily embedded in GINs. However, firms have to be very globally connected and innovative, partly because of international food and health regulations, and partly because of the perishability of the product. MNCs or small providers servicing MNCs are the main drivers of GINs in this industry, suggesting that GINs in this industry are evolving as part of an expansion from first exporting, then global production, and slowly, global innovation. A strong degree of sector embeddedness is registered in Denmark's sectoral innovation system. Few companies engage in true GINs. Those that do, tend to be the large biotech related companies. Research and innovation policy has played a much more active role in the northern case. In Denmark, policy has explicitly prioritized increased innovation and research in this sector with the overall policy aim to lead innovation in the field while also increasing the competitiveness of the sector internationally. One challenge it faces however is the limited supply of highly trained personnel domestically. It is thus trying to attract skill from abroad.

In general Africa is an attractive and fertile source of agro-food products. SA agro-processing sector is tied firstly to a specific sub- national region (because of climactic requirements) and secondly, is a relatively inward-looking industry, with the proportion of firms exporting or engaging in innovation being below the national average. A general consensus in the industry is that the single most useful policy intervention would be to strengthen the basic education system, widening the pipeline of skilled candidates. The SA case also focuses on accessing outside markets for domestic products. A number of challenges are identified in the report also in this regard. It is noted here that some EU standards can act as a barrier to SA imports especially if they do not address certain specificities (i.e. the case of traditional plants). A desire to increase integration of the local offices of MNC is detected.

Summary and implications

Based on results focusing on barriers to international collaboration, we can expect a slower GIN evolution in sectors dominated by complex engineering knowledge and advanced production equipment.

Knowledge and capacity building aspects of these geographical levels are important – there might be certain linkages/factors that need to be strengthened at regional/national level. There is a need to address what kinds of initiatives actually link global collaborative efforts.

The results from this WP suggest that working for the development of Global standards is important in all sectors. Specifically, (i) the incoherence in standards works as a barrier; (ii) their development could provide a level playing field also for new products; (iii) Global standards work as motivations for innovation and as a barrier for market access.

The studies carried out for this WP revealed that there are examples of indigenous firms that use MNC affiliates to enter foreign locations with products linking up small stand alone companies with MNCs.

SYNTHESIS REPORTS OF COUNTRY SECTOR REPORTS

1. SYNTHESIS REPORT: ICT

The synthesis report on ICT is compiled on the basis of 5 country sector reports.[4]

Author: Heidi Wiig Aslesen (Heidi.W.Aslesen@bi.no), Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP, Norway, participant no.10**)**

1.1 Introduction

The general research question for WP9 is; What GIN patterns are forming in the selected sectors, and to what extent are these influenced (driven, constrained) by contextual conditions specific to these sectors? According to widely used classification there are key difference among sectors as sources of innovation and the appropriability mechanisms (patents, secrecy, lead time, learning curves, and complementary assets) are different (Pavitt 1984).

There is a dynamic evolution of industries internationalisation, driven by multiple reasons such as costs, technology and innovation. Research has showed that companies may start with offshoring low skill and routine work but then expanding into more advanced and complex activities such as innovation (Lewin et al., 2009) and that multinational companies (in the North) have evolved from having an innovation strategy that augment the firms knowledge base (by connecting to foreign R&D environment and access local knowledge (Florida, 1997)), to a home base replacing innovation strategy (Lewin et al., 2009). This synthesis report will among other things question this proposition by presenting the result of 5 sector reports that have studied the dynamics of Global Innovation Networks in the ICT sector in their 5 different countries, both from the North and from the South.

The ICT sector is widely labelled as a representative of science-based regime – assumed to be characterized by a knowledge base firmly embedded in the life sciences and physical sciences (Bloch et al. 2009). A more refined picture is provided in Malerba (2004), where it is concluded that in "telecommunications equipment and services a convergence of different technologies, demand and industries with processes of knowledge integration, combination and production specialization has taken place" and global networks among a variety of actors are relevant. Software, on the other hand, "has a highly differentiated knowledge base (in which the context of application is relevant) and several different and distinctive product groups in which specialized firms are active. User-producer interaction, global and local

[4] Joseph, K. and V. Abraham (2011). "WP 9 Country sector report: ICT in India". INGINEUS interim report. Kalvet, T. and M.Tiits (2011). "WP 9 Country sector report: ICT in Estonia". INGINEUS interim report. Chaminade, C. (2011). WP 9 Country sector report: ICT and automotive in Sweden. INGINEUS interim report. Aslesen, H.W. and S. Herstad, (2011). "WP 9 Country sector report: ICT in Norway". INGINEUS interim report. Lv, P. and X. Liu (2011). "WP 9 Country sector report: ICT in China". INGINEUS interim report.

networks of innovation and production, and the high mobility of highly skilled human capital are all present". In general one can say that the ICT sector consists of two distinct components, which are complementary to each other at the level of the firm: a codified platform and a tacit firm-specific, knowledge. This suggests that sub sectors and activities within the ICT sector can represent innovation dynamics that are both synthetic and analytical.

In this report ICT is classified as NACE 2 codes: "26.30 Manufacture of communication equipment","62.01Computer programming activities"," 62.02 Computer consultancy activities", "62.03 Computer facilities management activities", "62.09 Other information technology and computer service activities".

1.2 Regime conditions in the ICT sector

NORTH

The ICT sector in Norway accounted in 2006 for just below 5 per cent of private sector employment in firms with more than 5 employees. These firms are more innovation active (i.e. conduct innovation activities such as e.g. R&D) than the Norwegian average (65 per cent compared to the average 35 per cent) and show high rates of product innovation; yet, they are predominantly small or medium sized, and not affiliated with corporate groups. It is reasonable to believe that other industrial sectors are critical to the ICT sector not only as customers, but also as providers of knowledge externalities upon which innovation in the ICT sector may feed. Excessive emphasis on the activities of the ICT sector as such, and its *direct* collaborative or sourcing linkages to the domestic economy, may come with the risk of such indirect interdependencies being neglected. It also comes with the risk of neglecting GIN linkages between domestic ICT development and knowledge sources abroad which operate through the activities of firms not defined as part of the ICT sector.

ICT are considered to be a strategic industry in Sweden and according to VINNOVA (2007) the ICT industry is responsible for 12% of the Swedish industrial production and 15% of the exports. A majority of ICT firms are standalone companies (88%), rather small firms with less than 50 employees that mainly target the domestic or regional market. When exporting, mainly European markets are targeted. The ICT industry in Sweden is responsible for almost a third of all business R&D and it performs near 70% of all the ICT-business related R&D. The innovation effort in R&D is reflected in the number of innovations as well as in the degree of novelty; 16% of the ICT firms have introduced new to the world innovations, suggesting an indication that Sweden is specialized in high-added value activities. Firms seem to follow an innovation strategy that is both a combination of technology push and market demand. Firms produce most of their technological inputs in-house, suggesting that the most basic research (the one that is still several years before production) relies heavily on the skills and technological competence base of the firms. The case studies show that it is more in the development phase that the inputs from the market become more important.

The ICT sector in Estonia is rather small; varying between 4-7% for value-added, profits, exports, employees and turnover, the largest sub-sectors, measured by the number of employees, are computer programming, consultancy and related activities (5,900 employees) and manufacture of communication equipment (3,200). Most of the ICT exports are generated in the field of manufacturing of electrical and optical devices (80% of total ICT exports), 52% of the Estonian ICT companies do not have any exports at all, the largest exporters are under foreign ownership. 84% of the companies have only local owners, totally foreign owned companies can be mostly found in the fields of programming and consultancy and sales of ICT. The largest companies in the provision of the telecommunications services, the most profitable part of the Estonian ICT sector, are completely foreign owned. Estonian ICT manufacturing sector is part of the larger Nordic ICT manufacturing cluster. The Estonian ICT sector is important in the national innovation system as other branches demand most of the production generated by the sector, having also positive effects on generating innovative solutions. Signs can be observed i.e. in the software industry, which has started to build strong links with universities and research groups, and pursues research activities also in-house (Kalvet and Tiits, 2011). Further, governmental structures are important users of telecommunications equipment and services, office machinery, computers and software, whereas the government's affection for novel technological solutions has had a positive effect on a number of public sector initiatives (Kalvet et al. 2002; see also Kalvet 2012).

Only 16 % of Norwegian ICT firms with more than 5 employees have sourced R&D services domestically in Norway, and only 5 per cent have sourced such services, parent group units abroad included. The ICT sector is the second lowest ranking with respect to R&D purchases abroad, with only approximately 2 per cent of total R&D spending allocated to such purchases. The INGINEUS survey shows that most firms have their largest markets regionally or domestically, the exceptions to this rule are oriented towards markets in Europe or the USA. The domestic market orientation can be explained by strong domestic opportunity conditions, and possibly also in the size composition of the industry.

The share of innovative enterprises in the ICT sector in Estonia is high, in the manufacture of computer, electronic and optical products ¾ of the companies are technologically innovative, mostly process innovations, generally seen as the most dominant form of innovation to increase productivity and improve the flexibility of production and provision of services. R&D investments are small in most of the firms and most innovations are incremental, most of the turnover of developed product innovations comes from those that are new only for the enterprises, i.e. providing only a short-term competitive edge.

Summing up regime conditions in the NORTH

The size composition of the industry, innovation activity and its market orientation suggests that the ICT in the North is heavily embedded in regional or national user-producer relationships. The opportunity conditions at the regional and national are high and the markets willingness to pay seems high. Potential GIN formation is constrained by strong domestic demand, and (presumably) dependence on knowledge externalities from ICT-oriented R&D conducted in other sectors.

The data reveals that opportunities for innovation in the ICT sector are high but stemming less from technological development per se, than from the sector itself experimenting with new market structures (i.e. dual markets), new business models and new services oriented towards core regional or national industries. The pervasiveness of parts of the ICT sector makes it applicable to a variety of products and markets. The sector consequently serves to 'bridge' a set of technological opportunities which are already in place, in existing or arising markets.

The ICT sector is rather heterogeneous when it comes to its knowledge base, through the case studies we found that it could be divided into two distinct components, which are complementary to each other at the level of the firm. On the one hand, all firms build on 1) a codified technological platform, which represent a potential for GIN formation as the knowledge is highly codified. The other knowledge condition is linked to the 2) tacit, and often firm-specific, knowledge linked to development of new services and applications. This form of knowledge constrains GIN formation, because its development is located in the interface between customer collaboration, internal knowledge development and specialized knowledge spillovers from other industrial activities, making it highly context specific and sticky.

It seems that two different technological regimes exist side by side; a small-firm based regime fed by ample opportunities to develop new ideas and concepts based on the existing platform provided by ICTs; and a large-firm sector which both feed on this process with external experimentation (thus reducing the need for own long-term R&D under high volatility and uncertainty conditions), and contribute knowledge (e.g. through spillovers from labor mobility) upstream and complementary capabilities downstream to the same entrepreneurial regime. The basic competencies necessary to enter into the game of software and service development is relatively widely distributed and the innovation-pull from the demand side is strong.

Opportunities are seen in technologies and markets. The knowledge base differs between sub-sets of firms, but most activities in the service industry are related to the soft-service dimensions of ICT. The cumulativeness is high, as the largest share of firms show that most of the knowledge generation is carried out in-house by accumulation of complex, specialised knowledge which is not easy to imitate or relocate – its immediate network of collaboration partners are found at the regional level.

SOUTH

The ICT industry is one of the most fast growing industries in the past two decades in China, and has made great contribution to China's economic development, and the industry has been accounting for more than 80 per cent of the total export of high technology products in recent years, the three largest export destinations are US (23.8%), EU (15 countries, 22.7%) and Hong Kong (22.4%) (Lv and Liu, 2011). China is now the world's biggest ICT exporter ($180 billion). The sector is innovative, as much as 75,2% of the respondents in the INGINEUS survey reported product innovations while 54,5% had introduced new services, with the largest share being new to the industry (as opposed to new to the world).

India has emerged as a leading player in the export of IT software and services, with software and IT Enabled Service (ITES) exports that have been doubling in almost every second year and an emergent player in business process outsourcing (BPO). In 2011almost all the leading IT software companies have established a development base in India, the sector accounts for over 16 per cent of India's exports with presence in over 170 countries and a customer base that include most of the fortune 500 companies. This together with large scale takeover of foreign IT firms by Indian firms appears to have contributed significantly towards enhancing India's credibility in the world market. The growth of the sector has been made possible by taking advantage of the large pool of skilled manpower (with over 300 universities and 13,150 colleges produces about 2.46 million graduates and about 290,000 engineering degree and diploma holders every year on the one hand) and opportunities opened up by new technologies that increasingly splintered off services from its providers and an ample supply of manpower for ITES services at a much lower cost[5] as compared to other countries. Improvement in the telecom infrastructure leading to improved connectivity coupled with reduction in the cost of communication *inter alia* on account of increased competition also facilitated the ITES boom[6]. According to Nasscom (National Association of Software and Service Companies) surveys reached a level of 2.23 million professionals in 2008-09. It is shown that the industry is creating job opportunities for highly qualified (majority with an engineering degree) young graduates with a relatively short experience.

India's ICT industry emerged mainly as an export activity focusing on the lower end of software services by taking advantage of the availability of skilled manpower, such as customized software development at the lower end of value chain by carrying out low-value added design, coding and maintenance (Kattuman and Iyer 2001). Indian firms are increasingly getting engaged in highly skill demanding areas like chip design and R&D and thus are moving up the value chain marked by a shift away from Business Process Outsourcing to Knowledge Process Outsourcing (Parthasarathy 2006). The ITES/BPO services, experiencing a boom at present, have certain characteristics that could contribute to broad based development. While employment in the Software sector has been mainly for the highly skilled IT professionals, the ITES sector generates more broad based employment and is more employment intensive than the software sector (Joseph 2004). The ITES/BPO has the potential of generating substantial employment for the growing number of educated youth in the country and the sector is found geographically diffused across different regions in the country and generating more linkages with rest of the economy.

As reported by (Lv and Liu, 2011) none of China's MNCs have been listed in the world top 250 firm classification (OECD, 2006), [7] and in 2009, China's four largest ICT exporters were all subsidiaries of Taiwanese Firms, and the fifth largest ICT exporter was Nokia with the exports of $8.4 billion. The ICT industry also relied heavily on foreign imports of key components and advanced equipment for production.

[5] It has been estimated that on the average the labour cost in India in the ITES sector is only about 14% of that in US.

[6] The cost of a one-minute telephone call from India to UK and US, for example, has fallen by more than 56 per cent during 2002-03 (DoT Annual Report 2002-03) and the downward trend still continues.

[7] OECD, IT Outlook, Paris, 2006.

INGINEUS survey shows that the ICT sector in India represents a highly globally integrated sector in that about half the firms was either subsidiary or headquarters of MNCs. Particularly important is the rise of MNCs head quartered in India (15,5%), hitherto to unknown to Indian manufacturing is atypical of the traditional manufacturing sector in India. It can be stated that Indian ICT firms are to a large extent mid sized firms (39 percent accounting for more than 39 percent), with considerable presence of very large sized firms (40 percent of the firms had 250 or more full time employees). Local firms are relatively small; nearly 70 percent of the stand alone firms had less than 250 employees, and more than 28 percent had less than 50 employees.

Advances have been seen in many technology fields in China, such as mobile communication, operating system, wireless internet, next generation network and high definition television, and leading MC in the sector are now Chinese (ZTE, Huawei, and Lenovo). According to China INGINEUS Survey, most of the ICT firms are relatively small and the proportion of stand-alone company is 44% (27% MNC subsidiary, 29% MNC headquarter). Data from the Ingenius survey shows that most firms have their largest markets domestically (59%), and such a domestic market orientation suggesting domestic opportunity conditions linked to market size. One fifth of the respondents reported export activity, the largest export market being Asia (Australasia included) or the US. 58 percent of the firms in the INGINEUS survey India claimed that export was the biggest market. There seems to be a diversification of markets between the local firms and the MNC; more than 50 percent of the stand alone firms in the INGIENUS survey were catering either to the local demand or the domestic demand while subsidiaries of MNCs and MNC headquarters had their largest market as exports (more than 70 percent of both MNC subsidiaries and head quarter firms had claimed that their largest market was export market). This market orientation difference characteristics is expected to have its implications on the opportunity conditions as well as the innovative behaviour of firms (Joseph and Abraham, 2011). The largest market destinations for Indian firms were North America (79%), followed by South America (55%).

The nature of activities undertaken by the industry in India was driven by the exogenous factors leading today to a diversification towards IT enabled services, and there are indication that Indian ICT industries becoming increasingly innovative. However, the Ingienus survey indicate difference across firms of different organizational categories; MNCs with head quarter in India are the most innovative firms in Indian ICT sector across various categories of innovation activities, followed by MNC subsidiaries. The stand alone firms are the least innovative among the lot. In general, the bulk of the firms are not found to be engaged in any R&D activities. In-house technological inputs is the most important source of innovation, especially for the stand-alone companies (73% report this), suggesting limited external knowledge inputs to these standalone firms, suggesting them to be less likely to be active participants in GINs. These firms are also smaller and have lower level of innovative activities. Indian firms are largely export oriented with limited innovative ability as stated earlier, however, those firms that engage in innovative activity are essentially seeking collaborators and building networks at the local and national level for innovation as well as internationally (Joseph and Abraham, 2011), the pattern in innovation, sources of technology and the collaborative strategies suggests a dichotomous nature of ICT sector in India as well.

With the rapid development of technology capability or technology standard of Chinese firms, a large share of firms also serves international market. This seen in relation to firms being highly innovation active could suggest opportunity conditions in both domestic markets and international markets.

Despite initiatives by various state governments, the foreign investment in the ICT sector in India is still concentrated in a few states as Delhi, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh has a share of 93 per cent going by the number of foreign firms. Foreign firms are found to be more export oriented as compared to the locals firms in these regions, and annual compound growth rate are higher for foreign firms than local, suggesting them to be more dynamic as compared to their local counter parts.

Thus while stand alone firms in India do under-perform in the traditional markets, the unconventional and sometimes developing country markets are where stand alone firms get competed out by their MNC counterparts. To the extent that the standalone firms are less exposed to the more demanding world market as compared to their MNC counterparts, it is likely to have its bearing on their innovative behaviour and potential for being a part of GINs (Joseph and Abraham, 2011).

Summing up regime conditions in the SOUTH

For the ICT companies in the South the opportunity conditions are found both in large domestic markets as well as in export markets as China and India represents the worlds largest ICT exporters, the share of export constantly rising. As this mode of internationalisation is constantly rising, this can potentially paw the way for modes of internationalisation that entail more integration into foreign markets. MNC with headquarters in India is rising, suggesting a stronger integration into foreign markets and potentially also GIN formation. There has also been takeovers by foreign firms in India by Indian companies.

Rapid development of technology and technological capability and skills can be seen as good opportunity conditions, rising also the propensity to engage in GIN. Especially the rising pool of skilled workers and ICT employees with university and engineering background gives good opportunity conditions for the ICT sector in India and China.

Cumulativeness is lower than for the North firms in that a lower share of technological inputs comes from within the firms, and at the same time showing lower propensity to innovate. There is also a great divide among the ICT actors, the small stand alone firms with low innovation shares and low export and the MNC being more innovative and export oriented also taking part in R&D activities, suggesting different potentials to take part in GIN, suggesting that if the accumulation of complex, specialised knowledge are held and developed by indigenous firms. Even though there has been rapid changes and that the global orientation of the ICT industry as a whole in the South do seem to be more internationally oriented, it can still be questioned if these knowledge linkages show signs of the sector in the South are moving up the value chain.

1.3 The context of GIN formation in ICT

This section focuses on international linkages including but extending beyond intra-corporate networks established by means of FDI. The purpose is to understand what kind of linkages, targeting what kind of actors located where, that has formed in the ICT sector and how these may interact to create a dynamic evolution of GIN. Both offshoring and innovation collaboration has been used as indicators for GIN.

NORTH

The case studies in Norway suggest firms that are able to combine the two main knowledge components by staying updated on or contributing to the development of ICT platform technologies while at the same time drawing insights from and adapting products to various contexts of application are the one with the highest potential for GIN formation. Offshoring of R&D is a relatively rare phenomenon in Norwegian ICTs. When such offshoring is conducted, the main location factor is access to qualified human capital and specialized knowledge. We have also seen that innovation collaboration and R&D sourcing at home is relatively rare. Taken together, this suggests that the industry is highly dependent on skills available in labor markets, combined with proximity to important customers/markets. These are locations factors which are highly specific to certain places.

The geographical scope of the innovation collaboration network of the average Norwegian ICT firm is well below other sector averages. This reflect the combined effects of a lower overall propensity to engage in contract R&D (in favour of in-house knowledge development), and a lower propensity to engage in collaboration altogether (again, in favour of in-house knowledge development). The propensity to collaborate in innovation in Norway is slightly lower among innovation active Norwegian ICT firms than among active firms in other sectors; while 37 per cent of ICT firms maintain some form of collaboration, as many as 45 per cent of innovation active firms in other industries do. Off the total number of collaborators in ICT, as many as 35 % collaborate with customers located in the same region and customers seems to be of higher importance than for other industries. Once ICT firms have decided to engage in formal collaboration, the geographical scope of the collaboration network is well above country averages.

Swedish firms have a high propensity to collaborate with external partners as compared with other EU firms, being the most important ones the suppliers (78%) and clients (64%). Interestingly, there is a very high proportion of innovative firms that collaborate with China and India, even within small firms. The ICT firms that are surveyed, shows that most linkages are at domestic level and that the research collaboration network of ICT firms is rather contended geographically. The case studies in *Sweden* suggest that the drivers of innovation as well as the geographical spread of the innovation activities is highly contingent to the nature of innovation (and possibly also the stages of the innovation process). Core basic research is done mostly internally or in collaboration with a handful of very strategic customers, while applied research and development can be done with a larger number of partners. Geographically, core research is close to the HQ and not spread in different locations worldwide although the ideas can come from subsidiaries, while applied research and

development take place in many different locations around the world in close proximity with the market. ICT firms use a variety of partners both in Europe and internationally, suggesting a diverse and geographically dispersed research network. This is highly coherent with the kind of knowledge that is dominant in part of the ICT industry (codified platform technology) more likely to be transferred across geographical distances and across different partners. One of the ICT cases indicates that "the development of new ideas involve often not only the HQ. Different subsidiaries teams participate for example in specific sections of pre-development where the ideas are shared. If instead an idea is developed in a subsidiary it is usually sent to the HQ where the core research is. The HQ takes therefore the control". This strategy, which can also be observed in the other ICT cases show how MNC operate as 'systems integrators' which 'know more than they make' that outsource detailed activities to suppliers, however, maintaining in-house concept design and the ability to coordinate R&D and design, and manufacturing by suppliers (Massini and Miozzo, 2010; Brusoni et al., 2001).

The majority of ICT firms in Sweden do not outsource or offshore production or innovation activities (80%) but there are some firms that offshore only R&D (3%) or R&D and production (5%). The main motivation is the access to qualified human capital at a lower cost, both for offshoring of production and innovation, followed by the availability of specialized knowledge in the host region as well as access to other infrastructure and new markets. The cases show that firms may locate innovation centers around the world to tap into specific competences (pool of qualified human capital, software development skills). By looking at the reason for offshoring, it seems that the aim is directed towards both strengthening of domestic operations, a home-base augmenting (HBA) R&D strategy that requires the development of links with host-country R&D systems in order to enhance the knowledge base at home and to connect more closely to the foreign R&D environment and access local knowledge (Kuemmerle, 1999, Florida, 1997).

Estonia is frequently considered as one of the successful, if not the most successful Eastern European catching-up economy, has taken great steps to internationalise its economic system and to attract foreign capital and foreign direct investments, resulting with entrance into the Global Production Networks (GPN) (Kalvet and Tiits, 2011).

The largest share of innovation collaboration in Estonia takes place within the relevant value chains (production networks), while only a fraction of companies co-operate directly with public research institutes. The companies have limited R&D co-operation with external partners, also intramural innovation activities are most widely practiced and considered the most important sources for innovation next to suppliers and clients.

Entrance into GPN has not lead to an automatic upgrading of the local nodes (subsidiaries, affiliates, but also independent suppliers and sub-contractors) into the nodes of global innovation networks. Estonia ranks highly in the various international comparisons that benchmark the development of the information-society, the United Nations e-government survey (United Nations Department of Economic and Social Affairs, 2008, p.81) ranks Estonia 13th, describing it as a country "reinventing itself from the confines of the previous Soviet era into a Baltic catalyst for digital adoption and innovation".

Offshoring of R&D activities is not commonplace among the *Estonian* ICT enterprises, explained by the fact that a fairly small number of relatively well known enterprises are

responsible for the majority of the business R&D investment and/or independent product development activities (Kalvet and Tiits, 2011). The sub sectors of the ICT sector have different needs when it comes to being present in a market. Estonian ICT firms sub-contract parts of software development to lower costs locations in Eastern Europe, suggesting that production of certain types of software, mainly directed towards the mass market, can take place anywhere. Nordic countries dominate as sources for foreign direct investments into the largest ICT companies in Estonia and have been driven by Estonia's proximity to the Nordic economies. Several of the largest (both foreign-owned as well as indigenous) companies with a subcontracting-only profile have little contacts with other companies, educational and R&D institutions. Most of the co-operation in the introduction of technological innovations occurs either domestically in Estonia or with the various European partners.

Despite the potential advantages of engaging in GINs, the majority of Swedish firms still maintain the development of their innovation in house and, when they collaborate, they do it in cooperation with a handful of actors, usually located in close proximity. There are a number of barriers that may hamper the possibilities or willingness of firms to collaborate with external partners for the development of new product or services. For one of the ICT case studies in Sweden the subsidiary in China is considered to be key in the area of radio base stations and, although its main tasks continue to be the development of incremental innovation for the Chinese market and the MNC HQ foresees that the Chinese center could conduct more core-research activities in the near future. Another case study illustrates the diversity of actors and geography; The universities represent an important source of innovation for accessing generic and scientific knowledge that is not related directly to the product that needs to be developed, and the cooperation happens both at local but also at global level (important is the cooperation with some American and Australian and in the last period Chinese universities). Collaboration also takes place with operators (who in turn have the networks with the equipment manufacturers) and component suppliers and in a typical project, the main partners will be located in Western Europe and USA, although some less important collaboration may also take place at local level.

The innovative companies have import and export relations mainly with various Scandinavian or European enterprises (with regional offices). Scandinavian countries act as gateways to the world for ICT firms in Estonia. Import or export relations with countries located far from Estonia are rare. In the manufacturing of computer, electronic and optical products and in telecommunications, firms report innovation collaboration with the US, and some firms with collaboration with Indian and Chinese companies. MNC headquartered in Estonia are true GINs with local RTD undertaken locally, however, other knowledge intensive activities are carried out in other European countries.

The emergence of GIN in Estonia is about greater specialisation and gradual upgrading of the value chain relationships by being complemented with applied research and product development, management of multi-site production and supporting facilities, global brand development and marketing. Intramural innovation activities are the most widely practiced, among ICT firms in Estonia, and the main sources of knowledge for innovation are clients and customers. When it comes to international linkages domestically owned enterprises do not have, as a rule, any specific units outside Estonia. Export is oriented towards proximate markets such as Latvia and Lithuania. GIN patterns of MNC subsidiaries depend substantially

on the foreign owners. They are typically either a subsidiary of a bigger multinational enterprise that has been established specifically for servicing the Estonian market, or a smaller production or development unit that caters mostly for the foreign markets. In the case of the latter, the foreign owners tend to be the ones who 'open the doors' for exports in Scandinavia and beyond (Kalvet and Tiits, 2011). There are some examples of highly innovative Estonian ICT firms that have been able to build on the presence of MNC subsidiaries and use them as strategic partners in entering foreign markets. Examples of strategic business alliances like this is the company Reach-U which has developed a special software that allows to detect the geographic location of mobile phones based on the distance from nearby base stations. The MNC Ericsson sells this product to its customers (network operators) under its own name. Webmedia is originally an Estonian software firm, which as established its own subsidiaries at different European markets. They use both their own subsidiaries as well as larger MNCs, such as Microsoft, in order to sell its products and services. Most of the indigenous ICT enterprises continue, however, to serve predominantly the domestic market, so the actual extent of integration into GINs remains modest.

Summing up context of GIN formation in the NORTH

There seems to be a polarization of the industry between a very small number of internationalized firms, and a large number of domestically oriented small firms, a key factor when interpreting the global innovation network affiliation of the industry, and not least the future prospects of global innovation networks.

It can be indicated that the GIN potential in this sector is linked to the ability of firms to use global markets as sources for innovation, i.e. the ability of firms to successfully penetrate and learn from international markets and lead users. This potential does not materialize in the sector as a whole, due to a strong domestic demand drive. The case studies show that once firms become international players they gain access to far more diverse information and technology inputs than what is available domestically, and they work systematically with harnessing them.

The ICT sector in the North is in general heavily oriented towards internal knowledge development, however tightly linked to interaction with customers/clients. Offshoring of R&D is relatively rare but firms in the North engage in outsourcing of accounts management, operations and the like, suggesting that these actors are highly linked to a global network of business service providers as opposed to a network of partners for innovation collaboration. Nevertheless, these companies search globally for relevant input into their companies. Those few firms that do offshore production or innovation do this to access qualified human capital that cost less and are more specialized.

In general the industry in the North seems highly dependent on skills available in local labor markets, combined with proximity to important customers/markets. The picture that emerges in the ICT sector in the North is that of GINs being only marginal - most of the innovations are developed and commercialized domestically, most sourcing of technology is still internal to the firm, and the majority of firms does not collaborate for innovation (those that do are oriented towards Western Europe) or do not offshore innovation nor production.

SOUTH

China

The INGINEUS survey shows that 14 per cent of Chinese sample firms have offshored production, while 18 per cent have offshored R&D. Analysing the factors that motivates offshoring, the survey result show that market access is perceived as important by most firms in their offshoring processes, then followed by knowledge infrastructure and services, whereas financial incentives and human capital appear far less important (Lv and Piu, 2011), which suggests the combination of market-based and technology-based orientation. The findings are consistent with the case interviews that MNEs are more willing to establish their foreign R&D centers in regions with huge market size or market potential, in order to capture various opportunities; in addition, these regions should be good knowledge clusters with skilled labors (Lv and Piu, 2011). Cheap production resources are still the third most important factors (14 out of 34 observations) behind the decision to offshore production. The case companies reflect true GINs, in that they have innovation activity and collaboration both in Northern and Southern countries, as well as R&D activity also located in home country and region. The main driver of its R&D internationalization is not only to make good use of local advantageous intellectual resources, but also to get more close to operators in developed countries (Lv and Piu, 2011).

The case studies do seem to indicate that MNC in China embedded in true GINs have an orientation of R&D centres in developed countries that are different from those in developing countries; the former mainly aims to develop cutting-edge technologies and conduct the predictive R&D activities for the future. These R&D centres are technology-based or basic research oriented. R&D centres established in the South seems to focus more on value-added services, mainly regarded as a correspondence for local market development and using local human resources, such as in the Indian research and development centre, it makes good use of local talents with advantages of software development and English language skills. These R&D cebters are market-based or applied research oriented, however, increasingly assuming some basic research, due to great importance of developing country markets and skilled talent pool (Lv and Piu, 2011).

Both inward FDI and outward FDI is one of the main drivers of GIN formation of the ICT sector. The cases studied also show that MNC subsidiaries regard China as a strategic focus of R&D investment, These subsidiaries have experiencing a more than 30% per year growth in the past several years, and more than 20 per cent of its employees in China are engaged in R&D activities. Its global supply network is polarised among three regions of America, Europe and China. The case companies interviewed all have extensive operation with local partners, such as joining Industry-Academia Cooperation Forums and several alliances, the set up of joint labs with the knowledge infrastructure and with dominant players in the ICT located in the region/domestically. At the same time these case companies are globally linked, and factors considered include presence in lead markets, close to production, close to customers, cooperation with public research and so on.

The largest share of Chinese firms' innovation collaboration is with customers and suppliers (59%, 40%), and 1/5th report collaboration with domestic knowledge infrastructure. The collaborations that are carried out with foreign partners are with clients and suppliers in North America and Japan (Australasia), with shares ranging from 8-10% of the respondents. Foreign/external linkages are not distinctively oriented towards joint innovation projects, even though supplier – customer relationships in the ICT industry do result in an innovative output, suggesting more incremental innovations as result of those types of foreign relations than what the potential actually could have been in an planned formal innovation projects.

The survey in China shows a sector that is heavily oriented towards internal knowledge development (76 per cent of sample firms produce most technological inputs in-house) linked to customer collaboration. Chinese firms R&D linkages to foreign actor groups are mostly linked to customers and suppliers (63% and 53% respectively), most of these linkages are formal suggesting user-producer relationships. Linkages to foreign competitors, consultants and research system actors are rare, suggests that international linkages in the ICT industry predominantly take the form of value chain interaction. The effect of this could be a loss of potential new knowledge, especially linked technology or basic research, that can spur more radical innovations as opposed to more incremental). In general, the stand alone companies have fewer R&D linkages towards foreign actor groups, than subsidiaries of MNC or MNC headquarter, and these relationships are formally organised to a larger degree than for standalone companies. MNCs with headquarter in China have a higher share of firms reporting linkages with customers, competitors, consultants, and government abroad than subsidiaries and standalone companies, suggesting market-based linkages abroad. Subsidiary of MNCs (with headquarters in other countries) are more active to establish linkages with suppliers and research organizations abroad than the other two types of firms, suggesting more technology-based linkages abroad.

Of the case companies studied many of them show 'globally-linked' approaches to innovation, which "pools the resources and capabilities of many different components of the MNC – at both headquarters and the subsidiary level – to create and implement an innovation jointly" (Bartlett and Ghoshal, 1990).[8] Being a MNC subsidiary (Chinese unit started to collaborate with parent company and other overseas R&D facilities) or being a headquarter of a MNC helps induce global innovation networks.

There are examples of well functioning alliances (i.e. TD Industry Alliance) covering all parts of the value chain and including domestic large firms, SMEs, foreign MNEs, universities and research institutes. Such an alliance can be regarded as part of GIN and many members are both rivals and partners in domestic markets or international markets (Lv and Liu, 2011).

Due to huge market size, increasingly mature customer group and low cost but a qualified talent pool in China, there are strong linkages between firms and Chinese national innovation system (NIS). MNCs seems in general to be more embedded in GIN than stand alone companies, however, the embeddedness in NIS (formed by national and regional policies, dependent on the organisational form of the company) are all factors that form the potential of

[8] Bartlett, C.A. and S. Ghoshal (1990), Managing innovation in the transnational corporation, In C.A.Bartlett, Y. Doz and G.Hedlund (eds), Managing the Global Firm, London: Routledge, pp. 215-55.

GIN formation. It seems that when a firm has broad innovation networks and linkages *in* China, the propensity to be part of GIN is higher, supporting.

INDIA

India is already known as a location with abundant supply of manpower at relatively low cost, a key factor in determining the in-shoring decision of firms. Motivations for offshoring of production are much stronger than Offshoring of R&D, and knowledge and skill related factors are important motivations for offshoring. While offshoring is much less prevalent incase of standalone companies in India, the subsidiaries and head quarters are increasingly engaged in offshoring.

Indian ICT firms seem to be more inward oriented when it comes to innovation, suggesting high cumulativeness and a strategy for knowledge development at the level of the firm that lower the propensity to engage in collaboration network outside the boundaries of the firm, and therein GIN. Regardless of the activities considered, more than 75 percent of the firms claimed that they conducted their functions internally (Joseph and Abraham, 2011). Those firms that delegate functions of the firms to others are mostly MNC subsidiaries or headquarters, and the functions have been delegated with preference for subsidiaries in developing world rather than the developed world. However, when it comes to delegation of technology and process development functions the developed country subsidiaries were preferred to developing world subsidiaries. Again it seems that the local stand alone firms are not embedded with the GINs while it takes place in case of MNCs. When the largest share of firms are stand alone companies that have few external linkages indicate an innovation system that is unconnected to global innovation networks. The linkages that are seen are mostly very formalized linkages showing structured networks. The lack of informal linkages with global actors can suggest that the actors loose out on relevant knowledge that can generate innovation activities. There is this dichotomous situation where either firm's have formal structured linkages or they do not have linkages at all, suggesting a weakly embedded network relation among actors in the GINs.

Barriers to such formal innovation linkages are many, and approximately 70 percent of the Indian MNC head quarter firms agreed that there were serious barriers to internationalization (Joseph and Abraham, 2011). possibly associated with little experience in international collaborations for innovation and in functioning as global MNCs. Barriers emphasizes by MNC headquarters in India was the cost of changing the current location of operations and the ensuing costs was an extreme barrier to international collaborations. Other factors of relevance are a general lack of resources (such as venture capital) that firms from India must deal with when attempting to grow and globalize. While stand alone firms do not make global interactions, and hence have limited barriers to global interactions, MNC subsidiaries' need for collaborations is also very limited and restricted to their parent firms (Joseph and Abraham, 2011).

Summing up context of GIN formation in the SOUTH

The general ICT firm in India and China are also heavily oriented towards internal knowledge development, and linkages to the international knowledge structures are rare suggesting that most linkages are value chain interactions, both nationally and internationally.

Motivations to offshoring seem to be linked to access to markets, knowledge infrastructure and services, showing both home-base augmenting and home-base exploiting strategies (Kuemmerle, 1999). In general, offshoring is not a major agenda of Indian and Chinese ICT firms, a fact that needs to be viewed against that these countries has abundant supply of skilled manpower at a low cost. Nonetheless, there are significant differencesacross firms in that standalone firms hardly engage in offshoring, but subsidiaries and headquarters of MNC do.

R&D centres are also being established abroad. An explanation to these differences between "South" and North" might be that a larger share of firms in the developing countries in the survey is part of MNC, either as headquarters or as subsidiaries.

The general finding is that the local stand alone firms are not embedded in GINs while MNCs are, this applies for both Northern and Southern firms. The global linkages found are mostly vertical linkages into foreign markets; however, there are also signs among the global players such as MNC that knowledge linkages are also becoming important from the South. An emerging strategy of "reverse offshoring" can be detected in which firms headquartered in countries from the south that earlier has been offshore service providers, open offices in home countries of their customers (such as Infosys, Wipro and Tata consulting)(Bunyaratavej et al. (2011)). This can be seen as a new and emerging strategy of sourcing from emerging economies (op.cit.).

1.4 GIN barriers and policy implications

NORTH

Norway

In parts of the ICT sector, modularity, standardisation and generic codes for communicating technical knowledge are highly present; nevertheless, this seems not to be sufficient for ICT industry firms to overcome challenges of coordination and communication in GINs.

ICT firms still experience problems with respect to identifying relevant knowledge on a global scale. Yet, once firms have internationalised, they gain access to much more diverse information and knowledge. They are then forced to work actively with establishing the internal communication channels which are necessary to diffuse this across locations. Those who (due to necessary absorptive capacity and financial strength) manage to overcome these challenges of search, internationalisation and subsequent integration are amply rewarded with innovation inputs. Particular strongholds, such as integrative skills, closeness to lead markets,

R&D activity and innovativeness seems still to remain being in the HQ of the enterprise group.

The most important localization factors at play in supporting the ICT industry is a) access to competent labor (and thus knowledge developed by other ICT or non-ICT sector firms), and b) the demand base. In addition, firms in the sector point to c) funding constraints, which are likely to influence not only their innovation activity in Norway but also their ability to internationalize. Consequently, policy can support innovation through education effort. The government can also directly influence the demand drive so important in the sector by acting as a lead customer; and indirectly by means of regulation. However, as such efforts serve to 'contain' the sector at home, it is important that complementary policies seek to support the internationalization of the industry.

Sweden

Changing the current location and related costs as well as difficulties managing globally dispersed projects are considered to be important innovation collaboration barriers for ICT firms. In the cases also other barriers where discussed such as culture distance and by time differences in the different zones. Functions that require tacit knowledge and experience are difficult to globalize, suggesting that globalization depend on the type of activities carried out in the firm, and the decision to coordinate projects from the HQ or delegate it to the subsidiary depends on the nature of the innovation. In some of the firms interviewed, there also seemed to be a diversification of tasks being performed in Sweden, and the ones taking part in the subsidiaries. If an idea is small and incremental like changing the design of a product then the decisions on how to proceed with the production is made at a local level by the expert committees. However the larger and more radical technological ideas where sent to the product council in Sweden where the product development decisions were made.

One of the factors that impacts more positively on the internationalization of innovation activities is the qualification of human resources. On the other side, the factors affecting negatively are almost all related to the higher costs of internationalization (availability of risk capital and economic support) and, in the case of ICT, the lack of stronger IPR regulations or enforcement or, even more important, the harmonization of different regulations and standards, as the cases show. One of the cases indicated that what was important at policy level is the harmonization of different regulations at international level (like, for example standardization or radio frequencies in different part of the world).

Estonia

Attempts to internationalise its economic system have been since the early 1990s mostly related to the attraction of foreign capital and foreign direct investments, resulting with entrance into the GPN. Estonia's integration into the GINs has to do with the upgrading of the competititive advantages of the Estonian firms, and moving up in the value chain from basic assembly or systems integration to more demanding business functions (Kalvet and Tiits, 2011).

A variety of instruments are in place that support excellence in ICT R&D in Estonia, including both the national Centres of Excellence and Competence Centres programme, but also the generally competitive R&D funding system in Estonia, which prioritises high quality research. The interaction between academia and industry remains still weak and relatively random; only a limited number of local key players are very well integrated with GIN. The primary weaknesses derive from the existing low number of R&D personnel and the weakness of the supply of additional qualified ICT specialists (both in terms of quantity and quality; see also Kattel and Kalvet, 2006). A number of the ICT R&D units have insufficient international technology and business management skills to advance their position in international R&D and innovation networks, and to manage (and co-ordinate) R&D projects. Closer ICT R&D and business co-operation with the neighbouring countries in Baltic Sea Region would prove beneficial, in particular, linkages with Nordic countries could be more actively used by Estonian researchers and entrepreneurs as a gateway that allows for joint access to far away markets, e.g. the Americas, Asia, etc.

In more established fields of ICT, international supply and R&D networks have been already formed around bigger players (MNC) quite some time ago. Now, with the increasing concentration of the ICT industry the barriers to entry continue to mount, giving room only for actors with specialised advantages, the limited existence of Estonian entities with such characteristics remain in this context a considerable threat for prospective GIN formation in Estonian ICT industry.

Estonian ICT industry lacks critical mass and perceives great barriers to entry in the global innovation networks. In order to enter into GIN, the sector must build specialised knowledge or technology in order to become attractive partners or to sites for R&D, linking it to the need to strengthen supply of qualified labour and the related public knowledge base, i.e., public education and research system in the field of ICT RTD in Estonia. A large number of separate support instruments (e.g., Target Funding, Estonian Science Foundation grants, infrastructure and mobility grants, various smaller contracts, etc.) enforces the fragmentation of the public RTD base even further.9 Efforts aiming at the increase in opportunities for international mobility have clearly been very beneficial both in terms of strengthening the local knowledge base and expanding professional networks internationally. At the firm level, managers are in need of international business and technology management skills.

Summing up GIN barriers and policy implications NORTH

Challenges related to coordination and communication of innovation relevant knowledge across boundaries is a problem for both small independent firms and for MNCs. The lack of ability to overcome challenges related to absorptive capacity and organisational structure able to recognise, use and integrate external knowledge will prevent firms to access innovation

[9] As a rather drastic illustration of fact, one of representatives of a major public RTD organisation indicated during the interview that the ratio of funding contracts to researchers is in his organisation currently 1:1. Obviously, such a fragmentation not only reduces significantly the productivity of researchers, but leads also to unnecessarily high administrative load in handling a very high number of contracts.

relevant knowledge at the global scale. These barriers will affect their potentials to advance their position in international R&D and innovation networks.

An adequate competence base seems to be of great importance for the working of the ICT sector, suggesting that a well functioning educational system and mobility of newly educated and experienced employees are important. One the other hand, the innovation dynamics of the ICT sector is dependent on interaction with users in many domains, demanding customers and lead users will be equally important. The interdependence between the internal knowledge base of the employees together with localised demanding customers would create dynamic clusters with strengths that could link to international innovation networks and partners.

Internationalisation of the ICT sector has been constrained by lack of ICT specialists both in terms of quantity and quality, suggesting that certain sectors need to go abroad in order to find specialist knowledge as small economies such as Sweden, Norway and Estonia cannot provide what is needed. Given that the knowledge pool needed is provided globally, incentives and knowledge to access these pools of knowledge seems to be important, but at the same time building regional capacity.

As discussed earlier, many facets of the ICT industry is based on more tacit knowledge hard to globalise, so at the firm level the decision to globalise is much linked to the type of activity and the nature of innovation that the firm engage in, and of course the general firms strategy on where to perform knowledge intensive activities (in headquarters or subsidiaries).

Internationalisation is also dependent on the possibility to actually protect your knowledge or innovations, the appropriability regime that you are part of. So the greater possibility to use IPR regulations or enforcement, the potential for internationalisation will rise. At the international level harmonization of standards and regulation within sectors could also help cross border activity.

SOUTH

China

The implementation of a more liberal “attracting-in” policy led to a sharp rise in FDI in many sectors, and ICT sector also included, promoting an embeddedness of Chinese ICT sector into GPN and slowly also indications of global innovation networks. The “walking-out” policies in the past thirty years in China have promoted a group of domestic firms emerge to be important players in global ICT market. The two-way penetration of inward FDI and outward FDI is one of the main drivers of GIN formation of Chinese ICT sector.

In China the impact from the financial crisis was felt differently among the interviewed firms, ranging from “little if any impact”, to “increase in outsourcing motivated by lower costs” and in form of weaker consumer demand and that larger projects have been postponed. Among the surveyed firms, it seems that the financial crisis will have a significant impact on the GIN formation of the sector, or the ICT firms' innovation activities more broadly, since more than half the firms plan to increase innovation effort, and 10 per cent of firms plan to relocate innovative activities from abroad.

According to (Lv and Liu, 2011) Chinese ICT firms experience problems with respect to identifying relevant knowledge on a global scale, and managing globally dispersed projects. Further, Pv and Liu (2011) has summarized these main challenges at the industry level, and thus issues for policy. Firstly, to create a friendly innovation environment, especially strengthening IPR regulation or enforcement. Although the government haven taken measures to strengthen IPR protection, the problem of piracy in China remains serious. The problem of weak local institutional settings giving weak IP regimes is difficult to remove in short-term in developing countries. Secondly, to change the pattern of labour cultivation, as the availability of qualifications in the labour market is still a problem of ICT sector. Many firms point out that they have to give extensive training to fresh graduates. Policy can intervene in the industry – academia cooperation, not only attaching importance to the research system, but also the educational system to provide more qualified labour in the ICT fields. Thirdly, although a few Chinese MNCs have been rising in the world market, but in general they remain small in size. Few domestic firms are capable of controlling China's own export and innovation networks or developing competitive technological sources. Therefore, more competitive domestic firms should be cultivated and the competitiveness of domestic firms should be improved. Challenges perceived by individual firms are some different between domestic firms and foreign MNEs in China. Chinese firms are still not good at international capital leveraging, such as lack of experiences in overseas merger and acquisitions, and inter-disciplinary management talents engaged in international operation. Many foreign MNEs are worried about the fast learning or imitation capability of Chinese firms, and some have developed a positive attitude, that the best way is continuous innovation to develop faster than Chinese firms.

India

Public policy has played a key role in the emergence, growth and structural transformation of India's IT sector and have made available not only a large pool of skilled manpower but also an array of institutions that helped the development of the IT sector (Joseph and Abraham , 2011). The use of satellite links for data communication by TI's development centre in Bangalore in 1987 also served to demonstrate to the government the critical importance of providing satellite data communication links for software exports from India. Hence, the government started to provide the high-speed communication links in the Software Technology Parks (STP).

The share of foreign affiliates in the service sector increased from 12 per cent in 1991 to nearly 46 per cent in 2001. One could infer that the liberalized policies were highly successful in attracting foreign direct investment into the emerging areas of service sector in the country (Joseph and Abraham , 2011).

The financial crises seem to have relatively little effect on innovation strategies among the surveyed firms, a general finding is that MNC headquarters strategies differ from MNC subsidiaries and stand alone firms. A relatively low proportion of MNC headquarters intend to increase innovative activities a large proportion of them consider re-location abroad also as a strategic option to address financial crisis (Joseph and Abraham, 2011).

Even though public policy has had an important role in building the ICT industry in India (especially linked to manpower and infrastructure), there are still a wide range of constraints that are being confronted by the firms. From the INGINEUS survey it is stated that a majority of firms regard public incentives, economic support and intervention for generating skilled labour force as important for enhancing innovation activity in the future. Development IPR related issues are also considered an important area for policy attention, as well as policy interventions towards strengthening universities and public research laboratories.

As most of the operating firms in India are stand alone companies, we might suggest that they follow the same patterns as stand alone companies in the survey. According to this, they are less innovative, have limited R&D orientation, is less in interaction with the knowledge infrastructure and are mostly oriented towards a domestic market that probably are less demanding than the markets MNC are oriented towards. The firms are competing for the same skilled manpower as the MNC, suggesting a stronger competition in the years to come. A greater penetration of IT in general in the Indian economy might lead to a more demanding national market, which again can wok as an inducement mechanism for the emergence of an innovative IT sector that might induce firms to join GIN (Joseph and Abraham, 2011).

Summing up GIN barriers and policy implications SOUTH

Establish appropriate coordination and communication mechanisms to facilitate knowledge flow at intra-firm level and firm-GIN level is a challenge also among ICT firms in China and India. Further, the working of IPR regime can be seen as a barrier for both the inflow and outflow of GIN, suggesting both a focus on the legal and formal aspects as well as the more informal and moral consciousness among employees.

Firms in the South do also report lack of qualified ICT personnel as a problem, suggesting a need to adapt and change the educational system. A continuous effort to strengthen universities and public research laboratories is important, and working towards strengthening the interaction between firms and the knowledge infrastructure should be important policy tools.

Building innovation capacity among indigenous firms in general seems to be important among firms in South, as our empirical data shows that the general level of innovation and R&D is low among the firms. ICT firms in general need to improve their own technological upgrading and take more active part in networking activities in order to gain new knowledge, eventually through GIN.

1.5 Conclusions – implications per sector for EU countries (North; Norway, Sweden, Estonia) and emerging economies (South; India, China)

In general, it is expected that GINs will develop more extensively in fields where knowledge is more readily codified (software) in a commonly accepted (scientific) language. Our findings from the ICT sector do not necessarily support this on a general level, but when looking at specific ICT categories and looking at MNC in the fields of ICT, GIN patterns can be found. Certain parts of the ICT sector in EU and in emerging countries are able to engage

in both endogenous learning within territorial systems and engage in external linkages (see Bathelt et al. 2004, Herstad et al., 2010). A question is then, have there been changes in the gravitation points with regard to where innovation related knowledge is generated?

Looking at the ICT sector at a global level, it do seem that there is a change in the gravitation and accumulation nodes within these networks as firms in the South both have larger shares of export and now have MNC originating from the South, however, lead users, demanding customers and major knowledge hubs still seems to be in the North (especially North America) and one can suggest that this is where major developments within the industry arise and where decisions are made.

Conclusions Northern firms – implications

The study of ICT firms in the North (defined here as Norway, Sweden and Estonia) show that the average ICT firm are small, innovative stand-alone companies heavily embedded in regional or national user-producer relationships – often in proximity to lead users in other sectors representing important regional or national clusters. The firms are domestically owned, with high internally oriented innovation activity and the most knowledge intensive activities and the integration and coordination of activities are rooted in dynamic regions of these small open economies.

For the largest player, with headquarter in the analysed countries, knowledge intensive and technological inputs are produced in-house in proximity to MNC HQ and in collaboration with subsidiaries, further out in the innovation process inputs from external partners are important. “The core has been developed in Sweden while incremental improvements of the innovation (implementation of the idea) came from the different subsidiaries (e.g. in Europe and partly also in China)”. Other cases report to have sales presence in proximity to customers, but R&D subsidiaries in selected context (mostly in Europe) with a strong emphasis on internal communication in the MNC and on the ‘socialization’ of employees into corporate routines and ‘tacit’ components of the knowledge base.

Most innovations are incremental stemming from new market structures, new business models and new services. In general these firms have few external partners when collaborating for innovation besides customer and suppliers, mainly in own region, own country or with other Western European countries. Most innovations are developed in collaboration with domestic customers, showing that the research collaboration network of ICT firms is rather contended geographically. The sector is relatively R&D intensive in Norway and Sweden, and the Swedish ICT sector is oriented towards more radical innovations (16% of ICT firms report to have introduced new to the world innovations) and locates some of the most strategic global players within ICT with MNC subsidiaries in both Norway and Estonia. In order to develop a dynamic ICT sector depends on (among other things) availability of highly skilled people, research facilities, demanding customers and lead users. Innovation in ICT seems to be a combination of technology push and market pull. ICT firms in the South do to a larger extent engage in innovation collaboration with clients, suppliers and competitors in North and South America, suggesting a further reach of Southern ICT firms’ global innovation linkages, possibly driven by MNC subsidiaries.

ICT as a generic field represents a large share of R&D activity in also other sectors. This means that the development and innovation activity that takes place within the ICT industry is intervowen with technology development in other industries as well, suggesting that the technological opportunities and the propensity to innovate lies in the user-producer linkages that are found, and as we see most of them are regional or domestic. In many ways Northern firms serves to 'bridge' a set of technological opportunities which are already in place, in existing or arising markets. This means that GIN formation in ICT is constrained by demanding customers and knowledge externalities from ICT conducted in other sectors.

Certain kinds of transaction intensive services have become commoditized (i.e., back-office functions and call centres)(Duke University ORN & BOOZ, 2007; Hejiman et al., 2008; Lewin et al., 2009, Bunyaratavej et al., 2011), explaining the general rise in offshoring of lower end software services to Southern countries by both small firms and firms that have not internationalised earlier. Nonetheless, very few Northern firms offshore innovation or production, when they do, qualified human capital and specialized knowledge is the motivation, supporting research showing a shift from offshoring being driven by labor costs, to offshoring being a strategy to search for talent (Lewin, et al. 2009). The case studies show that factors driving these strategies are both due to a lack of people with relevant skills regionally, as well as the current cost of relevant talent regionally showing a mixed motive for searching abroad.

The scarcity of European nationals studying science and engineering has reduced the number of qualified personnel available to be employed (Lewin et al., 2009). The global search for new talent can be looked upon as signs that more advanced services are being offshored, however, our data do not support that the majority of firms offshore knowledge intensive activities. However, the cases show that Northern MNC do locate innovation centres around the world to tap into specific competences. These strategies can also create pressures to drive new types of both firms and services to engage in both new kinds of offshoring as well as more innovation related searching and collaborating with global players.

The challenges perceived in general by the surveyed firms are linked to develop an organization and to develop knowledge capabilities able to manage geographically dispersed innovation activities as well as the costs are considered to be important barriers to GIN. Many of the ICT firms are small and have limited resources, information systems and web-based collaborative technologies can help in coordinating globally dispersed high-value activities (Massini and Miozzo, 2010).The challenges of actually identifying relevant knowledge on a global scale are important barriers for small domestically oriented firms. In order to be attractive partners in GIN there is a need for greater specialisation and gradual upgrading of the value chain relationships, process that needs to be carried out at the regional level.

The main conclusion is that integration into GINs remains modest among the Northern countries. This is especially so for indigenous firms, suggesting that MNC not only can be gateways for export and import relations, but also for more knowledge intensive linkages leading to potential GIN. There are cases showing that MNCs tend to orchestrate the GPN/ GIN at the global level, while the smaller (often domestically owned) firms continue to operate predominantly at the regional/national level.

The ICT industry is heterogeneous and do seem to consist of two distinct components which are complementary to each other at the level of the firm: a codified platform and a tacit firm-specific, knowledge. From the above analysis it seems that most of the firms are based on knowledge which is sticky and contextual, and from that has comparably weak linkages to global innovation networks. This is partly due the mentioned knowledge conditions, combined with strong opportunities for innovation in domestic markets and an apparent inability overcome the initial barriers to internationalization. To some extent, this reflects the immaturity of a sector which as expanded very rapidly during the last 15 years, based on such domestic opportunity conditions. Once these barriers have been overcome and subsequent coordination and organization challenges have been met; ICT firms are able to link up to and capitalize on the wide range of external information and knowledge inputs which then become available. This results in the polarization of the sector which we can observe at present.

In order for Northern ICT firms to take part in GIN their activities must be in line with global standards in the ICT sector. A policy implication of this for EU will be the need to speed the ICT standardisation process in order to create not only European technology standards but lobby for global standards. Removing the barriers of incoherence in standards will make space for general innovations in this sector no matter where they are done. As have been documented in this report, there are many firms in the sector that are small, stand alone companies, sticky to the context. Harmonization of ICT standards will make it possible for all firms to gain in the global flow of knowledge and people. The interdependencies that can be seen between ICT sector and other sectors make it important for policy makers to see the overall effect GIN at the national or sectoral level.

Conclusions Southern firms – implications

The average ICT company in the South is also a small, stand-alone company showing low shares of R&D and innovation. These firms have few external linkages in general, and hardly any foreign external linkages. The ICT industry has been one of the fastest growing industries in China and India the past decades. The ICT sectors have emerged as an export industry and the nature of ICT activities first initiated was driven by exogenous factors/demand. China is the world's largest ICT exporter, however, dominated by subsidiaries of foreign MNCs (top 4 from Taiwan, the fifth NOKIA). In China, 80% of export from high tech products derives from ICT. In India, 16% of total export comes from the ICT sector. Both countries show great advances in sub-fields of the IT sector, and clusters have developed in these countries build upon function based rather than industry based activities (Massini and Miozzo, 2011).

The development of the ICT sector have been possible through a large pool of skilled workers, rapid development of technological capability and technology standards, splitting up of value chains and with opportunity conditions in both domestic and international markets.

The large share of export of products suggests that much of what is produced in the sector in the South is oriented in to mass markets. The 'development' of the products/services necessitates regular interaction with lead users. The lack of proximity to lead users and demanding and advanced customers is a challenge with regard to making the industry more innovative and knowledge intensive. There are examples of firms and sub activities of ICT

moving into emerging value adding innovation partnerships – mostly through MNC subsidiaries or MNC headquarters. There is a need to develop more innovation oriented expertise in the indigenous ICT firms in the South, as they are the least nationally and internationally embedded. In the South as well as in the North, there seems to be a polarization of the industry between small indigenous locally oriented firms and larger global MNCs. For the indigenous firms to grow beyond the entrepreneurial stage it is necessary to either develop a larger organizationally embedded knowledge base and set of complementary capabilities, or source these from large firms holding them, meaning a stronger relationship between MNCs and indigenous firms. Further, the survey results show that a relatively high share of firms from developing countries undertake strategic management, product development and corporate governance in developed countries, suggesting an offshoring strategy driven by the need for proximity to markets.

ICT do not follow in the paths of more traditional manufacturing activities that often have developed sequential internationalisation of manufacturing (Levy, 2005) and GPN. The ICT sector and services in general shows the low capital intensity and electronic form of delivery meaning that services offshoring can grow and relocate faster (Dossani and Kenney, 2004), and as such enter straight into GIN. The activities in the ICT sector are heterogeneous, as mentioned earlier, computer programming and consultancy can probably relocate faster than manufacturing of computers, giving a more nuanced picture of the ease to which such activities can relocate.

Both countries have large increase in employment in the ICT sector. The last years there have been several examples of Southern firms that have taken over global ICT players, enhancing Southern firms' credibility in the world market for ICT. In China, none of the MNCs are listed in the top world top 250 firm classifications. In India there has been a rise of the MNC headquartered in India, a trend that is seen as atypical compared to other dominant sectors in the country. As mentioned earlier, an emerging strategy of "reverse offshoring" can be detected among firms headquartered in the South, who have created extensive operations, have opened offices and actively recruit in home countries of their customers (Bunyaratavej et al. 2011). This can be seen as a new and emerging strategy of sourcing by emerging economies (op.cit.).

In both countries the sector is regionally concentrated and large parts of sales are domestic. However, in parts of the Indian software and software services the larger share of what is produced in the country is exported, confirming that many of the indigenous ICT firms have been created as a response to organisational functions outsourced from the North, and as such replacing these activities to the South. As such opportunity conditions can be seen in the recent wave of outsourcing/offshoring, and even though China and India show an upgrading in the provision of skilled services, they face a "moving target" competing with firms in developed countries producing specialised and new types of services (Massini and Miozzo, 2011), in proximity to lead users.

Offshoring knowledge intensive activities come with a risk in countries with weak local institutional settings and weak IP regimes. Research show that northern firms are less likely to offshore sensitive or volatile services categories. Further, MNC subsidiaries in countries where IP is weak tend to have strong links between subsidiaries and headquarters as substitute for inadequate formal IP (Ellram, 2008; Zhao, 2006). These are factors that affects the

potential regional spillovers of MNC location, and support the notion one necessarily do not learn more "by having strangers visit" (Ebersberger and Herstad 2011; van Pottelsberghe de la Potterie and Lichtenberg, 2001). On the other hand, "going abroad" or globally dispersed companies may not "bring back" knowledge to home countries either but redeploy it to other internal operations or external affiliates (Zaheer et al., 2009 in Bunyaratavej et al., 2011). The problem of weak local institutional settings giving weak IP regimes is difficult to remove in short-term in developing countries.

Public policy has played a key role in the development of the ICT sector with a diversified set of policy tools that have helped in both "attracting in" global ICT firms, as well as helping indigenous firms "out". There has also been massive infrastructure investments and policies directed towards increasing the supply of S&T graduates. Further, both national policies and tax incentives designed to 'reverse' the brain drain from developed countries, together with infrastructures and institutions, has resulted in virtuous cycles that have and will make these destinations even more attractive (Massini and Miozzo, 2010). Active policy directed towards attracting in and helping firms out, together with the cluster initiatives and building of regionally concentrated hubs, together with educational policy has created a world leading sector in China and India.

References

Aslesen, H.W. and S. Herstad, (2011). "WP 9 Country sector report: ICT in Norway". INGINEUS interim report.

Bathelt et al. (2004) Clusters and Knowledge: Local buzz, global pipelines and the process of knowledge formation Progress in Human Geography 28.

Bartlett, C.A. and S. Ghoshal (1990), Managing innovation in the transnational corporation, In C.A.Bartlett, Y. Doz and G.Hedlund (eds), Managing the Global Firm, London: Routledge, pp. 215-55.

Bloch, C; Ebersberger, B; Herstad, S; van de Velde, E (2009) External knowledge interfacing and technological regimes. Working paper.

Brusoni, S., Prencipe, A. and Pavitt, K. (2001). 'Knowledge specialisation, organisational coupling, and the boundaries of the firm: why firms know more than they make?'. *Administrative Science Quarterly*, **46**, 597-621.

Bunyaratavej, K., J. Doh, E. D. Hahn, A.Y. Lewin, S. Massini (2011) "Conceptual Issues in Services Offshoring Research: A Multidisciplinary Review". Group & Organization Management 36(1) 70–102.

Chaminade, C. (2011). "WP 9 Country sector report: ICT and automotives in Sweden". INGINEUS interim report.

Dossani, R. and Kenney, M. (2004). *The Next Wave of Globalization? Exploring the relocation of service provision to India*, Berkeley Roundtable on the International Economy Working Paper 156, September.University of California, Berkeley, CA.

Duke University Offshoring Research Network & Booz. (2007). *Offshoring 2.0: Contracting knowledge and innovation to expand global capabilities* (2007 Service Provider Survey Report). Durham, NC: Author.

Ebersberger, B., Herstad, S (2011). "Go abroad or have strangers visit? On organizational search spaces and local linkages". Journal of Economic Geography (2011) pp. 1–23

Ellram, L. M., Tate, W. L., & Billington, C. (2008). Offshore outsourcing of professional services: A transaction cost economics perspective. *Journal of Operations Management, 26*, 148-163.

Ernst, Dieter and Linsu Kim. (2002). "Global Production Networks, Knowledge Diffusion, and Local Capability Formation." *Research Policy* 31, 1417-1429.

Florida, R. (1997). 'The globalization of R & D: results of a survey of foreign-affiliated R&D laboratories in the USA'. *Research Policy*, **26**, 85-103.

Heijiman, T., Lewin, A. Y., Manning, S., Perm-Ajchariyawong, N., & Russell, J. (2008). *Offshoring reaches the C-Suite*. Durham, NC: Duke University & The Conference Board.

Herstad, S; Bloch, C; Ebersberger, B; van de Velde, E (2010). National innovation policy and global open innovation: Exploring trade-offs, balances and complementarities. *Science and Public Policy*, 37 (2), 113-124.

Joseph, K. J., (2004) 'Development of Enabling Policies for Trade and Investment in the IT Sector of the Greater Mekong Subregion', UNESCAP, 2004, http://www.unescap.org/tid/

projects/gms.asp.Joseph, K. and V. Abraham (2011). “WP 9 Country sector report: ICT in India”. INGINEUS interim report.

Kalvet, T. and M. Tiits (2011). “WP 9 Country sector report: ICT In Estonia”. INGINEUS interim report.

Kalvet, T., Pihl, T. and Tiits, M. (2002) *Analysis of the Estonian ICT Sector Innovation System: Executive Summary*, Archimedes Foundation, Tartu.

Kalvet, T. (Forthcoming 2012). Innovation: a factor explaining e-government success in Estonia. *Electronic Government, an International Journal*, 9(1).

Kattuman, P. and Iyer, K. (2003) "Human capital in the move up the value chain: the case of the Indian software and services industry." In Giovannetti, E., Kagami, M. and Tsuji, M. (eds.): *The Internet revolution: a global perspective.* Cambridge: Cambridge University Press, pp.162-179

Knell, M. Srholec, M (2008). Technological collaboration and foreign ownership across firms in Europe. Report, Innovation Watch-Systematic.

Kuemmerle, W. (1999). ‘The drivers of foreign direct investment into research and development: an empirical investigation’. *Journal of International Business Studies*, **30**, 1, 1-24.

Lewin A. Y., Perm Ajchariyawong N., Sappenfield D., & Aird C. (2009). *Is the global outsourcing industry in for a no-holds-barred competition?* (ORN & PwC Service Provider Survey Report). Durham, NC: Duke University.

Levy, D. (2005). ‘Offshoring in the new global political economy’. Journal of Management Studies, 42, 3, 685-693.

Lv, P. and X. Liu (2011). “WP 9 Country sector report: ICT in China”. INGINEUS interim report.

Malerba, F. (ed). 2004. Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe. Cambridge University Press

Massini, S. and M. Miozzo (2010). “Outsourcing and offshoring of business services: challenges to theory, management and geography of innovation”. Paper presented at the Conference ‘The role of business services for innovation, internationalisation and growth’, Italian Ministry of Industry and Research and Universities of Rome ‘La Sapienza’, Teramo, Camerino and Perugia, 2-3 December 2010, Rome.

OECD, IT Outlook, Paris, 2006.

Pavitt, K (1984) Patterns of Technical Change: Towards a Taxonomy and a Theory Research Policy 13, pp. 343

VINNOVA (2007). “Innovation and leading research”. http://www.vinnova.se/upload/EPiStorePDF/vi-08-08.pdf

Zaheer, S., Lamin, A., & Subramani, M. (2009). Cluster capabilities or ethnic ties? Location choice by foreign and domestic entrants in the services offshoring industry in India. *Journal of International Business Studies, 40*, 944-968.

Zhao, M. (2006). Conducting R&D in countries with weak intellectual property rights protection. *Management Science, 52*, 1185-1199

Appendix

Table 1: Summary; ICT in the "North"

	North		
	Norway	**Sweden**	**Estonia**
Descriptive	Innovative and a high share of product innovations. Mostly small and stand alone companies. Weak international orientation with high internally oriented innovation activity A very small number of large MNE actors show patterns which diverge distinctively from this.	ICT a strategic industry, 12% of industrial production and 15% of export. R&D intensive, innovative, small firms and most are stand alone firms. Mainly domestic sales, when export, mainly European markets.	ICT firms rather small, 52% have no export, the largest exporters are foreign owned. Most firms are domestically owned. Sector dominated by programming, consultancy and related activities and manufacture of communication equipment. Companies in the provision of telecommunications services are completely foreign owned. ICT manufacturing sector part of Nordic ICT cluster.
Spatial and sectoral contexts of GIN formation	ICT sector as a whole is heavily embedded in regional or national user-producer relationships. innovation in the ICT sector are stemming from new market structures, new business models and new services. Norwegian ICT sector consists of two distinct components, which are complementary to each other at the level of the firm: a codified platform and a tacit firm-specific, knowledge.	Innovative, with relatively high shares of new to the world innovations. Technological inputs produced in-house in proximity to MNC HQ and collaboration with subsidiaries, further out in the innovation process inputs from external partners are important.	Innovative firms dominated by process innovation, mostly incremental, low R&D intensity and few links with external partners.
Locations and internationalisation (actors and networks)	Domestic orientation towards customers. When offshoring, qualified human capital & specialized knowledge is emphasized. Highly dependent on skills available in labor markets, combined with proximity to important customers/markets.	Most linkages are at domestic level, the research collaboration network of ICT firms is rather contended geographically. MNC HQ shows a diverse and geographically dispersed research network. Little offshoring of production or innovation among firms.	Domestic orientation of firms, foreign linkages with Scandinavian and some other European countries from regional offices in Estonia. Little offshoring of R&D and innovation activities.MNC subsidiaries are not embedded in RIS/NIS.
GIN formation and policy implications	Geographical scope of the innovation collaboration network in the average	GINs being only marginal in the sector, when collaborating their research	Integration into GINs remains modest. Indigenous firms have

	Norwegian ICT firm is well below other sector averages. Challenges of coordination and communication in GINs. ICT firms still experience problems with respect to identifying relevant knowledge on a global scale. Most important localization factors at play in supporting the ICT industry is a) access to competent labor (and thus knowledge developed by other ICT or non-ICT sector firms), b) the demand base c) funding constraints	networks is wider in terms of variety of partners as well as global in character. Changing the current location and related costs as well as difficulties managing globally dispersed projects are considered to be important innovation collaboration barriers for ICT. Culture distance, time differences, nature of knowledge where face to face communication is crucial.	very few external linkages. Few examples of MNC HQ being able to link up with MNC sub and their GINs. MNC subsidiaries gateway for export/import relations. A need for greater specialisation and gradual upgrading of the value chain relationships. Must be complemented by applied research and product development, management of multi-site production and supporting facilities, global brand development and marketing.

Table 2 : Summary; ICT in the "South"

	South	
	China	**India**
Descriptive	World's largest IT exporter, large increase in employment, great advances in sub fields of the IT sector.	A leading player of export, and large scale takeover of foreign firms. The sector is regionally concentrated.
Spatial and sectoral contexts of GIN formation	Rapid development of technological capability and technology standard with opportunity conditions in both domestic and international markets. Clusters of IT firms, indigenous firms small	Sector emerged as an export industry. Growth made possible by large pool of skilled workers and splitting up of value chains. Nature of activities driven by exogenous factors leading to a specific diversification. ITES sector generates more broad based employment and is more employment intensive than the software sector. MNC headquarters and MNC subsidiaries the most innovative and externally linked.
Locations and internationalisation (actors and networks)	Offshoring motivated by market access and access to knowledge infrastructure and to be close to operators in developed countries. MNCs are regionally embedded and globally networked.	Survey shows a highly integrated global sector due to MNC subsidiaries and headquarters which engage in offshoring activities and take part in innovation collaboration.
GIN formation and policy implications	Most firms inward oriented innovation focus, international linkages in the ICT industry predominantly take the form of value chain interaction. MNC the broadest functional and spatial scopes of external interaction. External technology linkages driven by subsidiaries. More firms report forms of global R&D linkages than actual innovation collaboration. Firms experience problems of the usage of harmonising tools,	Most firms inward oriented innovation focus, weakly embedded in GIN. GIN mostly found among MNCs when measured as innovation collaboration. Barriers for internationalization related to costs of change of location and ensuing costs. Especially MNC headquarters perceive barriers to international collaboration. Stand alone firms must become more innovation driven in order to be seen as relevant innovation partners,

	identifying relevant knowledge on a global scale, and managing globally dispersed projects. Half the firms plan to increase innovation effort as result of financial crisis. Policy action in ICT: public economic support for innovation activities, more stringent IPR regulations or enforcement and availability of higher skills in the labour force. Competitive domestic firms should be cultivated and the competitiveness of domestic firms should be improved. “Attracting in” and “walking out” policy effective with regard to built up of industry. Relied on imported technology and FDI, but hi-tech exports (Office machinery & TV and radio communication equip.) in 30% of total export 2005.Open door policy 1978; WTO member 2001.Improved infrastructure. Aggressive S&T strategic plan for 2020 (OECD 2007). Active policy, MNC and FDI form GIN patters, showing a move up the value chain among Chinese firms. Indigenous firms still needs technological ugrading, tighter embeddeness in NIS in order to improve potential for GIN linkages.	possibly starting by linking to the regional knowledge structure in order to upgrade. MNC HQ have the potential but a GIN strategy is costly – suggesting policy incentives for globalization. Public policy has played a key role, 1986 import licensing policy for software; 1990s full financial liberalisation,1980s Higher Education policy increased supply of S&T graduates,1990s creation of Software Technology Parks of India to develop telecommunication infrastructure and low cost internet. Development of general infrastructure. Incentives for stand alone firms to link up with MNC headquarters? Policy to reduce barriers for innovation collaboration directed towards MNC HQ?

2. SYNTHESIS REPORT: AGRO-PROCESSING

The synthesis report on AGRO is compiled on the basis of 2 country sector reports 10.

Author: Eric Iversen (eric.iversen@nifu.no), Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP, participant no.10)

2.1 Introduction

An important aspect of the Sector Systems of Innovation framework is that sectoral boundaries are not assumed to be given or static. Instead, the approach recognizes that industrial sectors continually transform as systems. (Malerba, 2005: 67) Changes in supply-factors as well as in demand characteristics are both seen as important in driving this transformational process forward. As in the national systems perspective, the institutional landscape shapes the way in which the different actors participate in this process and ultimately drive it forward. The interaction between entities, both those mediated by the market as well as outside it, is integral to the way the sectoral system evolves.

This document consolidates the case-study work on the agro-food sector in this light. It is based on two country case-studies of agro-food processing in Denmark and South Africa which are attached11. These in turn complement the case-studies done on two other sectors (ICT and the automotive industry). However, it should be appreciated that that a two country sample provides a limited basis on which to draw implications about GIN pattern formation, about the way in which GIN formation are affected by contextual conditions. Still the contrast between the two cases may be helpful to point out some differences in emerging economies from that of the EU-context.

Mindful of the limitations, this short synthesis uses results of the survey as well as information taken from the reports. This exercise allows us to introduce the way the industries are laid out the two countries, as well as the degree to which they link internationally on the supply and demand sides, and the degree to which they are active in innovative processes. Although the material provides a limited basis to draw strong policy conclusions for the industry in different country contexts, it does help to suggest and highlight some policy dimensions. These will be explored here.

The synthesis report is arranged as follows. The next section starts the presentation by comparing different aspects of the survey results. This is followed by an introduction to the more contextualized information that is found in the individual country reports. We include a general description of the sectors. This is followed by a brief discussion of the question of i) spatial and sectoral contexts of GIN formation, of ii) patterns of opportunity/constraints on

[10] Stine Jessen Haakonsson, "WP 9 Country sector report: Agrofood in Denmark". Tashmia Ismail and Helena Barnard "WP 9 Country sector report: Agroprocessing in South Africa".
[11] The full-reports for Denmark and South Africa, as well as the comparison report.

innovation and types of innovation, as well as iii) of location and internationalization in each of the country context. At the end, we explore some of the institutions and policy issues suggested in the reports.

2.2 Survey comparison

Any attempt at providing an accurate picture of this diversified industry in these diverse country contexts faces major challenges. This section reports on a first attempt at a cross-country survey that was designed to collect information about GIN formation in this and two other industries. The questionnaire includes questions about innovation, about collaboration partners, about information sources used when innovating, about outsourcing, as well as other questions. Some of the responses are discussed in the country reports. In light of the picture above, a comparison of the cross-country survey provides a basis to further discuss the GIN formation in the agro-foods industry. However, there are several important limitations associated with it. These are important to any attempt to generalize from these results. This section first notes these limitations. It then presents a comparison of some of the results on a set of GIN indicators.

2.3 Survey limitations

The first limitation is that the two countries are not necessarily representative of the industry as a whole it. Although each is remarkable representatives in a North-South perspective, they remain individual countries and as such they do not necessarily represent the state of agro-food industries today or for the way that GIN formation takes place in.

A further limitation is that it was not possible to achieve a complete and systematic survey of the agro-foods industry in the country contexts under study. The targeted populations were different in the countries, sampling was not done in the same way, and response rates varied. In terms of comparison, attempts were made to include the same general population. Still, the more basic differences in sampling make comparison unreliable. In brief, the weaknesses preclude using the results from this first iteration of the survey alone as more than a glimpse at GIN practices. Although this empirical lens is faulty, it still provides an interesting and potentially rich snapshot of GIN formation in different contexts.

2.4 Survey characteristics

In brief, the survey sample is not adequate to generalize about differences in the sector in EU and non-EU countries. However, it does provide a snapshot of the sector—and, more patchily, its subsectors— at the country or regional level. A characteristic here is that a large majority of firms claim to be R&D active or to be ‘innovative’ in one way or another. The sample is thus of ‘innovative’ firms in the agro-foods-sector. Differences in the degree to which different types of firms are global, innovative, and networked can be indicated in such a snapshot.

Keeping its limitations in the mind, the survey provides the following types of information about the sector:

1.Information about the supply as well as demand factors in the innovation process.

a.In terms of inputs to innovation, it provides information on linkages to diverse set of actors in a range of different geographical markets. It distinguishes between functions carried out in-house, within the corporation or in conjunction with outside partners; it reports on outsourcing activities, both in terms of production and of innovation activities; and it reports on general types of search among different sources of information.

b.In terms of demand, it provides detailed information on geographical orientation of the firms markets

2.Detail about innovation including its form (product, service, process, market, organization) and degree (new to market or new to firm)

3.Information about Non-market relationships (sourcing and collaborative links)

4.Information about partnerships involving types of agents other than firms (domestically and abroad)

5.And Information in different geographical contexts.

A first step is to uncover inherent patterns in the GIN variables, some of which are strongly correlated. This is done using a tetrachoric factor analysis based on a set of dichotomous variables derived from the survey. The following types of variables are used to see which load with each other. This indicates that given variables tends to correlate with each other, which in turn indicates that they may be related (via a third variable).

The variables we investigate are:

1.Type of firm: if it is large (over 500 employees), if it is involved in manufacturing (see above), if it is a standalone company. A control is if it is located in Brazil (Land1)

2.Global orientation: if its main market is domestic, if it outsources either its production or innovation activities (Offshore);

3.Innovation active: if it reports R&D staff, and if it claims to have launched an innovation that is ‘new to the world’.

4.Networked: if it linked to international actors, if it reports R&D linkages.

Firms were asked about their main subsector. Their responses might help us distinguish between firms with different knowledge bases, different positions in the value-chain, etc. There were broadly two types of activities: process (e.g. “Processing and preserving of meat and production of meat products”) or manufacture (e.g. “Manufacture of dairy products”). These differences might be expected to explain how global, innovative and/or networked the firms were.

Table 3: Factor loadings for (principal factor method), rotated[12]

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
European country			-0,80		0,35
Formal R&D employment	0,47	0,47	0,49	0,28	0,24
Innovative_high novelty	0,26	0,35	-0,26		0,74
Manufacturer				0,61	0,59
Sourced_in house		0,86			0,21
MNC affiliate	0,81			0,38	0,20
Large firm	0,73				0,41
Main Market Domestic		0,47			0,74
international links	0,55	0,53			0,34
university links	0,76		0,47		0,19
Offshoring	0,88				0,15

Four types of factors account for virtually all (95%) covariance. This indicates that four unobserved factors can be identified that link the firm-level variables in different ways. Interestingly, whether the firm reports employing one or more R&D researchers is one variable that loads positively for all four factors. The first factor is not linked to either of the country environments per se. In this group, large MNC companies are associated with formal research activities (formal R&D employees) and with innovative activities (they report innovations that are new to the world). These variables line up with a tendency to have international links and to have links with universities in their innovation activities. The common factor that aligns these firms dominates the population, accounting for 45% of the variance.

The second most dominant factor complements the first. In this group, firms are also research active and innovative, and also report international links. The firms are again not associated with either country and, in this case, are not necessarily large firms nor affiliated to a MNC. The distinguishing element is the tendency to source technology in-house and to report their domestic market as being their main market. The contrast between the two factors indicates research intensive firms that are either MNC and outwardly oriented on the one hand or self-

[12] Rotated using the Kaiser normalized matrix. The Kaiser-Meyer-Olkin is over .5 (0.51) indicating that the relation between observed correlation to partial correlation coefficients of the sample is adequate for this analysis.

sourcing and domestically oriented on the other. These two factors, together, account for two-thirds of the variation.

The third and fourth factors account for most of the remainder. The third strongest factor loads very strongly with South Africa (i.e. negative for Europe). The loading for formal R&D activity is strongest in the context of this factor. In addition, linkages with universities are also strongly associated with this group. In contrast, however, the tendency to innovate ("new to the world") is in fact negative. The fourth group is associated with manufactures that are affiliated with MNCs in the agro-food space. They tend also to be research active. In general the third and fourth factors involve research active but non-innovative firms. The contrast between research activity and innovation activities is most clear in the factor that lines up with South Africa, whereas some aspects of manufacturing oriented firms is found in the fourth factor.

We now look more closely at the basic breakdowns associated with different dimensions of the agro-food firms. The type of firms—especially the question of whether they are associated with a MNC is focused on. In the first table we see that the MNC affiliation corresponds to the larger firms in the sample. Those that do not specify tend to be very small. The greatest number of firms however reports being stand-alone, with 240 employees on average. We note however that firm-size/company type does not influence the average number of export markets (about 0.8) or the tendency to report international sales (where about 40 percent of the firms).

Table 4 : Basic information of the international orientation of firms: ownership and average values for employees, proportion of firms claiming international sales, and average number of export markets

Company Type	N	Employees	International sales*	Export markets
unspecified	26	30,0	0,0	0,0
standalone	74	241,0	0,4	0,8
MNC affiliate	22	611,4	0,5	0,8
Total	122	322,8	0,4	0,6

Source. INGINEUS survey. Agro-foods sample.

The average number of functions that a firm reports is not different for standalone than for MNC affiliates: the big difference is with the small firms in the sample. However, the tendency for the firm to outsource functions—even most functions—is more strongly related to whether a firm is affiliated with a MNC. This also involves the tendency to offshore technological and/or innovation activities more generally. Here almost half of the MNC affiliates cited this as a dimension of their localization, while the same figure was less than 10 percent for standalone firms.

Table 5: Tendency of firms to involve outside actors: number of functions performed by the firm, the average percentage of functions outsourced, and the proportion of firms that 'offshore' production or innovation activities.

Company_Type	N	Functions	Functions outsourced	Firms that offshore activities
unspecified	26	1,4	0,0	0,0
standalone	74	11,0	0,1	0,1
MNC affiliate	22	10,9	0,2	0,5
Total	122	9,0	0,1	0,1

Source. INGINEUS survey. Agro-foods sample.

A last question involves difference between the innovativeness of the standalone firms in general from the MNC affiliates. Here the tendency for formal R&D activities is clearly related to firm size and the MNC affiliation. Half the larger MNC affiliates report being R&D active, with larger R&D teams in these cases.

Table 6 : R&D active firms in the agro-food sector, by firm-type, average number of R&D employees, and number of innovations reported in the previous 3 years

Company_Type	N	R&D Active	R&D Employees (mean)	Innovations (mean)
unspecified	26	0,0	0	0,3
standalone	74	0,3	4,0	7,6
MNC affiliate	22	0,5	10,7	7,3
Total	122	0,2	4,4	6,0

Source.. INGINEUS survey. Agro-foods sample

In sum, the picture we get from the survey gives us only limited leeway to interpret difference between the agro-food industry in the South (ie. in South Africa) and in the North (i.e. in Denmark). The factor analysis does indicate that the firms in the first country context tend to be (in the sample) more involved in formal R&D than the average but also less likely to report innovations that are 'new to the world'. The analysis indicates there are different archetypes among the firms. The major differences tend to be drawn along the lines of the ownership (and size) of the firms involved. Among the MNCs, there also tends to be a higher proportion of manufacturers among the MNCs and these tend to be different from the other firms. We should again note that these differences may be more a symptom of the sample rather than the overall population.

The snapshot reveals some differences between the firms in terms of how global (in terms of export markets, international sales, international links, etc), how innovative (formal R&D activities and the tendency to report successful innovations) and how networked (functions oursourced, offshoring). This snapshot provides the basis for the next sections to introduce

contextual information from the case studies conducted in the two countries. These in term will be further developed in the country papers that are attached.

2.5 Descriptions of the sectors in each country

There are many differences between South Africa and Denmark that make affect the degree of GIN development as well as its potential. Some generic aspects characterized by huge differences include country endowments, climate, extent of arable land, market proximity and access, labor and capital markets, etc. In addition, there is the question of the heritage of the sector in the country contexts and how developed the innovation system is in each.Some basic dimensions are introduced here.

Denmark

The Danish innovation system has its roots in an agrarian economy and still relies to some extent on agriculture and food-production. The agro-food industry is one of the most important sectors of the Danish economy where it is seen as core industry. Denmark is the third largest food cluster in the European Union (ECA 2010) measured in the number of people employed in the industry. The industry is characterized as innovative and export-oriented.

The Danish agro-food sector accounts for approximately 20% of Danish exports. Products are predominantly sold within Denmark and Europe (64 percent of sales). This reflects the nature of the product-markets, which are dominated by limited shelf lives and local or regional preferences. Competitiveness of the agro-food industry in Denmark is thought of as strongly related to innovation and increased research intensity leads to a higher degree of internationalization of the market.

The Danish agro-food sector is highly specialized within the areas of dairy, ingredients, beer and meat.13 The innovation system in the sector has grown out of the accumulation of knowledge domestically and a high concentration of network linkages. The industry is dominated by small and medium sized enterprises (SMEs) and very few large scale multinational companies (MNCs). The companies are internationalized but predominantly European. In terms of innovation, the industry has two main types of international companies. One is a set of very specialized companies with a high level of internationalization; the other one innovates in Denmark and sells abroad. Additionally, four universities and a number of research institutions interact with industry actors.

Cluster-formation involves collaboration across companies, industries, and public and private actors. The companies are embedded in their particular value chain and in the overall Danish

[13] In terms of products, the industry is involved in the development of and production of: processing and preserving of meat and production of meat products; processing and preserving of fish, crustaceans and mollusks; processing and preserving of fruit and vegetables; manufacture of vegetable and animal oils and fats, manufacture of dairy products; manufacture of grain mill products, starches and starch products; manufacture of bakery and farinaceous products; manufacture of other food products; and manufacture of prepared animal feeds.

agro-food innovation system. Government support has focused on 'clusters' in the agro-food industries and promoted research and life-long learning. Most of the networks in the agro-food sector involve Danish industrial actors. Few are international in scope.

South Africa

The South African agro-food sector is dominated by large-scale commercial producers who feed raw material into the agro-processing industry. The apartheid era left 87% of South Africa's farm land in the hands of its 13% white population. This resulted in a consolidation of the agro industry that still shapes the sector. An informal farming sector does exist with indigenous forms of innovation taking place. This however happens on a very small scale with little economic impact.

Food processing is a vital sector in the South African economy. Agriculture contributes about R36 billion (in 2007) to the national GDP; primary agriculture contributes 3% whilst the agro-processing sector contributes about 7% to GDP. The agro-food complex (inputs, primary production, processing) contributes approximately R124 billion to South Africa's GDP and employs 451 000 people in the formal sector (DTI, 2010). The agro-food sector— and larger MNC in particular— is concentrated in the Gauteng region where roughly half of the approximately 4 000 food processing companies currently operating in South Africa are based.

In terms of numbers the majority of firms in the agro-food sector sector tend to be smaller standalone firms with a national or domestic focus. In terms of turnover/revenue however we find that large scale producers dominate the industry. Of the firms with export markets we note that Western Europe is the most popular destination for South African produce. There are larger firms captured in the data, 22% of the INGINEUS sample are subsidiaries of multinationals, 17% of the firms were over 1000 employees and 21% of firms had between 250 and 999 employees.

The complementary SAIS (2005) survey shows that foreign firms (MNC subsidiaries) tend to be innovative with all the foreign firms in their survey falling into the innovative group. The overwhelming majority or 73% of the domestically focused firms are non-innovative. Therefore the size and international focus of the firm will likely have important implications for GIN formation.

A set of South African products are being developed which are seen as having high competitive potential. These include organics, essential oils, packaging, floriculture, medicinal plants, natural remedies and health foods. The potential of these products has led to global best practice knowledge to flow into this particular section of the industry.

2.6 Spatial and sectoral contexts of GIN formation

The agro-food sector is a diverse industry which involves multiple value chains. The agro-food industry is generally characterized as a traditional, relatively low tech industry which is largely oriented towards local markets. Processing often involves capital expenditure on property, plant and equipment. The agro-food industry tends to be strongly attached to

physical locations due to its geographical and climate-dependent nature. This combined with the perishable nature of its product pose a challenge to reaching international markets.

Innovation tends to be process related and originate in other sectors, for example those to enhance produce durability and lower transport costs. The innovative challenges and potentials are thus very different from that of the other sectors of the study. The difference is greatest in relation to the ICT industry which is much less dependent on local conditions and where competition dynamics are much different. While the cases of Denmark and SA illustrate some of these factors in the agro-food sector, they suggest there is potential for internationalization in certain areas.

2.7 Patterns of opportunity/constraints on innovation and types of innovation

Denmark

The majority of Danish agro-food companies are generally engaged in incremental innovation rather than new-to-the-world innovations. For one third of the companies these innovations are developed in-house or within their group, while two thirds innovate in collaboration with others. Hence, the industry is very strongly engaged in networks – within the Danish system.

The industry actively accesses and sources new technology. The further upstream specialized large companies are in the value chain, the more active they are in global innovation networks. On the other hand, companies with market oriented innovation strategies tend to be more locally connected to specialized research institutions. The agro-food industry appears to be going through a period of restructuring, based on changes in the transport sector, innovations related to conservation, and a tendency for companies to explore new tastes beyond their home markets. A large proportion of the recent break-through innovations made in the Danish food industry relate to providing ingredient and enzymes solutions for globalized customers.

While the Danish agro-food innovation system does show more traditional features of being supply driven and linked to localized production and networks, new tendencies are emerging in some specific technology areas of the industry. The Danish agro-food innovation system has co-evolved with the Danish innovation system, and today hosts five of the largest food related biotech companies in the world.

Following Kuemmerle (1999), the internationalization of innovation tends to involve one of two processes: either knowledge augmentation or knowledge exploitation. Hence, one group of Danish companies has become specialized in bio-technology. In this group, innovation is performed globally and there is a high degree of collaboration with a wide range of actors. This provides the scope for global breakthrough innovations in specialized niche markets.

The other group of companies focuses on the consumer-markets. This focus involves incremental innovations such as applying products to new markets either international (local tastes) or functional (the gourmet value chain, organics, and healthy foods). Innovation includes applying and developing technology from other technological fields such as robotics, preservation and packaging. These actors also engage in global innovation networks but more

with the aim of sourcing new raw materials or marketing their products in new markets. In sum, the Danish agro-food innovation system uses both the exploration and the exploitation model in pursuit of internationalizing innovation in the sector.

South Africa

The SA experience of opportunities and constraints with regard to innovation is somewhat different. Innovation in the agro-food industry is partly demand driven. It is shaped by 1) multinationals who have strict requirements that are used to promote and protect their brand; 2) from legislators; from export markets such as the EU with comprehensive sets of standards which suppliers must conform to. Innovation is also driven by the inherent nature of the product, which is its perishability. A large amount of innovation is concerned with either extending the sellable life of the product or with the distribution and logistics of transporting the goods to market before they become unusable.

Regulation of goods for export: Food products that are to be sold internationally (particularly in Europe) must also conform to comprehensive regulatory and legislative requirements because of the potential health impacts of edible goods. Stringent rules and quality control checks exist around produce exported into international markets. One of the largest of these export markets is Western Europe. Standards set in the EU have a significant impact on driving innovation in the agro sector to meet these international standards.

This means that the food processing industry is governed more strictly than the other sectors studied (Auto and ICT). Innovators must take into account legislators. This makes it important that the firm develops a greater awareness of and collaboration with institutions in order for innovation to be shaped by the demands of institutions. Among MNCs there is great emphasis on the protection of their brand demanding consistency in their supply and often having strict guidelines around composition. Meeting these demands and the competition amongst producers to be the supplier of choice for these lucrative MNC contracts is also a driver of innovation in this sector. Using the Pavitt typology (1984) a pattern of large scale producers and specialised suppliers dominates the landscape.

Localised research/innovation to ‘tailor’ products to local conditions or markets: As found in the Danish case, large Multinationals in this sector place are beginning to establish international sites for limited research and innovation activity. Danish multinational, Novozymes, is one such supplier of specialised goods which are enzymes, for use in multiple agro-food sector formulations and processes. R&D for Novozymes is however not carried out in South Africa. Some innovation does happen in Johannesburg, this is largely to localise the offerings for users in SA where for example the quality of flour used in the baking process is different. Temperature considerations may also require the adjustment of product to withstand the higher temperatures of African summers. Novozymes conduct their R&D in India, China, Denmark and the USA. The Johannesburg office is largely focused on sales into SA and Sub Saharan Africa.

For the reasons described above we observe that the bulk of innovation in the sector can be divided roughly into two main areas: 1.logistical and transport and 2. preserving and processing. This sector is also characterized by overlaps of technology development from

other sectors. Increasingly the agro sector adopts technologies to make processes more efficient and to raise quality standards. The biotechnology industry is an area where we note multiple overlapping innovations and technologies assimilated to make possible this sophisticated and complex area of innovation.

2.8 Locations and internationalization (actors and networks)

Denmark

The four companies represent two different types of internationalization of R&D: offshoring of innovation as a part of a knowledge augmenting strategy; and, internationalizing their markets, not their innovation activities. All four companies are strongly embedded in the Danish sectoral innovation system for agro-food. All four case-companies have strong relationships to university partners in Denmark as well as companies in their value chains. Companies I and II also collaborate with universities, among other places in the US, India and China. This is in specific specialized areas (surface grown enzymes, bio-fuel). Following, their innovation activities become geographically spread and localised into specialised units. Their Danish headquarters operate within all the different areas and coordinate the process. Two of the companies are engaged in the Agro Food Science Park: Company I and IV are very active and collaborate with local players in this cluster. For example company IV is involved with the full-package solution on ice-cream mentioned earlier.

The more high-tech (or bio-tech) - the more global: company I and II have strong collaboration and established R&D facilities globally. The correspondence between high-tech and internationalization is also found in the South African example. However, here it is incoming MNCs who are doing more of the biotech work.

The current financial environment is testing the sector in both contexts. In the context of the downturn, Danish multinational Novozymes has streamlined functions to save costs. Rather than replicating IT and finance functions across all its subsidiaries, the company has centralized these functions at a site in India. Both IT and finance could be easily handled over data channels. The company saved on human resource costs by cutting back on replicated staff globally and hiring Indian labour which was cheaper, abundant and of suitable standard. The results show little impact of the current financial crisis. None of the companies intend to relocate production or innovation, 14% of the companies consider increasing innovation while a small part of the companies in the survey consider reducing innovation activities. The same picture was found in the case companies. All of them reported increased R&D spending. All four case companies have positive prospects for the future as their business areas are within solutions to emerging problems: food crisis, longer shelf life for products, second generation bio-fuel etc.

South Africa

At each stage of the value chain and depending on the destination of the product, we find differing drivers for innovation and therefore different types of innovation occurring. The

report identifies four stylized factors (underlined below) which are crucial to firm's activities in the agro processing sector.

International market and processed product: All produce which is exported will be subject to rigorous controls on quality, safety and health. International markets are lucrative markets for the firm and firms are therefore driven to raise their standards and innovate toward achieving these international standards.

As this is a manufacturing heavy process, innovation on equipment occurs which is largely incremental and rarely 'new to the world'. These manufactured goods must however compete in a global arena. The South African wine industry is an example of an agro processing industry which has managed to compete in more developed international markets like the EU. Products going to the EU would have to match or supersede the quality, taste and experience of products manufactured in these international markets. This places importance on the 'recipe' or ingredients and marketing strategy used. Innovation can therefore be seen in the development of flavorings, nutrition and increasing the natural content of products especially in markets where health is valued such as the EU.

International market & fresh product: This group of firms is affected by considerations that are similar to the ones due to the standards of the international markets they export to. We see far more activity in this quadrant however as South African fresh produce is valued internationally for its variety and its seasonal difference with northern markets which require fresh produce during the long winter months. Innovation here involves the preservation of the fresh produce with preservative coatings which delay ripening, very precise and controlled storage facilities and well-structured cold chain logistics and transport.

Local fresh produce: This is the least demanding market but also carries the lowest returns. Consumers' demand for fresh produce necessitates the development of a good distribution network, logistics and transport capability.

Local processed market: This is a relatively competitive sector in South Africa with global firms like Nestle, Coca- Cola and Unilever competing with each other and with large local firms such as Tiger Brands. As this is a processed product which is manufacturing intensive we expect to see innovation in the machinery and manufacturing process which are largely incremental. Competition amongst brands for retail buyers involves the goods novelty, taste and the marketing strategy of the firm. A large amount of 'product innovation' occurs in this space locally.

In terms of outlook, South Africa was partly sheltered from the brunt of the financial crisis due to the strong regulatory control which prevented banks from extending reckless credit. GDP in 2008 did slump and began recovering mid-2009. Interestingly, the crisis spurred 37 % of firms in our SA sample to increase their innovation efforts whilst Danish firms reacted very differently. Here 44% of respondents reacted to the crisis with 'few or no changes' and only 5% would increase innovation efforts. This result implies that either SA was protected as suggested earlier or that the crisis saw firms wanting to take advantage of new opportunities in order to recover faster than their competitors post crisis. South African firms find it difficult to export processed product into the EU at present, which protects its markets with tariffs and trade barriers. As SA's trading links with China grow SA firms are expected to

target this market as Chinese food production increasingly fails to meet the local demand which sees China importing food from global destinations.

2.9 Concluding discussion

In general, we find a strong degree of sector embeddedness in Denmark's sectoral innovation system. Few companies engage in true GINs. Those that do, tend to be the large biotech related companies. In contrast, the SA agro-processing sector is tied firstly to a specific sub-national region (because of climactic requirements) and secondly, is a relatively inward-looking industry, with the proportion of firms exporting or engaging in innovation being below the national average. In this light we cannot characterize the agro-processing sector as heavily embedded in GINs. Only a few firms are global (or indeed innovative). However, those firms have to be very globally connected and innovative, partly because of international food and health regulations, and partly because of the perishability of the product. MNCs or small providers servicing MNCs are the main drivers of GINs in this industry, suggesting that GINs in this industry are evolving as part of an expansion from first exporting, then global production, and slowly, global innovation.

From the perspective of the South, the EU market is attractive. In order to gain access to it, SA firms need to follow EU regulation. This form of regulation drives innovation in these firms, as conformance means finding new ways to do things that will not only make their products available on the northern market but also attractive on it. In general Africa is an attractive and fertile source of agro-food products. South Africa provides a relatively stable and 'safe' political environment which helps to attract FDI and to encourage trading partners with firms in the North. One aspect of the institutional setup is employment legislation which, while contributing to stability also means that SA may be a relatively expensive place compared to other regional locations.

South Africa is an entry point into the rest of the African continent, and is trying to position itself as a regional hub to increase its attractiveness in a fast-growing region. The factors that are identified that can get in the way of better integration of organizations in SA with MNC and other international partners. These included a limited skill pool (especially a shortage of engineers and biochemists), relatively 'high costs of labor' and relatively small market size vis-à-vis BRIC countries. In addition, a sense of geographic 'isolation' was indicated to reduce integration of the local offices of MNCs.

Skills in the South: A major underlying factor of the limited skill pool is a crisis in SA educational system, according to the report's authors. Major investments in education have yet to lift all boats. SA still relies on a minority of schools (about 6 percent in white areas) to yield successful candidates in math and science. This situation limits the emerging cohorts of students who could build up the skills base and leaves universities playing a remedial role when they accept previously disadvantaged students. Firms have stepped in to improve skills, often to address immediate rather than long-term challenges. Firms have also grown to recognize and respect the contribution of universities. The authors observe a general consensus in industry that the single most useful policy intervention would be to strengthen the basic education system, widening the pipeline of skilled candidates.

The SA case indicates that skills in this industry tend to overlap with other industries, biotech in particular. This suggests that the sector might benefit from linkages to outside sources of knowledge, such as universities. However the report also indicates that the sector does not tend to source competencies from universities. Thus, this suggests potential to improve the development of competencies between firms in different sectors and/or better linkages with universities. Other policies to improve university-industry collaboration may also be useful. This is the case benefits of up-skilling may extend beyond the immediate application in the firm or indeed in the sector.

Market Access: The SA case also focuses on accessing outside markets for domestic produce. A number of challenges are identified in the report also in this regard. One involves quality and health standards. It is noted here that some EU standards can act as a barrier to SA imports especially if they do not address certain specificities (i.e. the case of traditional plants). If so, a challenge is to improve regulation in order to continue to provide a level-playing field also for novel types of products. On the other hand, the report notes that meeting standards set in the EU have a significant impact on driving innovation in the agro. South African firms have however built up an understanding of the EU rules, and even new exporters have a substantial body of peers they can ask for advice. A question is how this learning effect can be leveraged so that the firms can spend more time to innovate.

In relation, research and innovation policy has played a much more active role in the northern case. In Denmark, policy has explicitly prioritized increased innovation and research in this sector. Policy has actively supported the sector through education, through subsidies, and through programs to support clusters and to facilitate networking and innovation nationally. Policy initiatives have included opening an agro-food park. The overall policy aim is to lead innovation in the field while also increasing the competitiveness of the sector internationally. It also seeks to balance this with environmental objectives as well as to link the sector with tourism. One challenge it faces however is the limited supply of highly trained personnel domestically. It is thus trying to attract skill from abroad.

The overall aim of the work-package is to suggest appropriate sectoral policies to address such challenges/opportunities and to feed these back into the larger frame of the project. However, it should be appreciated that that the limited country samples provide a limited basis on which to draw implications about GIN pattern formation, about the way in which GIN formation are affected by contextual conditions. Still the contrast between the cases might be helpful to point out some differences in emerging economies from that of the EU-context. This document has attempted to consolidate findings from the country reports and to compare them.

3. SYNTHESIS REPORT: AUTOMOTIVE

The synthesis report on AUTO is compiled on the basis of 4 country reports[14].

Author: Eric Iversen (eric.iversen@nifu.no), Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP, participant no.10**)**

3.1 Introduction

The basic concept of an automobile's operation has remained unchanged for over a century. During its history, several periods of fundamental change have helped reorganized the industry. The creation of the global innovation network that characterizes the sector has been a central current in these changes. Today, new challenges suggest that the industry is again entering a period of pervasive reorganization and reorientation. One ingredient of the change is the move towards low-carbon propulsion systems, the other involves integrating BRIC markets. These changes are testing the GINs that have grown out of earlier periods of shock, such as the take up of flexible production and 'toyotaism' during the 1990s.

In this light it is important to get a better understanding of the auto sector in terms of the current and potential role of GINS. The four country studies that this document introduces provide a closer look at GIN formation from the perspective of the industry in Brazil, Italy, Germany and Sweden. These countries are host to large and diverse auto industries. In general, the auto industry has a very different history and different position in these country contexts, both in terms of its integration in the domestic innovation system and its position in the larger economy. However, there are common denominators that emerge across the different national contexts in terms of GIN formation. Understanding the similarities and differences may help the industry address emerging challenges.

This document consolidates findings from the country reports and compares them. The overall aim is to suggest appropriate sectoral policies to address such challenges/opportunities and to feed these back into the larger frame of the project. However, it should be appreciated that that the limited country samples provide a limited basis on which to draw implications about GIN pattern formation, about the way in which GIN formation are affected by contextual conditions. Still the contrast between the cases might be helpful to point out some differences in emerging economies from that of the EU-context.

This document first introduces background about the industry in each of the country contexts and how the empirical information was collected. It then presents a selection of GIN dimensions that were noted by national cases, focusing in particular on the role of ownership

[14] Eike W. Schamp. «WP 9 Country sector report: Automotive in Germany". INGINEUS interim report. Davide Castellani and Filippo Chiesa. «WP 9 Country sector report: Automotive in Italy". INGINEUS interim report. Gustavo Britto, Eduardo Albuquerque, Otávio Camargo. « WP 9 Country sector report: Automotive in Brazil". INGINEUS interim report. Chaminade, C. (2011). WP 9 Country sector report: ICT and automotive in Sweden. INGINEUS interim report.

and corporate organization on the one hand and on knowledge-bases and technological conditions on the other. In light of this contextual information, results from a preliminary cross-country survey are presented. The document ends with observations and implications about GIN formation in this sector.

3.2 The auto industry in four country contexts

The auto industry has long been a global industry. There are many changes that have taken place during its history that have influenced the way and the extent to which the industry is global. The organization of car production has undergone several fundamental shifts during its history. These shifts should be briefly introduced at the outset as they affect GIN formation. The first was the technical revolution of "fordism" in the early 20th century. During it, American and European car manufacturers started to become international while broadly following a multi-domestic strategy. As a result, there was no such thing as a global innovation network in its proper sense during this stage of the industry. The potential for global innovation networks was only opened up after a second shift. This was more of a revolution in the auto sector (toyotism), and it gave rise to increasing modular organizations. Modularization was first involved into production processes and then into R&D processes. In fact it is only during the past decade that the internationalisation in R&D has extended to the BRIC countries. In this light, challenges can be said to come from three directions: increasing modularity in organization (within large first tier companies), integration of BRIC countries, and shifts in technology.15

The auto industry also encompasses many activities which may be very distinct. It can be broken down into five industry sectors: the OEM (original equipment manufacturers) or car manufacturer (assembly), systems suppliers (SYS) who cater to the final good assemblers and who combine modules from component suppliers etc. These may be specialist firms, which supply parts and components with a high degree of innovativeness and specificity (SPEC) as well as those engaged in engineering and design activities (ED); or sub-contractors, which produce more standardised parts and components.

The automobile industry has developed differently in the different countries surveyed in this report. The differences are important when taking stock of the degree to which global innovation networks have been instrumental to the industry in each country. The important trends laid out were collected in the different national contexts according to a common recipe involving three complementary steps: a) through the dedicated INGINEUS survey (not carried out in Italy), b) through firm-level case studies (including specific firms) as well as c) through desktop research.

This combined approach provides a basis on which to triangulate between contextual and empirical information so as to provide a common basis on which the GIN formation could be compared across country. Here a certain degree of comparability is assumed. It should be noted however that the ‘automobile industry’ as it stands in the different countries may

[15] This observation was provided by Eike Schamp, the author of the German report, who is a long time expert of the auto-industry. We are grateful to him for providing this concise appraisal of challenges.

involve very different industries. The differences can be summed up in terms of the number of native OEMs in the car and truck production systems in the country: Brazil has no native OEM but is host to a number of subsidiaries of foreign car companies; Italy is home to a single consolidated OEM, Sweden is home to car and truck producers, where its strength lays with the latter; and Germany which has an integrated car and truck production system involving multiple competitors.

In this section, we lay out some of the defining aspects of the industry as it has taken root in the 4 country contexts. These provide a basis on which to compare and contrast important dimensions of GIN formation in these national contexts. We draw on the contextual information collected as it bears on the question of GIN formation. In the following, we introduce different aspects of the country cases in comparative terms. We look at the role of ownership, aspects of the knowledge base, and institutional factors that influence the development of the industries in these regions/countries and their reliance on global innovation networks.

Brazil

Brazil is the sixth largest automaker in the world, behind Japan, China, the USA, Germany and South Korea. The Brazilian auto industry produced 3.2 million vehicles in 2008. It can be divided into car manufacturers characterized by few large multinational companies and auto-parts companies characterized by a more fragmented structure of small local enterprises. A large network of suppliers of systems and parts is organized around automaker companies which tend to produce for the local market (regional and national). Domestic demand currently accounts for 70 percent of growth.

The Brazilian auto industry has gone through several cycles since its start in the late 1950s which have defined the industry today. The Brazilian report focuses on the auto industry in a given, geographically proscribed area: the state of Minas Gerais. The industry is relatively young in this part of Brazil. Some of the factors related to the development of the auto industry in this region are reviewed here. In general, the combined role of ownership and the role of state sponsored incentives are integral to the development of the auto industry in this case.

Organization and localization

An important feature of this case is that the auto industry was not located in the state of Minas Gerais traditionally. It was introduced by an agreement between a foreign automaker (Fiat) and the local government. This location decision in 1974 was not based on local knowhow. It was to a large degree facilitated by state incentives. The state government became a partner of the enterprise while providing a set of fiscal, financial and infrastructure incentives. In addition to state support, the location of Fiat in the region was also drawn by the appeal of a location away from congested areas of the country. Another important factor was that this gave Fiat a bridgehead to the growing Brazilian market, where Volkswagen, GM, and Ford were already established.

The Minas Gerais region today houses two MNC headquarters. In addition there are a number of MNC subsidiaries primarily affiliated to automakers and first tier suppliers: these subsidiaries tend to have their own chain of suppliers and systems that ultimately supply the automakers. A population of home-grown auto-parts and components makers, principally standalone companies, (est 200) have grown up in this region. The firms thus range from very small local firms to very large MNC affiliates. There are no small firms in the Brazilian sample. In terms of the overall structure of the sector, a large network of suppliers of systems and parts is organized around automaker companies. The later, produces for the local market (regional and national). Only one company identified the export market as its largest one, whereas 46% have the local regional market as the most important.

The phases of the global industry (see above) had its effect on the direction of the auto industry in this region. Fiat was to begin with vertically integrated. During the restructuring of the industry in the late 1980s, automakers became less vertically integrated. This change in organizational form was crucial to the further development of the Minas Gerais. This led to the expansion of production and, ultimately to growth of the local auto parts companies. State incentives were also used in this phase to lure auto-parts companies to the region during this phase. At first, R&D activities were found to move out of region during the 1990s in the name of rationalization. The report notes sources that indicate the tide has changed.

Knowledge-base and technology conditions

The next question is the importance of technology to the localization of the industry. The report says that the move to rural Brazil allowed Fiat to develop its "economy car", to introduce its ethanol motor, and to experiment with a flexible production structure. So aspects of the local market and local demand were important: and these aspects had a technological dimension. That said, the role of any preexisting knowledge base was not noted. The report notes that MNCs are important to the promotion of R&D in Brazil. It is noted however that the internationalization of R&D extended to the BRIC countries. Official sources indicate that MNC are a major source of R&D expenditure in Brazil (accounting for nearly 45% of total expenditures). It also notes that there is relatively little public support for R&D. Notwithstanding, R&D expenditure has grown significantly in Brazil in recent years, growing as much as 50 percent in the automotive sector since 2000.

Italy

The Italian automotive industry has a long history. The auto industry has consolidated through the years and is today characterized by a single large final good producer, the FIAT Group. The FIAT group includes Alfa Romeo, Lancia, as well as the high-end brand Ferrari and Maserati. A large proportion of the activities of the FIAT group are located in Turin and the Piedmont region and the automotive industry is also concentrated in the same areas. This geographically proscribed region is the focus of the Italian report.

This means that the Italian report provides a picture of the region in which the MNC in the Brazilian case grew up. It is also a mirror image in terms of the cars produced here, with a focus on mid and high end markets. Another difference is that this region is the dominant location of the auto industry in Italy, accounting for 40% of Italy’s automotive firms and

approximately 50% of the region's employment, in contrast to the last case. Unfortunately the Italian case does not use the same survey and is not directly comparable. We review some of the factors related to the development of the auto industry in this region. In general, we see an agglomeration effect which has grown up around Italy's automaker.

Organization and localization

The Fiat Group is integral to the auto industry in Italy, not least from a historical perspective. A definite clustering effect has grown up in its home region over the history of the industry. As a result, the auto industry is much more diverse, more advanced, bigger and older in the Piemonte region than in Minas Gerais. A substantial array of independent firms is found through the five major clusters of the industry. The share of Italian headquarters and foreign-owned firms is higher than in the rest of Italy, while affiliates of foreign multinationals account for about 50% of firms in the OEM cluster (MOD and SYS). The Italian report stresses the importance of small, privately held domestic companies to the position of Italy in the automobile sector, saying that the Italian entrepreneurs prefer to stay independent.

The domestic firm is the manufacturer of the final product and is the incumbent integrator of the clusters that have grown up in the region. Market opportunities in the industry are largely shaped by the role of the FIAT Group accounts for a large share of average sales. The report notes that firms in Piedmont show a higher dependence on order from FIAT group's domestic plants. Substantial reliance of domestic order is noted also for sub-suppliers, while OEM and E&D tend to serve foreign plants (such as that in Brazil). Italian firms in the automotive sector are, as most Italian firms, relatively small and independently-owned. Roughly 70% of the companies employ fewer than 50 people and the average firm size is less than 150 employees.

Knowledge-base and technology conditions

The concentration of the Italian auto industry around one actor shapes the characteristics of supply chain in the Italian case, since for a large number of firms FIAT is the major client and the geography of production. The report notes that the diversity of the auto market means that the knowledge and opportunity regimes as well as the characteristics of GIN may be sharply different according to the segment of the industry. Many Italian suppliers export, although most firms serve nearby markets (mainly in Europe) and a large part of exports is directed towards FIAT plants abroad. A link between innovation and internationalization was identified in Italy at the subsector level, with more innovative intensive companies (e.g. in the specialist firms) being more international.

Germany

Germany is Europe's largest producer and exporter of passenger cars and heavy duty trucks. It is the world's fourth largest producer of passenger cars, and the fourth largest producer of commercial vehicles (2008). It was one of the first countries to develop a substantial automotive industry at the beginning of the twentieth century. Today, Germany's economy is highly specialized in the production of automobiles. The production and consumption of cars

employs about 2.8 million or 14% of Germany's total labour (2005) force, accounting for 20 % of annual turnover from German manufacturing industries. These activities are located in several different parts of the country, which correspond to the where the large producers are located.

Germany's economy is highly specialized on automobile production relative to other Western countries. The sector is dynamic and extensive. It hosts three competing premium model car producers, three competing volume car producers, and two heavy truck producers. According to the report, a quarter of the top 100 global systems suppliers are German. In addition there is extensive home-grown set of larger, often family based suppliers in an array of different sectors, in addition to small and medium companies. In sum, the auto-industry accounts for 14% of German employment and about one fifth of turnover in the country's manufacturing sector.

Ownership and organization

The German automotive industry is characterized by competition among three premium model producers (Audi/Volkswagen, now including Porsche; BMW, Daimler), among three volume producers (Ford, Opel, Volkswagen) and among two heavy truck producers (Daimler, MAN). These are largely concentrated in different parts of the country. They are supported by sophisticated supplier industries including very large companies such as Bosch or BASF, a strong "Mittelstand" of larger, often family based suppliers and a host of medium and small suppliers from different sectors such as mechanical engineering, electrical and electronic industries, textile and rubber industries, and plastics industries.

The report indicates that German automotive industry is nationally-based but has long been internationally oriented. It exports between two-thirds and three-quarters of the vehicles it produces. The report notes that early investment by the US car companies (Ford and Opel) served to introduce US suppliers to Germany, especially after WWII. A current period of consolidation is reportedly afoot internationally. The report notes that financial investors are penetrating the German automotive industry and that there has been a rash of mergers among the very large system suppliers. The supplier's sector in Germany is largely characterized by standalone companies of a small and medium size which, although exporting part of their production, mainly work for the domestic market.

The report indicates that domestic markets are shrinking and consumer requirements are changing in fast growing but less wealthy export markets. These factors have raised the question about how long the technological and production regime might survive. The options of moving more into electric vehicles and more into BRIC markets entails a shift of innovative activities to other sectors and countries. If there is a radical shift in technology and geography, it is indicated that Germany will retain a strong base not least in knowledge and innovation of the sector.

Knowledge-base and technology conditions

Germany's position in the auto-industry has been according to the report reinforced by innovation activities in the sector. The level of innovative intensity is ascribed in part to

Germany's focus on the premium model segment where user requirements push the innovation cycle. The report notes that R&D expenditures are high relative to other OECD countries. In addition, they have risen steadily in Germany, not least in this sector where about three quarters of the companies are innovative active. The report notes that the industry is diverse and that innovation practice is not uniform in the industry. Rather it may reflect how knowledge systems are organized in the different subordinate technological fields. An intensive and close cooperation with partners external to the company seems to be required, in particular for the OEMs and the first tier suppliers.

The report emphasizes that companies in the sector rely predominantly on in-house knowledge inputs and a close control of cooperation in innovation processes through their R&D centers at home. There is reported a strong hierarchical organisation of model development in the German automotive sector. Anecdotal evidence is described of linkages between industry and universities, where large technical universities in Germany tend to have an institute on automobile technology with good links to industry actors. The large research institute sector is also active. There are many regional "cluster" associations where the automotive industry is spatially concentrated. In these areas, German technical universities are reported to have specific programs of applied research for the cluster firms, mainly in process innovation and application of products. In addition, the report notes strong support from political programmes, at the regional, state and EU levels. It is noted that many programmes require collaboration between firms and research labs and universities. The report indicates a strong preference for an improved skill formation in Germany, in part via own investment efforts into linkages both covering education and research to (nearby) universities.

Sweden

Sweden also has a home-grown auto industry but on a different scale from the German case. Like Germany, Sweden is home to passenger car companies, which have weakened and been sold in the current climate, and truck companies (Scania and Volvo) which remain strong. Employment is about 140000 in the Swedish automotive sector but is considered to be a strategic industry in Sweden. The largest share of Swedish auto firms targets the domestic or regional market. At the same time, almost 40 percent also target international markets. They work either for large assemblers that, with few exceptions (Volvo and Saab) are from outside Sweden or to module assemblers, which may be located in Sweden. Swedish auto-parts firms that export, tend to do so mainly to the European market or the US market.

Ownership and organization

It has generated a number of native brands among car and truck makers, including Volvo Cars, Scania, and Saab Automobile. These originally Swedish carmakers were incorporated to US car-makers during the 1990s and have been prominent in the recent consolidation in the industry. The takeovers during the toyatism era meant that production was integrated into European production systems and have therefore not been independent in the same way that the Italian or Germany car companies were. Now that they have been sold on, their futures are less clear. Sweden does host suppliers specializing in electrical and electronic equipment, pressing and stamping, and safety accessories such as airbags. These tend to be first tier

suppliers and their technology and research centers are usually located in very close proximity with the final customer, usually the large car assemblers. Most auto-parts firms are standalone SMEs (fewer than 250 employees). Auto-part firms either work for large assemblers that, with few exceptions (Volvo and Saab) are from outside Sweden or to module assemblers, which may be located in Sweden. While the largest share of proportion of auto-part firms mainly target the domestic or regional market, a large proportion also targeting international markets. Main export markets are found in Europe and the US, with a small proportion directed towards Asian countries.

Knowledge-base and technology conditions

Most Swedish automobile firms report significant R&D activity. This high effort in R&D is reflected in the number of innovations as well as in the degree of novelty. Both the high R&D expenditure as well as the high degree of novelty in innovation products and services, indicates a specialization in high-added value activities within the automotive industry. The types of products in which Swedish autopart firms are specialized are electrical and electronic equipment, pressing and stamping, safety accessories, like airbags, etc. They are usually first tier suppliers and their technology and research centers are usually located in very close proximity with the final customer, usually large car assemblers. What the Swedish cases seem to suggest, is that the drivers of innovation as well as the geographical spread of the innovation activities is highly contingent to the nature of innovation. Core basic research is done mostly internally or in collaboration with a handful of very strategic customers, while applied research and development can be done with a larger number of partners.

3.3 Survey comparison

Any attempt at providing an accurate picture of this diversified industry in these diverse country contexts faces major challenges. This section reports on a first attempt at a cross-country survey that was designed to collect information about GIN formation in this and two other industries. The questionnaire includes questions about innovation, about collaboration partners, about information sources used when innovating, about outsourcing, as well as other questions (see below for details). Some of the responses are discussed in the country reports, where Italy bases itself on an earlier survey. In light of the picture above, a comparison of the cross-country survey provides a basis to further discuss the GIN formation in the automobile industry. However, there are several important limitations associated with it. These are important to any attempt to generalize from these results. This section first notes these limitations. It then presents a comparison of some of the results on a set of GIN indicators.

3.4 Survey limitations

The first limitation is that while the set of countries corresponds to major car producers, the set of countries are not necessarily representative of the industry at the global level. This is especially the case for non-EU countries where Brazil is the sole representative: this excludes the important Asian countries as well as the US. A further set of limitations is that it was not possible to achieve a complete and systematic survey of the auto industry in the country

contexts under study. To make up for the shortfall in the empirical basis, the country reports provided more contextual information. This introduced idiosyncrasies in the way the survey was carried out in the different countries. In Italy, the survey was not carried out in the same round, due to the availability of a similar and recent survey. The targeted populations were different in the countries, sampling was not done in the same way, and response rates varied. This poses a range of problems for the countries. In the context of the individual countries, the survey provides an incomplete and somewhat biased view of the industry. In addition response rates which are low but variable. The annex (Annex 1) provides details on survey coverage and responses for the different countries.

In terms of comparison, attempts were made to include the same general population (e.g. firm-size). Still, the more basic differences in sampling make comparison unreliable. Furthermore, the same survey was not carried out in Italy due to the availability of a similar and recent survey. The survey results for Italy, while congruent, are not harvested from the same survey and are difficult to compare. In brief, the weaknesses preclude using the results from this first iteration of the survey alone as more than a glimpse at GIN practices. Although this empirical lens is faulty, it still provides an interesting and potentially rich snapshot of GIN formation in different contexts.

In brief, the survey sample is not adequate to generalize about differences in the sector in EU and non-EU countries. However, it does provide a snapshot of the sector—and, more patchily, its subsectors— at the country or regional level. A characteristic here is that a large majority of firms (75%) claim to be R&D active or to be 'innovative' in one way or another. The sample is thus of 'innovative' firms in the auto-sector. Differences in the degree to which different types of firms are global, innovative, and networked can be indicated in such a snapshot. Keeping its limitations in the mind, the survey provides the following types of information about the sector:

Information about the supply as well as demand factors in the innovation process.

In terms of inputs to innovation, it provides information on linkages to diverse set of actors in a range of different geographical markets. It distinguishes between functions carried out in-house, within the corporation or in conjunction with outside partners; it reports on outsourcing activities, both in terms of production and of innovation activities; and it reports on general types of search among different sources of information.

- In terms of demand, it provides detailed information on geographical orientation of the firms markets
- Detail about innovation including its form (product, service, process, market, organization) and degree (new to market or new to firm)
- Information about Non-market relationships (sourcing and collaborative links)
- Information about partnerships involving types of agents other than firms (domestically and abroad)
- And Information in different geographical contexts.

A first step is to uncover inherent patterns in the GIN variables, some of which are strongly correlated. This is done using a tetrachoric factor analysis based on a set of dichotomous

variables derived from the survey. The following types of variables are used to see which load with each other. This indicates that given variables tends to correlate with each other, which in turn indicates that they may be related (via a third variable). The variables we investigate are:

- Type of firm: if it is large (over 500 employees), if it is involved in manufacturing (see above), if it is a standalone company. A control is if it is located in Brazil (Land1)
- Global orientation: if its main market is domestic, if it outsources either its production or innovation activities (Offshore);
- Innovation active: if it reports R&D staff, and if it claims to have launched an innovation that is 'new to the world'.
- Networked: if it linked to international actors, if it reports R&D linkages.

Firms were asked about their main subsector. Their responses might help us distinguish between firms with different knowledge bases, different positions in the value-chain, etc. There were broadly two types of activities: process (e.g. "Pressing stamping and roll forming") or manufacture (e.g. "Manufacture of parts and accessories"). These differences might be expected to explain how global, innovative and/or networked the firms were. Only about a third of the firms (n=49) specified a main subsector (these mainly in Brazil). A majority (mainly in Germany) specified 'none', which might be interpreted to mean that more diversified respondents found it difficult to specify a single sector. A variable (ProdProc3) is defined to capture firms that categorized themselves mainly as a manufacturer.

Table 7: Factor loadings for (principal factor method), rotated[16]

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Land1		-0.2712	0.7077	-0.5102	0.1196
Innovative~4	0.3268	0.2833		0.5000	0.5193
researcher~y	0.7470	0.4332			0.1725
ProdProc3			0.8727		0.2186
Type2				0.7602	0.4088
Big_binary	0.6469	0.5593		-0.3219	0.1238
Main_Market4	0.8253				0.3172
INT_LINK		0.7505			0.3908
RD_LINK_bin	0.7589	0.3874		0.2941	0.1801
OFFSHORE	0.2996	0.7104			0.3941

Four types of factors account for virtually all covariance. This indicates that four unobserved factors can be identified that link the firm-level variables in different ways. These generic factors can suggest different types of firms. The first and most dominant factor involves large innovative firms that are not associated with a country context (neither negative nor positive

[16] Rotated using orthogonal varimax. The Kaiser-Meyer-Olkin is over .5 (0.54) indicating that the relation between observed correlation to partial correlation coefficients of the sample is adequate for factor analysis.

for Brazil). This group tends to have R&D linkages and to engage in outsourcing activity. But, a defining aspect of this group is that the main market tends emphatically to be at home.

The second group is also associated with large innovative firms, but especially those in European countries (land1 is negatively associated). These correlate strongly with international linkages and with offshoring activities. There is again a correlation with R&D linkages. This group can be seen in relation to group four which also lines up with European countries. This fourth group however involves small ("Big" is negative) standalone companies who account for a lot of the variance associated with a high degree of innovativeness, though not necessarily related to R&D. These do not especially correlate to markets. The one variable that lines up with firms located in Brazil is the tendency to report being involved in manufacturing. This is Group 3. In the next step we investigate factors that contribute to the tendency of the firms in this sector to be more globally oriented and more innovative according to the survey.

International orientation

There are several dimensions according to which firms may be considered more or less 'global'. This pertains also to the degree to which they are involved in 'networks'. In practice the involvement of firms in networks that are more or less global is considered. In the first step, we investigate a set of dimensions that determine how global a firm is. The second step will consider the effect that the relationship between the way in which—and the degree to which— a firm is engaged in global network and its innovativeness. This is assumed to be a two-way relationship.

A total of 148 auto firms responded to this round of the INGINEUS survey: half of these were located in Brazil, a third in Germany and the rest in Sweden. The firms sampled tend to be large firms, with an average of over 400 employees[17]. Roughly a quarter of the firms report affiliation with a multinational corporation, either as the headquarters or as a subsidiary. Standalone companies account for about half the sample. A further quarter of the sample does not report corporate type. These tended to provide little information, including about international sales and number of export markets. Those that did, tended to be larger firms, on par with MNC subsidiaries.

Table 8: Basic information of the international orientation of firms: ownership and average values for employees, proportion of firms claiming international sales, and average number of export markets

Company Type	N	Employees	International sales*	Export markets
Not specified	36	633,3	2,8 %	0,0
standalone company	73	284,8	63,0 %	1,2
subsidiary of an MNC	32	636,0	40,6 %	0,7

[17] Firm-size was not systematically sampled for. Germany widened its sample to include smaller firms to improve comparability with Brazil. There was no sampling procedure.

MNC Headquarters	7	685,7	71,4 %	1,4
Total	148	419,5	43,9 %	0,8

Source: INGINEUS survey. Automotive sample.

* SWEDEN standalones all report international sales

This first table indicates that on average 44 percent of the firms report international sales. MNC subsidiaries (as well as the less reliable 'not specified' group) are less likely to report international sales than average. A solid majority of standalone companies and of MNC headquarters report international sales on more than one foreign market. It should be noted that the former is specially influenced by Sweden, a relatively small country in which all standalone firms report international sales. Foreign in this case means predominately other European countries. In addition, the number of MNC headquarters is small. In general, the initial impression is that the auto industry is oriented towards international markets.

The survey asks a number of questions about firm-functions and the degree to which they are carried out in association with external actors. We now look at the i) portion of functions that take place externally, ii) the degree to which firms source their technologies, and iii) the proportion of firms outsource productive and/or innovative activity.

Table 9: Tendency of firms to involve outside actors: number of functions performed by the firm, the average percentage of functions outsourced, and the proportion of firms that 'offshore' production or innovation activities.

Company_Type	N	Functions	Functions outsourced	Firms that offshore activities
Not specified	36	2,2	0,6 %	2,8 %
standalone company	73	10,7	14,2 %	21,9 %
subsidiary of an MNC	32	13,3	22,5 %	43,8 %
MNC headquarters	7	15,3	34,3 %	71,4 %
Total	148	9,4	13,6 %	24,3 %

Source. INGINEUS survey. Automotive sample

On average, automotive firms report carrying out 9 functions (including 'strategic management', product development, marketing etc)[18] either independently or jointly with other actors. Affiliates of MNCs tend to engage in substantially more functions than do standalone companies. In addition, the proportion of the functions carried out by entities other than the reporting firm is on average fifty percent higher for MNC subsidiaries than for

[18] There are 10 functions that can be carried out independently or jointly in 6 locations, ranging from in-house activities to those outsourced outside the base country. This column counts the total number (maximum 60) that firms indicate on average.

standalone companies. Over a third of the functions are outsourced by the MNC headquarters, either to its own subsidiaries or others.

The same distinction between standalone companies and MNC affiliates is found in relation to the propensity of the firm to 'offshore' elements of its production and/or innovation activities. Here factors that influenced the proportion of firms to report one or more factors as important to offshoring their activities are tallied. This practice is a defining aspect of MNC affiliates, particularly MNC headquarters. On average, a quarter of the companies surveyed related their placement to offshoring activities; MNC headquarters were three times as likely as standalone companies to engage in this practice.

Innovativeness

The vast majority of surveyed companies claim to be innovative and/or R&D active. Almost three quarters (74%) of the sample reports R&D activity and/or some recent innovative activity. Innovations can involve very different activities. The types of innovations covered are i) launching new products or ii) new services; ii) introducing new production methods or iv) new marketing and/or logistic methods; and/or v) introducing new organizational modes. These may be considered 'new to the firm', 'new to the industry' or 'new to the world'. Firms can claim to have engaged in more than one such activity during the preceding 3 years.

In addition there is information about whether the firm engages in R&D activities as well as an estimate of the number of full time R&D employees. This together with the number of innovations claimed provides a baseline for comparison of the innovativeness of the different types of firms. This baseline is presented in the next table.

Table 10: R&D active firms in the automobile sector, by firm-type, average number of R&D employees, and number of innovations reported in the previous 3 years

Company_Type	N	R&D Active	R&D Employees (mean)	Innovations (mean)
Not specified	36	5,6 %	0,6	1
standalone company	73	47,9 %	9,2	7
subsidiary of an MNC	32	62,5 %	17,1	7
MNC headquarters	7	57,1 %	27,0	8
Total	148	41,2 %	9,7	6

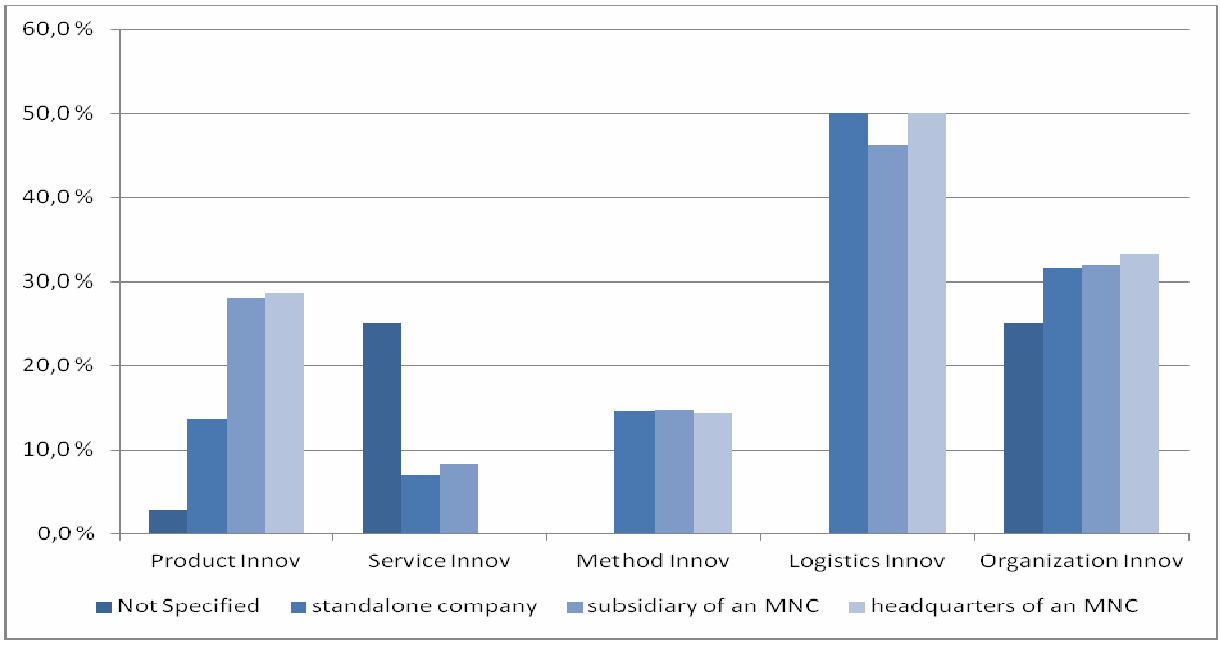
Source: INGINEUS survey. Automotive sample

Table 10 illustrates that R&D propensity and intensity as well as innovative degree varies by firm type in the automotive sector. The average number of R&D employees and the average number of innovations per innovative active firm increase down the table towards MNC headquarters. At the same time a greater proportion of MNC subsidiaries than headquarters claim to be R&D active. This appears to be an aberration, which might be due to a misunderstanding of 'innovativeness' and/or to the small sample of MNC headquarters. The

measure of innovative degree is given in terms of the number of innovations claimed by the firms, which again can range a span of different types of innovations as well as different levels of novelty.

The following figure focuses on the percentage of firms that claim innovations that are 'new to the world' by firm-type and innovation type. It illustrates that there is a common tendency for firms in the automotive sector to engage in new modes of logistics or market organization, which may be important to participate productively in the product chain. Around half of the innovative firms claim to have introduced novel solutions, independent of firm-type. The related area of organizational innovations is also high (around 30 percent of innovative firms significantly changing their supporting processes) broadly similar across firm-types. Here firms that did not classify themselves are an exception. These firms appear to be distinct in their markedly higher tendency to engage in 'service innovations', an area of innovation not usually linked to the auto industry.

Figure 1: Innovative activity by firm-type: percent of firms claiming to have launched an innovation in one or more of the following categories in the preceding 3 years.



Source. INGINEUS survey. Automotive sample.

A third innovation type, where the propensity is broadly the same for the different firm types, involves launching a significantly new production method: this form of innovation is found at about 15 percent of the innovative firms in the automotive sector. The one type of innovation where firm-types tend to distinguish between standalone companies and MNC affiliates is in the traditional category of 'product innovators'. Here, the latter are almost twice as likely to have launched a new product in the timeframe as standalone companies. This may testify to a size–effect (with the latter being smaller) and/or to the position of the latter in the supply-chains.

3.5 Concluding discussion

The national cases emphasize some general aspects of this vast sector and the role of innovation in it. In sum, the impression is that the automobile sector is a very broad and diverse industry that involves many interrelated activities. This increases the scope for a division of labor not only in the production process—but also during the innovation process. With reference to the attempt to distinguish between science and technology based modes ("STI") of innovation and an experience-based mode by doing, using and interacting (DUI), the German report indicates that the automotive industry is a little of both. The reports observe that innovation in the automotive industry, both in terms of processes and products, is traditionally seen as incremental in nature. This is a noted a characteristic of mature industries with large companies. Despite this, it has seen a rash of pervasive changes especially in the organization of production processes, but also in product development, and in individual sub-technologies. It notes the 'cross-technological character' of the "sector", noting that different modes of knowledge and innovation apply to different degrees and at different places in product and process development of the automotive industry.[19]

The section starts by taking stock of generic aspects of the sector before considering some of its aspects in the different regional or country contexts. Some generalizations can be made about the vast automotive sector.

Production processes: The take up of flexible production and 'Toyotaism' during the 1990s led for example to the adoption of various lean manufacturing principles such as just-in-time and hierarchical supply chains, etc. The consequence of the reorganization was felt differently in the different countries. However, some common adjustments continue to be seen across subsectors and firm-types, with high—and broadly uniform— levels of innovative activity registered for organizational and logistical innovations: albeit at a lower level, the incidence of process innovation is also common across firm types.

Product development: the basic concept of an automobile's operation – namely, traction by a petrol-based internal combustion motor – remained unchanged for over a century. There have been some changes, for example the automobile is being geared towards smaller automobiles, lower cost, higher efficiency and reduced CO2 emissions. The rising importance of emerging markets coincides with these concerns.

New technologies that are of current importance in the automotive industry are classified in the Brazilian report according to four large groups: a) alternative modes of propulsion (e.g. electrical or fuel cell motors); b) on-board electronics for the control of vehicle functions; c) combining information and communication technologies for navigation and safety systems; and d) utilizing lighter and more resistant new materials. As the German report points out, the automotive industry is a cross-sectoral industry. For example, electronics, software development and mechatronics (i.e. the interface of precision engineering and software) and new materials are among the key technologies of the automotive industries.

[19] See especially the German as well as the Brazilian case studies for a background for two different perspectives on the role of innovation in the sector.

Industry structure is important to the modes and linkages of the industry. The technological innovation activities have been affected by the international competition process, which is largely oligarchical. The industry consolidated as it matured. This affected how product development activities are organized, for example between the headquarters and their branches located in developing countries. The MNCs structured their research and development activities at the global level, at a moment when the international oligopolistic industry was already established. The paramount dimension R&D activities assumed in the competition process and in the international expansion of the MNCs led to the development of new forms of organizing such activities – specifically, the decision of decentralizing R&D or not at the international scale. Choosing a certain competitive strategy and a certain product policy makes the company adopt a particular international division of labor with its branches regarding product development.

In light of these general dimensions of the industry we investigated patterns that emerge both in the national reports and in the responses to the survey. The intention was again to triangulate between the survey-data—which we stress, is a somewhat biased snapshot— and the complementary contextual reading of sector level analysis. This allowed us to tentatively draw some cross-country implications of GIN formation for this sector. We recap on some of these points here.

The factor analysis indicated that the automobile industry, as presented in this snapshot, involves several archetypical types of firms. The most important transgresses the country contexts reviewed here. It involves large innovative firms whose main market is at home. This archetype corresponds to the large firms found in all countries, where large suppliers sell primarily to the domestically located car company. In terms of international links, these firms tend to be more involved in offshoring of production and/or innovation activities than average. Two of the other factors correspond specifically to firms in Europe: the first involve large firms the second small firms. In both cases, these firms have a high propensity to be innovative. In the case of the large firms, innovation is accompanied by having R&D department; while among the smaller firms this is not necessarily the case. Both size-classes report R&D collaborations. In addition to their inclusion in the first factor, the only factor that specifically loads with the Brazilian sample is the tendency to report involvement in manufacturing. One interpretation that is suggested by a comparison of the reports is that the European firms tend to be involved in a wider range of activities (manufacturing and processes) while Brazilian firms may be more specialized on given manufacturing tasks.

The factor analysis suggested that the type of company (small or large, whether affiliated with an MNC or not) is an important determinant of whether it is innovative and the degree of its international involvement. In addition we compared raw breakdowns of organizational types and different aspects of innovation and internationalization. The raw breakdowns suggested that both the standalones and MNC headquarters in the sample were involved in a larger number of export markets and had a higher level of export sales than MNC subsidiaries. We found that around half of the innovative firms claim to have introduced novel solutions, independent of firm-type. Particularly organizational and market innovations pervade the different types of firms in the automobile industry. Process innovations are also independent of size classes, but for a smaller proportion of firms. What emerges is that the firms that are affiliated with an MNC are much more likely to engage in product innovations, suggesting

that a division of labor in the sector. These also tend to be much more involved both in outsourcing and offshoring functions. In this sense there seems to be a division of labor between MNCs and standalone companies in the automobile industry.

3.6 Policy observations

The empirical information collected both in the survey and the contextual information is of course not conclusive in terms of making policy pronouncements. However there are several things to note. The most explicit policy dimension to emerge from this exercise involves the role of the regional government in attracting the auto-industry to the Brazilian region of Minas Gerais. This form of attracting FDI, which has also been used to attract investments into EU, was apparently successful not in initiating but also in helping the industry there to adapt during the global reorganization of the industry. A question is how successful it has been to encourage innovative local companies to emerge. The report also said that there is limited public support of R&D.

The only clear result from the survey is that the Brazilian population is more specialized in manufacturing: while the European firms both small and large are generally more innovative. This may be a factor of the market or other contextual factors that are not observed. The literature however does suggest the danger of 'hollowing-out' of the competencies of the domestic companies. This challenge and the importance of maintaining a certain level of 'absorptive capacity' over time, suggest the importance of promoting RD&I activities in house. And there is one factor the survey does tend to establish across the three sectors it covers, and that is the relationship between R&D activity in house and the propensity to engage in international activities.[20]

As the European reports in particular illustrate, the industry is no stranger to public policy measures designed to support innovative capacity. This is noted particularly in the German case where several layers of supports (EU, national, and state) target different areas of this wide-ranging sector. This suggests first that policy coordination between the different levels is important. It also suggests the importance that the policy measures help the industry address emerging challenges. The immanent reorganization of the industry is raised as a special area of concern. On the one hand, this involves the ongoing efforts to adapt and integrate lower carbon technologies into cars; on the other, it involves adapting the market to emerging markets. Fiat's adaptation of its economy cars to the Brazilian market and its attempts to make use of alternative fuels (ethanol) in the 1970s indicate that this is not entirely new terrain for the industry.

However, current reports support the proposition that a period of consolidation among carmakers and suppliers may have begun.[21] Industry observers indicate that horizontal

[20] I.e. Proportion of Sales Abroad, Binary Sales abroad, Offshoring. Preliminary regression analysis —not reported here— support the position that R&D activity is the most robust predictor for the propensity to engage in international activities. To be reported in Wiig Aslesen & Iversen (2011).

[21] See Saab's bankruptcy, postponement of the merger between Porsche and VW, the breakdown in collaboration between VW and Suzuki.

mergers between carmakers are not particular to the current industrial landscape. What appears to be a trend however is that the number of mergers of system suppliers and component suppliers are increasing and that this may lay the basis for global innovation networks.[22] A shift in the global organization of the industry suggests a myriad of challenges for different parts of the industry. These entail a raft of potential and legitimate policy concerns and implications. In light of the already considerable policy attention in the sector, this study can help link these concerns more explicitly to the question of how different actors participate differently in innovation networks. If formalized R&D activities correlate with an increased propensity to integrate in GINs, this may for example suggest supporting inter-firm collaborations with third countries—such as Brazil— in existing programs to that target alternative propulsion and affiliated technologies.[23]

The automobile industry is very large and made up of many parts, as we have seen and as the reports elaborate on. Within this industry (or the part covered by the survey), the study suggests there is a difference between two types of innovators, other things being equal. On the one hand, there are those who develop new products. Here there seems to be a division of labor between smaller and larger firms, where size and affiliation with a MNC affect the propensity to launch novel products. On the other hand, there are those who report novel organizational innovations either in the value chain and/or in within the company. Both types of innovation are linked. The picture that emerges is that this type of innovation is more a function of the sector whether you are small or large, part of a MNC or a standalone company. The relevance of this activity for GIN creation seems clear—more efficient actors in the value-chain might be expected to be more involved internationally. From the sample, we however do not observe that organizational innovations in the value-chain have an additional positive effect on international sales or international links beyond that of other types of innovation. The important thing seems to be that the firms are innovative in other ways as well.

The country reports and the overall study point out there is there are GIN patterns that emerge in this sector. However more comparative study into the innovative networks of this sector is needed before more conclusive policy implications can be drawn.

3.7 Annex of the specific samples

Brazil

The analysis carried out in this report is based on three information sources. The background information comes from the Brazilian version of the Community Innovation Survey (2003, 2005, 2008). It also drew on the INGINEUS survey and six case studies.

[22] Again, we are indebted for this summary of the situation to Eike Schamp, the author of the German report and long time industrial expert.

[23] This focus of collaboration with third countries and a balanced consideration of RD&I expenses coincides with a recent EU project (Innogrips), where one part treated policy aspects of Open Innovation.

Sample: The survey was carried out on a sample of firms, which was created based on three distinct sources: *The Annual Registry of Social Information (RAIS), the Auto-parts Union Contact List (SINDIPECAS) and* data previously gathered from interviews with employees of a few key companies in the automotive sector. The survey targeted only companies located in the State of Minas Gerais which is the home of large multinational automakers and of a significant part of their supply chains. In all, 107 firms were chosen from RAIS, 66 from the SINDIPECAS and 88 from previous research projects, in a total of 266, which account for 100% of companies directly classified as or pertaining to the automotive sector in the state. The raw dataset was then reduced to 241, after cleaning the sample.

Company size: the survey was sent to companies with more than 30 employees in 2008.

Response rate: 69 companies responded to the survey.

Germany

Information is drawn from documents from the German association of automobile producers (VDA), from universities as well as private research and marketing companies. There are several caveats to the survey: it does not cover the few original equipment manufacturers (OEMs) in Germany – BMW, Daimler, Ford, Opel (GM), and Volkswagen (including its brands Audi and Porsche). Its focus is on the automotive supplier industry. In this industry, the survey mostly covered medium sized automotive companies and excluded both the global first-tier system suppliers and the very small third-tier suppliers in Germany. This is an important limitation as both tiers are very well represented among the German automotive industry.

Sample: The automotive production system includes companies from very different sectors. There is no clear-cut cross-sectoral data base, not least because large systems suppliers have emerged that combine very different technologies from different sectors for automotive production. On the other hand, the small third tier suppliers stick to their technology but sell to very different markets. The database was established using information from a private data provider, covering companies which either belong to the statistical sectors of vehicle production and parts production for vehicles or, if not, have indicated that they sell large part of their products to the automotive industry.

Company size: The minimum size of the companies was first limited to 50 employees as the innovation literature says that very small companies almost do not report innovation activities (Rammer et al. 2010, 12). This provided a sample of 690 companies. However, in order to make the survey comparable to other countries and sectors, it was later extended to further 384 small companies with less than 50 employees.

Response rate: the response rate for the companies above 50 employees was 6.8% and 1.6% for small companies.

Italy

The Italian survey included much higher numbers than the other three countries. It involved a survey administered by the Chamber of Commerce of Turin, in collaboration with Centro Studi Luca D'Agliano for the INGINEUS project in 2009 and 2010. The survey consists of 18 questions in 2009 and 23 in 2010, out of which, 12 relate to the INGINEUS questionnaire, although they are not always identical. They also often report results for Italian-owned firms and for foreign-owned separately.

Sample: representative of the universe of the Italian automotive industry, which is composed of about 2,600 corporations.

Response rate: a high response rate of over 70 percent (1865).

Within the INGINEUS consortium, Sweden was the only country that conducted the survey in two industries: Autoparts and ICT.

Sample: The dataset used to identify the survey universe was from Statistic Sweden, selecting all the firms that operate in the Autoparts sector for automotive, corresponding to the NACE 2 codes. For Autoparts that provided an eventual sample of 176 firms.

Company size: The data base lists small, medium-size and large organizations. In order to ensure the comparison with other INGINEUS countries, we only considered firms above 5 employees.

Response rate. Of the 176 firms, 24 responded, giving a response rate of 13.6%.

ANNEX 1- COUNTRY SECTOR REPORT: ICT IN NORWAY

Authors: Heidi Wiig Aslesen (Heidi.W.Aslesen@bi.no) and Sverre Herstad (sverre.herstad@nifu.no), Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP, Norway, participant no.10**)**

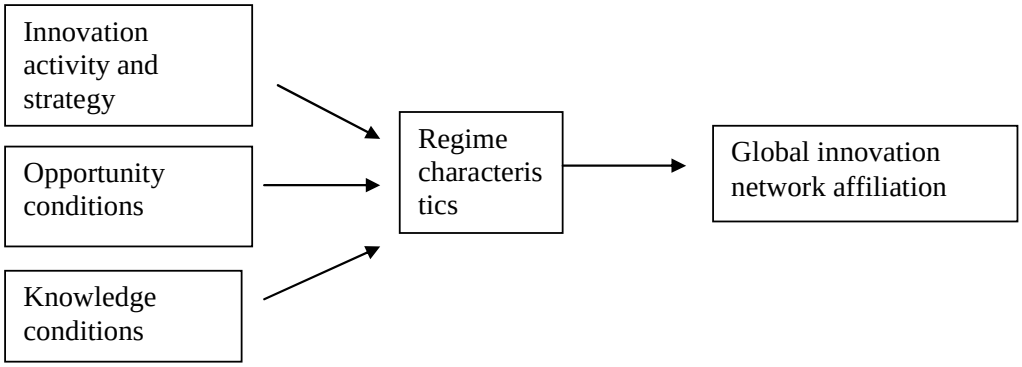
1.1 Introduction

The purpose of this country sector report is to analyze the dynamics of GIN formation within the Norwegian ICT sector, and understand their potential impacts at the national economy level. The following empirical report provides the basis for the Norwegian country report. It presents empirical evidence in accordance with the theoretical framework supplied elsewhere, and conducts a preliminary discussion of how this material should be interpreted.

The general research question for WP9 is ; What GIN patterns are forming in the selected sectors, and to what extent are these influenced (driven, constrained) by contextual conditions specific to these sectors?

With this as a starting point, this sector report discusses how such conditions influence the global innovation network footprints of Norwegian ICT firms. As GINs emerge from a need to seek out and coordinate complementary knowledge assets on a global scale, we focus on the *knowledge & cumulativeness conditions* of the sector. As the last instance motive of GIN linkages is to profit from innovation, we focus on the *opportunity* conditions prevalent within Norwegian ICTs.

The analysis depart from, and thus contribute to nuancing, the common assumption that firms within ICTs are born globals, operating in a fast moving environment, based on knowledge which evolve and diffuse rapidly across actors and space.



1.2 Methodology

The following is based on empirical data from a) the dedicated Ingineous survey, and b) four strategically selected case studies. In addition, it draws background information from c)

Community Innovation Survey 2006, which provide a representative description of the Norwegian ICT sector at the individual establishment level. The definition of the ICT *sector* was predetermined by the project, and applied.

The dataset used to identify the survey universe is derived from the public central business register in Norway, "The Brønnøysund Register Centre". This register is one of many sources that commercial enterprises use to build up databases for publishing business statistics and analysis and is also used by Statistics Central of Norway. The specific dataset used was extracted from a commercial register (Proff Forvalt - Eniro), as this is the solution subscribed to by BI Norwegian School of Management, and therefore readily available for researchers at this institution. The data are national and since the original source is the national register centre, the selections of firms that are included in datasets are mostly independent of the provider. We identified 2477 initial addresses pertaining to units operating within the three selected industries (C10+11, C26.3 and J62) with more than 5 employees. However some were units of a single company with different outlets, some were published without e-mail adresses. After manually working through the list we were left with 1522 respondents with address information.

The survey was conducted in three steps. First, we conducted a pilot survey which targeted five selected firms, which provided us with feedback on the questionnaire. This feedback was communicated to the project management. Second, an electronic questionnaire was sent to all 1522 respondents on which we had address information. The response rate was abysmal, with only 38 partial or completed responses. We thereafter decided to 1) focus on one industry (J62 with 756 firms) and 2) to use a commercial polling bureau to contact all firms and ask for an agreement in advance to respond to the survey. Finally 519 firms had agreed to be contacted. The contact was in most cases the managing director. At completion, we had all in all 182 partial and 127 complete responses.

The case study firms where identified by Ingenious in the three selected sectors. Each partner where to carry out 5 interviews with MNC that could be found in those partner countries carrying out interviews. The reason for selecting the same company across partner countries were to have the possibility to compare sector dynamics and GIN strategies from diverse regional and national innovation systems. The cases studies were also companies that we knew in advance had international activities (MNC), in order to understand internationalization strategies. A list of companies where identified and each country representative where to follow up on the suggested cases to see if the companies still had activity in the country. For ICT both Sweden, Estonia, China and South Africa followed up on the same companies. In the case of Norway we ended up with a list of companies and selected 4 of these and carried out 5 interviews (2 in the largest company). Below are some background characteristics of the interviewed firms:

Table 11: Key background characteristics of the interviewed firms.

	Location of HQ	Employess in Norway	Activity in no of countries
Case 1	Norway	300	9
Case 2	Sweden	≈ 600 / 226[24]	175
Case 3	Norway	≈ 8000[25]	14
Case 4	US	68	Not known.

1.3 Subject 1: the present nature of sector activities in your country

The Norwegian industrial system, which is strongly dominated by industries based on natural resources, had by 2006 fostered an innovative ICT industry which accounted for just below 5 per cent of private sector employment in firms with more than 5 employees (CIS2006, farming, hotels, restaurants and retail trade excluded). The same sector accounted for as much as 18 per cent of private sector intramural R&D in 2006. These firms are more innovation active (i.e. conduct innovation activities such as e.g. R&D) than the Norwegian average (65 per cent compared to the average 35 per cent) and show high rates of product innovation; yet, they are predominantly small or medium sized, and not affiliated with corporate groups: According to CIS2006, the degree of group affiliation is higher in the ICT sector than outside it, yet, lower among *innovation active* ICT firms than among other innovation active firms.

Table 12: Estimated key characteristics of the Norwegian ICT sector

	Number	Share (per cent)
All firms	1514	100
Innovation active	969	64
Present in foreign markets	640	42
Part of group	680	45
Innovation active only		
Small (emp<99)	941	97
Medium sized (emp 100-249)	20	2
Large (emp>250)	8	0,8
Part of group	446	46
Product innovation	729	75

[24] Source: Proff Forvalt(*600 employees is stated on their webpage, but Proff forvalt claim they only have 226, might be that these numbers reflect the department in Asker.
[25] Source: http://telenor.no/om/telenor-i-norge/nokkeltall/index.jsp

Process innovation	223	23
External innovation collaboration (any form/geography)	365	38
Regional innovation collaboration	250	26
Other domestic innovation collaboration	219	23
Foreign innovation collaboration	155	16
Note: Based on CIS2006, weighted establishment level data. Representative for firms with more than 5 employees. Nace rev 1.1 72.00-72.40, ISIC Rev. 4 J62. Reference period 2004-2006.		

Source: CIS2006.

Firms in the sector are also successful in transforming innovation activities into output, dominated by product innovations. 75 per cent of innovation active firms launched a new product during the reference period, compared to 56 per cent of other Norwegian innovation active industrial firms. On the other hand, only 23 per cent of active firms introduced a new production process, compared to 35 per cent of other Norwegian active firms.

The propensity to collaborate is slightly lower among innovation active Norwegian ICT firms than among active firms in other sectors; while 37 per cent of ICT firms maintain some form of collaboration, as many as 45 per cent of innovation active firms in other industries do. CIS2006 also reveal that off the total number of collaborators in ICT, as many as 35 % collaborate with customers located in the same region. This is comparable to the share in other industries. Yet, 58 % of ICT firm with collaboration state that customers are of somewhat or high importance, compared to a 37 % average for other industries. Data from the Ingenious survey show that most firms have their largest markets regionally or domestically (Table 14). The exceptions to this rule are oriented towards markets in Europe or the US (Table 15). A domestic market orientation can be considered part and parcel of strong domestic opportunity conditions, and the resulting size composition of the industry.

Table 13: Organizational characteristics, NOR INGINEUS survey sample (q2)

	Response Percent	**Response Count**
Standalone company	88,2%	112
Subsidiary of an MNC	6,3%	8
Headquarter of an MNC	5,5%	7
answered question		127
skipped question		55

Table 14: Location of largest market, NOR INGINEUS survey sample (q4.1)

	Response Percent	**Response Count**
Internal to your enterprise	0,8%	1

A regional market (local region in your country)	35,8%	44
Domestic market (rest of the country)	50,4%	62
An export market	13,0%	16
answered question		123
skipped question		59

Table 15: If an export market, was selected, then please indicate the 3 most important destinations in terms of sales (Survey q 4.2)

	Response Percent	Response Count
North America	50,0%	10
South America	15,0%	3
Western Europe	80,0%	16
Central & Eastern Europe	35,0%	7
Africa	15,0%	3
Japan & Australasia	15,0%	3
Rest of Asia	35,0%	7
Rest of the world (developing	5,0%	1
answered question		20
skipped question		162

The size composition of the industry, its market orientation and its collaboration patterns suggests that the Norwegian ICT sector as a whole is heavily embedded in regional or national user-producer relationships. Below, we will nuance this picture with reference to the case studies, and discuss the apparent polarization of the industry between a very small number of internationalized firms, and a large number of domestically oriented firms. We will argue that this polarization is a key factor when interpreting the global innovation network affiliation of the industry, and not least its future prospects.

Table 16: The relationship between size, group affiliation and international innovation collaboration

	Small	Medium sized	Large
Part of group	43 % (423)	76 % (15)	100 % (8)
Present on international markets	52 % (491)	67 % (13)	88 % (7)
Foreign innovation collaboration	16 % (149)	19 % (4)	13 % (1)

N (innovation active)	941 (100%)	20 (100%)	8 (100%)
Note: Based on CIS2006, weighted establishment level data. Parenthesis indicates number of firms, Representative for firms with more than 5 employees. Foreign innovation collaboration is with external (outside corporate group) partners only.			

Source: CIS2006

Last, it must be noted that the activities of the Norwegian ICT *sector* as defined by official classifications is not equal to Norwegian industry activity within the technological domain of ICTs. Firms defined as belonging to the ICT sector represent only a certain proportion of ICT development within the same economy, and these are highly dependent on investments not only in ICT hardware and software but in ICT-related knowledge development made by other industrial sectors. Although we cannot empirically investigate this issue here, it is reasonable to believe that other industrial sectors are critical to the ICT sector not only as customers, but also as providers of knowledge externalities upon which innovation in the ICT sector may feed. Excessive emphasis on the activities of the ICT sector as such, and its *direct* collaborative or sourcing linkages to the domestic economy, may come with the risk of such indirect interdependencies being neglected. It also comes with the risk of neglecting GIN linkages between domestic ICT development and knowledge sources abroad which operate through the activities of firms not defined as part of the ICT sector.

CIS2006 allow us to distinguish between the ICT sector and the technological area of ICT. Table 17 below show the mean share of intramural R&D by sector which target the technology area of ICT, and the share of total ICT technology area intramural R&D represented by each industrial sector. We see that investments in intramural R&D targeting ICT development constitute large proportion of the total investments made in intramural R&D, in particular in low R&D intensity sectors such as infrastructure, trade & logistics. We also note the large share of total ICT R&D conducted by the machinery, instruments & equipment sector, in addition to substantially important shares conducted by the transportation sector and knowledge intensive services not defined as belonging to the ICT sector. According to these estimates, the defined ICT sector account for about 40 percent of business sector R&D in the technology area; whereas R&D in the technology area in itself (inside and outside the ICT sector) account for an impressive 29,55 per cent of total NOR business sector intramural R&D.

Table 17: Share of intramural R&D targeting the technology area ICT, by performing sector.

	Share of sector intramural R&D targeting ICT technology area	**Sector share of NOR intramural R&D in ICT technology area**	**Sector share of total NOR intramural R&D**
Aquaculture	2,30	0,16	2,05
Extraction of petroleum & natural gas	1,41	0,33	6,89
Pulp& paper, food & beverages, leather	7,02	2,00	8,44

& tobacco			
Chemicals & Pharma	0,19	0,05	7,47
Metalls	2,40	0,30	3,69
Machinery, instruments & equipment	24,70	22,39	26,80
Manufacturing, other	2,06	0,05	0,75
Infrastructure	25,44	1,25	1,45
Trade & logistics	50,54	14,83	8,67
Knowledge intensive services, ICT excluded	34,14	18,41	15,94
ICT	66,59	40,22	17,85
Total (NOK 1000)		4 880 452	16 513 892
ICT technology area share of total NOR intramural R&D		29,55	
Note: Based on CIS2006, weighted sample (N=25 628). Numbers are 1) the share of intramural R&D in each sector targeting the technology area of ICT, 2) the share of NOR intramural R&D in this technology are accounted for by the different sectors, and c) the share of total intramural R&D accounted for by these sectors.			

Source: CIS2006

Summary 1: GIN affiliation and the nature of ICT sector activities in Norway

Norwegian ICT firms predominantly serve regional or domestic markets. Yet, they are highly innovation active, which illustrate strong opportunity conditions in these domestic markets. ICT firms are somewhat less oriented towards innovation collaboration than firms in other sectors, and once they collaborate, they customer is on average more important than in other sectors. The ICT sector in Norway only account for 40 % of private sector intramural R&D targeting the technology area of ICT, suggesting that it is densely interwoven with and dependent on technological development occurring in other industries. This is consistent with the tendency of ICT firms to collaborate with customers located in the same region.

Taken together, this means that GIN formation is constrained by strong domestic opportunities for innovation, and (presumably) dependence on knowledge externalities from ICT-oriented R&D conducted in other Norwegian sectors.

1.4 Subject 2: the nature of innovation in the sector

CIS2006[26] establishment level micro data show that 64% of Norwegian firms worked actively with innovation in the reference period 2004-2006, of which as many as total of 75 % launched a new product on the market during the same period. This is substantially above country averages, suggesting that the sector has favorable and ample opportunities for innovation at both market (output, pervasiveness) and input (technology, knowledge) sides. ICT firms covered by Ingineous survey material similarly show extremely high product and service innovation rates, although innovations which are new to the firm only dominate over innovations new to the industry and the world. The higher innovation rates in this survey compared to CIS2006 may reflect response biases or methodological differences; but they may also reflect that opportunities for innovation in the sector have grown throughout the decade.

Table 18: Innovation activities the past three years (survey q7)

	Share with innovation type	**Degree of novelty**				
		New to the world	**New to the industry**	**New to the firm**	**None**	**Response count**
New products	94,3 %	20,0 %	35,7 %	57,4 %	16,5 %	115
New services	92,6 %	12,4 %	32,7 %	66,4 %	14,2 %	113
New production processes	85,2 %	7,7 %	25,0 %	52,9 %	27,9 %	104
New logistics, distribution etc	80,3 %	3,1 %	12,2 %	33,7 %	57,1 %	98
New supporting activities	87,7 %	2,8 %	10,3 %	55,1 %	38,3 %	107

Yet, these high rates of innovation do not seem to reflect in broad external collaborative knowledge development, nor in patterns of contractual outsourcing of R&D work. Although the availability of technology "embodied" in hardware and software is a key characteristic of the ICT sector, contractual sourcing beyond this (e.g. R&D services) is relatively rare, because of constraints on modularization of innovation work which is heavily dependent on internal specialized knowledge resources, and because the structure of upstream component supply is radically different within ICTs than within e.g. traditional manufacturing industries, where large technology transfers occur through the supply chain. Most Ingineous survey

[26] The Community Innovation Statistics (CIS) are produced in 27 Member States of the European Union, 3 countries of the European Free Trade Association (EFTA) and in EU candidate countries based on the Commission Regulation No 1450/2004. The data is collected on a four-yearly basis. http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis

sample firms therefore claim that most technological inputs are produced in-house. We do note, however, that a substantial proportion of these survey firms buy most technological inputs form MNC with which they are not affiliated. It is reasonable to believe that this point to the importance of technology embodied in software and hardware acquired from such firms.

Table 19: The most important sources of technology, NOR Survey sample (q6).

	Share	Number
We produce most technological inputs in-house	58,4%	73
We buy most of our inputs from other branches of our own MNC	4,0%	5
We buy most of our inputs from firms which are not MNCs	15,2%	19
We buy most of our inputs from MNCs with which we are not formally affiliated	21,6%	27
We buy most of our inputs from public-sector organisations, e.g. research institutes, universities, etc	0,8%	1
answered question		125
skipped question		57

In the ICT industry, new services offered to customers are in rapid and continuous change, and so is the overall market structure and dynamic. In some cases, this includes the formation of new so-called double-sided markets, in which the providers of ICT-based services relate to several sub-markets. They sell internet access to one set of clients; and access to the resulting internet customer base including complementary services such as invoicing to another set (i.e. application developers or advertising agencies). Part and parcel of innovation in ICT services are such experimentation with the generation of not only new services as such, but new market and pricing structures. “The rules of the game are changing in a way that is disruptive to the telecom business”, says one respondent, and in this case it is related more to the formation of new market logics *enabled* by technologies which are present already, than the development of new technologies. This is reflected in a shift in the composition of core competencies (se next section) away from technical knowledge, with resulting changes in external network affiliation.

It has also during the last decade been reflected in opportunity conditions highly specific to the industry. All but one of the interviewed firms operates in markets where opportunities for innovation have been enormous, generated by very high rates of technological change combined with rapid absorption in existing markets. The cases represent firms that either have one main innovation at the core of their activities (i.e. a web browser or mobile communication technology) to firms that cover the whole value chain of ICT related activities (from ‘hardware’ telecommunication equipment to media and communication services). Even though these companies are in the same statistically defined sector, and all are innovative, the

nature of the specific interplay between technological opportunity, pervasiveness and market change faced by each case study firm vary substantially between them.

Case 3 operate in a context where the rate of change is slow and cumulativeness is high; demand is contingent on network capacity expansions and maintenance and oriented more towards operational reliability and maintainability than radical technological solutions. Both idea generation and subsequent development projects are carried out internally, innovation sources being internally generated tacit knowledge gained from the experience of skilled engineers. According to the Pavitt taxonomy (1984), the firm belong to the category of specialized suppliers where innovation is focused on performance improvement, reliability and customization. On the market side the company relates to a stable professional market for investment goods and the customers are demanding and competent within relevant technological areas. As such the market cannot be seen as a driver for radical innovation. It is representing a rather constrained demand side. On the other hand, it forces a very strong emphasis on incremental innovations and engineering excellence, which increases the reliance of the case company on specialized, tacit knowledge. This binds the activity to the present context of location, and centers innovation on its internal processes combined with sourcing of technology 'embodied' in component supply (see in particular Hauknes & Knell, 2009). This 'low opportunity-high cumulativeness' company must therefore be considered an 'outlier' when compared to the overall characteristics of the sector in Norway, and this is attributable to its role as hardware producer.

The second case has an innovative product directed towards a fast moving market, competing with the largest global players in the field. Their competitive advantage lays in that their product and their strength is their internal innovation capability and the focus on continuous development on the technical side. Other input factors are the technological possibilities and feedback from the markets. The respondent indicates that their competitors are better on the market side with regard to commercializing new products and innovations, suggesting that the respondents have strong opportunities for innovation, both on the technological input (strong internal technical competences) side and on the market side (from the business-to-business segment), however their ability to harness market-side opportunities is hampered by a strong orientation towards the technical aspects of the product.

The three other interviews represent cases that again relate differently to innovation opportunities. These are firms able to make use of external technological opportunities, using different open innovation strategies such as sourcing, search and collaboration. One of the cases has developed a strategy of acquiring new applications from external developers by offering these accesses to their pool of customers and through the purchase of strategic enterprises for market access (e.g. the purchase of a bank as a platform for the development of ICT-based financial services targeting consumer markets). The other company has a strategy of sourcing technology and competence in the form of small enterprises. Both companies take part in innovation collaboration with indigenous actors. For these firms the open innovation strategy linked to strong partnerships around its different international activities, is combined with an internal research and innovation strategy where there seems to have developed a strong internal innovation system within the enterprise able to accumulate knowledge and a competitive advantages. One of these companies stated that they had consolidated their

activities the last years in order to have focus on core activities and that the global system of innovation of which they are part is now to be the driver of innovation in the company.

Most of the respondents emphasized the role of the market as an innovation driver, explaining the companies' broad external search, collaboration, sourcing and direct investment in order to customize products and services to specific market needs. The companies' internationalization strategies were explained by closeness to market, and the importance of understanding and access local needs. As such market knowledge is used to diversify technologies and services. One of the firms had taken into use anthropologist to study people's needs and their perception of new services or technologies in a specific region. Such market knowledge can probably be characterized as more tacit and harder to standardize and to spread in the global enterprise structure, however, emphasizing the need for such specific knowledge in order to target your market.

Table 20: Innovation drivers & strategy in Norwegian case firms

	Opportunity conditions		**Strategy**
	Technology	**Market**	
Case 1	Relatively high technological opportunity due predominantly to strength of internal knowledge base & routines.	Low in domestic and medium in international markets – but less able to use potential for own innovation purposes besides core activity.	To be best on their core technology.
Case 2	Medium. Cumulative development of specialized internal competencies.	Low to medium in international markets. Constrained by conservative infrastructure investment market.	To continuously follow market demand, and cut production costs.
Case 3	High - induce entrepreneurial activity, acquires external knowledge as well as building own capacity to innovate.	High in domestic & international markets. High rate of new product & service introduction, driven partly by external developers.	Combine external, international search, collaboration and sourcing with broad internal communication and idea generation.
Case 4	High, due partly to intense small-firm based experimentation with new technologies.	High in domestic & international markets. Enormous parent group expansion supported by market with high product & service diversification & replacement rates.	Combine external, international search, collaboration & sourcing with broad internal communication and idea generation.

By way of concluding, both survey and case data reveal that opportunities for innovation in the ICT sector are high but stemming less from technological development per se, than from the sector itself experimenting with new market structures (i.e. dual markets), new business

models and new services. The sector consequently serves to 'bridge' a set of technological opportunities which are already in place, in existing or arising markets.

Summary 2: GIN affiliation and the nature of innovation in Norwegian ICTs

The Norwegian ICT sector is characterized by high innovation activity and opportunities, stemming from a strong demand side drive. This is linked to a strong emphasis on internal knowledge development and innovation activity. From this it can be indicated that the GIN potential in this sector is linked to the ability of firms to use global markets as sources for innovation, i.e. the ability of firms to successfully penetrate and learn from international markets. This potential does not materialize in the sector as a whole, due to a strong domestic demand drive. Constraining GIN formation further is *presumably* the dependence of the sector on spillovers from knowledge development in other industrial sectors. Yet, the case studies show that once firms become international players they gain access to far more diverse information and technology inputs than what is available domestically, and they work systematically with harnessing them.

1.5 Subject 3: the nature of knowledge

The above portrayed nature of innovation and opportunity conditions reflect direct in the composition of firm knowledge bases and the nature of knowledge development. Competing within the telecommunication and ICT sector require the development of sector specific knowledge assets, of which technical programming skills often constitute only a basic skill which does not set companies apart. Most of the companies employ "only" people with higher education, making the education system – and by implication the larger regional labor market - important for basic competence maintenance and expansion. ICT systems are based on a common "core" consisting of algorithms and other highly advanced mathematics, knowledge on which is supplied through this education system. Hence, many employees are part of the 'epistemic community' of programmers, in which a common language exist which eases communication across cultural and social distance, and enable – in itself – sourcing of knowledge-intensive activities.

One of the respondents explains how the company has a 'core technology' that travel well across the boundaries of the firm, and that it is especially within activity areas covered by this epistemic community that different enterprise units worked together, as other knowledge areas where more context dependent. Most of the respondents also stress that a lot of knowledge is accumulated which is highly specific to 'communities of practice' either within the organization or related to its location (e.g. the regional labor market).

The development of specific ICT *services* directed to different markets (or customer groups) appear to ad a distinct layer of *firm specific* knowledge development on top of this sector-specific platform. This knowledge relate to the understanding of specific customer or market needs, the ability to predict directions of development and the ability to select and discard

information and ideas from the outside. New services & applications are consequently based on a codified core upon which more tacit element are added and drive the development and final product. As such, many of the interviewed firms combine the STI and DUI modes of innovation in different stages of the innovation process, where synthetic knowledge and a STI-mode of innovation is found in the early stages, for thereafter apply a more DUI mode of innovation.

Several case firms therefore also stress the importance of knowledge embedded in the firms' culture and "language", and thus both the importance of "socializing" new employees into this and the challenges related to rebuilding this organizational context abroad. One of the respondents portrays a picture of high cumulativeness and of competences located in the interface between a "good blend of engineering professions and experience-based knowledge which is sitting in the walls". Further the respondents say that new employees can enter into stand-alone tasks after a couple of months of in-house training, but in order to understand the system as such they must have worked actively with it for at least a year.

This firm level cumulativeness - understood as knowledge accumulation of today can serve as building blocks for innovations tomorrow - is high for these firms even if their modes of innovation differ. One of the firms emphasize a pragmatic way of organizing innovation activities as we "just do it, we solve problems using the smartest people we have" without placing excessive emphasis on routines and on following traditional hierarchical lines. This underscores how "core competencies" extend beyond the mere technical aspects of the product to include internal processes and routines developed cumulatively. This, of course, is a routine in itself, well institutionalized in the company.

With respect to the overall degree of cumulativeness, we see indications of a certain polarization between the large-firm and the small-firm sector, but also of direct and indirect mutual interdependencies between these two sectors. In the large firms covered by our interviews, the underlying knowledge base is highly complex and developed by drawing on a relatively wide range of external information sources and academic fields. The knowledge base in these firms does seem to be cumulative and as such follow a pattern of "creative accumulation" where large firms dominate and industry concentration is high (see Breschi et al 2000). However, the two largest global players interviewed also reveal how this process of creative accumulation within such incumbents are interwoven with technology and application sourcing strategies which are highly externally oriented, thus presupposing the existence of small entrepreneurial firms or external application developers who – in turn - need the complementary capabilities offered by the large-firm sector. The largest interviewed firms goes as far as explicitly stating that they offer a complete package of extremely wide distribution (i.e. its existing customer base), but also complementary invoicing services etc. to small application developers.

This means that two different technological regimes exist side by side; a small-firm based regime fed by ample opportunities to develop new ideas and concepts based on the existing platform provided by ICTs; and a large-firm sector which both feed on this process with external experimentation (thus reducing the need for own long-term R&D under high volatility and uncertainty conditions), and contribute knowledge (e.g. through spillovers from labor mobility) upstream and complementary capabilities downstream to the same entrepreneurial regime. The basic competencies necessary to enter into the game of software

and service development is relatively widely distributed and the innovation-pull from the demand side is strong; yet, in order to grow beyond the entrepreneurial stageit is necessary to – also in this sector – either develop a larger organizationally embedded knowledge base and set of complementarity capabilities, or source these from large firms holding them.

Summary 3: GIN affiliation and the nature of knowledge in Norwegian ICT

The knowledge base of the Norwegian ICT sector consists of two distinct components, which are complementary to each other at the level of the firm. On the one hand, all firms build on 1) a codified platform, which represent a potential for Gin formation as the knowledge is highly codified. The other knowledge condition is linked to the 2) tacit, and often firm-specific, knowledge linked to development of new services and applications. This form of knowledge constrains GIN formation, because its development is located in the interface between customer collaboration, internal knowledge development, and specialized knowledge spillovers from other industrial activities, making it highly place-specific and sticky.

Our case studies suggest that the locus of innovation has shifted towards type 2 knowledge. This means that the potential for GIN formation is relatively limited if you are not able to engage in FDI or are part on an MNC – as you need to be present in the industrial contexts in which type 2 knowledge is located if you are to tap into it. Firms that are able to combine the two main knowledge components by staying updated on or contributing to the development of ICT platform technologies while at the same time drawing insights from and adapting products to various contexts of application are the one with the highest potential for GIN formation (as many of the case).

1.6 Subject 4: locations and internationalization

We not turn to consider explicitly how the above portrayed knowledge and opportunity conditions reflect in the global innovation network affiliation of the Norwegian ICT industry. As a point of departure, we recapitalize that collaboration propensities are below those found in other Norwegian industries, and that only about 5 per cent of Norwegian ICT firms source R&D services from abroad. We also recapitalize the apparent shift away from emphasis on the *technical* aspects of ICTs, towards the build-up of corporate knowledge bases which are more conducive to the ongoing identification and realization of ideas and opportunities *based on* technical platforms which are already there – or available through contractual sourcing.

According to CIS2006, only 16 % of Norwegian ICT firms with more than 5 employees have sourced R&D services domestically in Norway, and only 5 per cent have sourced such services internationally (Table 21), parent group units abroad included. Furthermore, we see that the ICT sector is the second lowest ranking with respect to R&D purchases abroad, with only approximately 2 per cent of total R&D spending allocated to such purchases. This reinforces the picture of the industry as heavily oriented towards internal knowledge development linked to customer collaboration.

Table 21: Norwegian R&D sourcing by sector and geography

	Share of total R&D in sector sourced from parent group unit or independent actors, by geography		Share of firms in sector with R&D sourcing, by geography	
	Abroad	**In Norway**	**Abroad**	**In Norway**
Aquaculture	2,14	8,31	12,03	32,56
Extraction of petroleum & natural gas	14,61	33,15	14,55	25,47
Pulp& paper, food & beverages, leather & tobacco	3,40	10,35	4,21	12,87
Chemicals & Pharma	15,94	5,87	27,23	30,49
Metals	4,66	7,78	5,13	19,92
Machinery, instruments & equipment	0,42	6,81	7,2	19,99
Manufacturing, other	3,29	18,52	7,17	29,03
Infrastructure	5,49	22,78	1,26	10,77
Trade & logistics	5,82	17,17	2,98	8,21
Knowledge intensive services, ICT excluded	3,04	19,99	3,63	9,62
ICT	2,32	5,03	5,25	15,76
All industries	4,92	13	4,81	13,87

Source: CIS2006.

Table 22 below show that 17 per cent of NOR survey sample firms have offshored R&D, which is high compared to the 5 per cent indicated by Norwegian CIS2006 data (table 21). This is most likely to due to differences in the definitions applied with respect to sourcing (CIS2006) and offshoring (Ingineous). In contrast to CIS2006, the dedicated survey data allows us to investigate in more detail the location factors which are at play in such offshoring processes.

Table 22: R&D offshoring propensities of NOR survey firms (Survey q9.1)

	Percent	Count
Has offshored R&D	17,4%	20
Has not offshored R&D	82,6%	95
answered question		115
skipped question		67

The point of departure for Table 23 is the 20 observations from Table 21 which have offshored R&D. The column marked 1 indicate the share of these observations which have stated that any given location factor is important, whereas the columns under 2 indicate the relative importance of the given factor for offshoring of production & innovation, respectively. We see clearly how human capital is perceived as important by most firms, whereas infrastructure, financial incentives and institutional conditions appear far less important. And – importantly – we note that only 6 out of 20 observations state that market access is an important factor behind the decision to offshore R&D. This means that it is predominantly factors on the input side which are perceived as important; and these in turn are dominated by factors *other* than those *directly* attributable to knowledge infrastructures and services. This observation is highly important with respect to the prospective implications of GINs, and for the purpose of developing policy.

Table 23: Location factors for offshoring of production & innovation, NOR INGINEUS sample (q9.2, assuming yes on 9.1, all important factors are to be marked)

	1-Overall Importance	**2-Relative importance of the factor**		
	Share stating importance of factor	**Offshoring of production**	**Offshoring of innovation**	**Response count**
Availability of specialized knowledge in region	52,4 %	81,8 %	36,4 %	11
Availability of qualified human capital in region	81,0 %	76,5 %	41,2 %	17
Access to knowledge infrastructure and services	38,1 %	50,0 %	62,5 %	8
Access to other infrastructure, cheaper production resources	47,6 %	80,0 %	30,0 %	10
Market access	28,6 %	100,0 %	16,7 %	6
Incentives for the location of activities (tax incentives etc)	23,8 %	100,0 %	60,0 %	5
Efficient financial markets	9,5 %	0,0 %	100,0 %	2
The level of ethical standards and trust	4,8 %	0,0 %	100,0 %	1
The enforcement of intellectual property rights	4,8 %	100,0 %	100,0 %	1
Following clients who are outsourcing	9,5 %	50,0 %	50,0 %	2
Other	4,8 %	100,0 %	0,0 %	1
Answered				21
Skipped				161

Note: Percentages under 1 are calculated with the total response count as base, and indicate the importance of the factor. Percentages under 2 are calculated with the factor response count as base, and give the relative importance of the factor for offshoring of production and innovation, respective. The Table must be therefore be read from left to the right.

Yet, there is one exception to this rule. The importance of the *domestic* customer to innovation in the Norwegian ICT sector becomes clearly evident when we now turn to consider its embeddedness in global innovation networks. The importance of this actor group is clearly revealed in Table 24, which show that almost 95 per cent of the firms in the sample have collaborated with customers. These collaborative linkages are distinctively oriented towards customers in own region or own country. We also note that this home-base preference appear to be stronger with respect to competitors, consultancy companies and – not surprisingly – government. With respect to the two former groups, this could be caused by high sensitivity towards trust and social/cultural proximity and by issues related to search costs. Between 75 per cent and 80 per cent of companies that state such collaborative relationships have established these at home.

Table 24: Collaboration partners used, most important innovation project last three years. NOR Ingineous survey sample (q8).

	Partner used	Geographical distribution of collaboration when maintained									
		Own region	Own country	North America	South America	Western Europe	Eeastern/ Central Europe	Africa	Japan Australasia	Asia, other	N
Customers	94,8 %	42,2 %	70,6 %	5,5 %	0,9 %	13,8 %	3,7 %	0,0 %	2,8 %	5,5 %	109
Suppliers	82,6 %	21,1 %	62,1 %	13,7 %	2,1 %	23,2 %	8,4 %	0,0 %	3,2 %	9,5 %	95
Competitors	43,5 %	28,0 %	78,0 %	8,0 %	0,0 %	12,0 %	0,0 %	0,0 %	0,0 %	0,0 %	50
Consultancy companies	48,7 %	33,9 %	75,0 %	0,0 %	1,8 %	7,1 %	3,6 %	0,0 %	0,0 %	1,8 %	56
Government	47,8 %	20,0 %	81,8 %	1,8 %	3,6 %	9,1 %	1,8 %	1,8 %	1,8 %	5,5 %	55
Domestic universities/research institutions	38,3 %	31,8 %	68,2 %	0,0 %	2,3 %	11,4 %	2,3 %	0,0 %	0,0 %	2,3 %	44
Foreign universities/research institutions	22,6 %	38,5 %	46,2 %	3,8 %	3,8 %	23,1 %	3,8 %	0,0 %	0,0 %	3,8 %	26
Other	7,0 %	25,0 %	37,5 %	12,5 %	12,5 %	37,5 %	12,5 %	12,5 %	12,5 %	25,0 %	8
Answered											115
Skipped											67

The interviewed firms are embedded in the national innovation system of their location (in this case Norway), but this embeddedness can only to a minor degree be attributed to collaborative linkages beyond customer interaction (case 4), or to research system support. Two of the companies are originally Norwegian, off which one has a 150 years history, and the other is a younger spin-off company. The former represents Norway's largest research environments within ICT, with extensive cooperation with universities and industrial partners. It is unique to the sector in the sense that it has through the years been involved in a broad specter of R&D activities, having the role as 'Nation builder'. Although listed on the Oslo and New York stock exchanges, it remains majority owned by the Norwegian government. The shift in the composition of core competencies away from technical aspects to a stronger focus on service and application development in various international markets have resulted in a substantial weakening of the linkages between this firm and the Norwegian NIS.

The latter company remain oriented towards the technical aspects of software development, but emerge as weakly linked to the innovation system in Norway due to a) a weak domestic demand base, and b) a distinct reluctance towards engaging in interaction with the Norwegian science system because, according to the respondent, these tend to benefit the research system more than the firm. To the extent that this firm is tied to the Norwegian economy it is through the large in-house knowledge base which it has developed cumulatively. Another case company (case 2) show a similar degree of weak domestic linkages externally, combined with strong and organizationally embedded 'sticky competences'. This case has previously had technical collaboration in Norway, and while it remains heavily oriented towards technical knowledge the respondent point out those weaker domestic linkages has followed from more attention being directed abroad. One of the case firms is present in Norway for the purpose of market fronting, and thus show relatively strong to its customer base in Norway on the one hand, and its parent group international network on the other.

It appears that *indirect* linkages to the larger economy, through the labour market, matter also domestically – either in contributing to their embedding (case 3) or in constraining this embeddedness (case 1 & 2 in particular). Combined with the strong emphasis among other industries on ICT technology area R&D, this raises questions concerning interdependencies between the ICT sector and other industrial sectors working by means of labour market externalities.

According to the case firms, the Norwegian economy represents strong supply side limitations with respect to quantity of labour with relevant skills. This supply side limitation on knowledge, combined with narrow although demanding domestic markets, has been a key driver behind FDI-based internationalisation of the ICT sector in Norway. By implication, the large share of the sector which has not yet internationalised by means of FDI can be assumed to be those which operate in domestic market niches and are too small to have experienced labour supply limitations, alternatively those which may draw most heavily on labour market externalities originating in other industrial sectors.

Summary 4: locations & internationalization in Norwegian ICT

Offshoring of R&D is a relatively rare phenomenon in Norwegian ICTs. When such offshoring is conducted, the main location factor is access to qualified human capital &

specialized knowledge. We have also seen that innovation collaboration and R&D sourcing at home is relatively rare. Taken together, this suggests that the industry is highly dependent on skills available in labor markets, combined with proximity to important customers/markets.

These are locations factors which are highly specific to certain places. This constrains the GIN network affiliation of the sector.

1.7 Subject 5: sector embeddedness in GINs

We keep in mind that, according to CIS2006 estimates, only 5 per cent of Norwegian ICT firms source R&D services from abroad, and that the sector only spend approximately 2,3 per cent of its R&D investments on such international purchases. The latter is very low compared to the 5 per cent spent abroad by the 'average' Norwegian firm. Applying the broader Ingineous survey definition of 'technology acquisition' changes these numbers somewhat, but does not alter the overall picture of a sector with a low international sourcing propensity. We also keep in mind how similar estimates indicate that only 16 per cent of Norwegian ICT firms have international innovation collaboration, as defined according to Eurostat and the Oslo Manual. Compared to a 20% average for all other industries combined, this is a low rate of collaboration-based internationalisation. Yet, CIS operate with a very strict definition of collaboration as involving mutual exchanges of knowledge, for the purpose of developing new knowledge, and sets it clearly apart from information use and contractual sourcing. The broader definition of 'linkages' used by the Ingineous survey show that only half of the sample firms have *not* established formal or informal linkages with customers abroad. Similarly, only about 42 per cent of the survey sample has not established linkages with suppliers abroad. On the other hand, linkages to foreign competitors and research system actors are rare (see Table 25 below).

Table 25: Informal and informal linkages towards foreign actor groups, NOR INGINEUS survey sample (q8)

	Formal	Informal	No linkage	N
Customers	29,1 %	27,2 %	49,5 %	103
Suppliers	36,2 %	26,7 %	41,9 %	105
Competitors	4,7 %	10,6 %	85,9 %	85
Consultants	17,4 %	19,8 %	65,1 %	86
Government	16,5 %	4,7 %	80,0 %	85
Universities/research labs	11,0 %	7,3 %	82,9 %	82
Other	5,2 %	0,0 %	94,8 %	58
Answered				111

Skipped				71

This suggests that international linkages in the ICT industry predominantly take the form of looser (early phase) innovation search and (implementation stage) sourcing of modular hardware/software, than committed innovation collaboration with external actors, abroad. Below we have therefore first calculated the average number of world regions in which firms in which firms in different sectors have a collaborative linkage. As Table 26 show, the average for the Norwegian ICT sector is below the country average. Yet, when we compare only those firms which already have decided to engage in collaboration (any form/geography), the picture changes as the sector now score above the national average. This is indicating that part of the story behind the weak international collaborative linkages of the Norwegian ICT industry is the lower propensity of ICT firms to engage in collaboration in general, following from a stronger dependence in intramural R&D combined with innovation search, more than a lower propensity to *internationalise* its collaborative network: Once the decision to engage in innovation collaboration as defined by Eurostat has been taken, the network is above country average internationalised and comparable to most other industries except Chemicals & Pharma.

Table 26: Geographical scope of Norwegian industry innovation collaboration networks, by sector

	Average number of world regions in which a collaborative linkage has been established	
	All active	**Collaborators only**
Aquaculture	0,80	1,13
Extraction of petroleum & natural gas	1,05	1,58
Pulp& paper, food & beverages, leather & tobacco	0,66	1,53
Chemicals & Pharma	1,70	2,21
Metalls	0,50	1,12
Machinery, instruments & equipment	0,77	1,56
Manufacturing, other	0,49	1,16
Infrastructure	0,65	1,13
Trade & logistics	0,52	1,39
Knowledge intensive services, ICT excluded	0,70	1,32
ICT	0,61	1,52
Average, all industries	0,65	1,41
N (weighted sample)	8922	3988

Source: CIS2006

Part of this picture is also the importance of collaboration and information diffusion within multinational corporate groups. Case 1, which has a strategy of combining selective customer interaction with deep, cumulative internal knowledge development, emphasises strongly the build-up of the internal socio-cultural basis for communication across subsidiaries in different world regions (see next chapter). Case 3 & 4 for ad to this picture, by pointing to the role of the corporate group network (and by implication affiliate units located abroad) as search spaces and knowledge diffusion mechanisms. Being present in numerous contexts exposes the group network to richer information (search); and the same presence serve as "platforms" for more committed external collaboration (Asheim, Ebersberger, & Herstad, 2010). Harnessing the advantages of GIN affiliation through multi-unit, multi-location corporate group networks forces a stronger explicit focus on building internal absorptive (affiliates in different contexts) and communicative (across affiliated units) capacity. However, one of the respondents says "there are instances of information overload, you cannot relate to all available knowledge that is developed through GIN". These issues of information overload, attention allocation and communicative capacity are critical in a sector which *increasingly* relies on linking diverse market information to technological opportunity, and will be treated below.

In sum, the quantitative data indicate that the Norwegian ICT sector is dependent on international information, which it gains through search interfaces that include corporate networks, and which do not overlap with collaborative linkages. It is dependent on b) customer interaction, which is heavily oriented towards customers at home and thus nurtured or constrained by domestic markets. The exception to this rule is large ICT companies which expand abroad for the purpose of seeking out more diverse market to interact with. Last, it is to a very little degree oriented towards sourcing of knowledge, beyond what occur as embodied in software and hardware. The low propensity to engage in international innovation sourcing appear somewhat contradictory the picture often portrayed of ICTs as a sector not only producing the technological foundation for such international sourcing, but also one engaging actively in it. Yet, exceptions of this rule are again found in large enterprises operating in high-opportunity environments (i.e. cases 3 & 4), in which intense external experimentation with new technologies and applications enable such large firms to build part of their innovation strategy on external sourcing of technology-based firms or applications.

The case studies point to the limitations of broad innovation sourcing. One of the case firms goes as far as revealing a distinctively negative attitude towards innovation sourcing. Collaboration with the domestic science system is described as a process of "training others", in the sense that the company is far more advanced in their field than relevant science system partners in Norway (implicitly elsewhere as well). The respondent point to the importance of being in control of the project and its resources, and to how work processes and management systems in the science system is less conducive to the companies way of working – "to little flexibility, and they move to slow". Further, the respondent was critical to the use of external knowledge milieus or consultants for the generation of 'core knowledge', because such strategies a) assume the existence of relevant competence bases externally, within the domain on which the company attempt to be world-leading, and because it entail that this core knowledge accumulate outside own organization. According to the respondent, from the perspective of his firm and area of activity the notion of large-scale "outsourcing" of work (including innovation) to low-cost countries is a bit strange: "We don't want to outsource

critical work, because we then fund knowledge development somewhere else. We have been very conscious about accumulating knowledge in-house by doing everything which is critical ourselves." The companies' vision is to still keep growing, and can at this stage not afford to 'give away' anything to other. The only possible exception to this, according to the respondent, is "when the knowledge is stable".

In general, the internationalisation strategies of the case companies reflect the different regime conditions they operate under. One of the companies, which still operate based on a distinctively "technical" knowledge base, have established offices in Eastern Europe with good supply of technically qualified and much cheaper ICT programmers – for reasons related to the education system but also because other industrial actors have served to "educate" the workforce. One of its subsidiaries was established as a direct result of another MNE closing down its plant there. These daughter companies are located where basic competences necessary to build up *internal* organisationally embedded knowledge bases are found. The company now has offices in 11 countries outside Norway, including China, Korea and Taiwan. Yet, 2/3 of product development activities are conducted in Northern Europe, i.e. Sweden and Norway. The process of greenfield-based internationalisation is described as gradual; partly due to lack of external location factor drivers and partly because the firm focus heavily on organisational development and integration of new subsidiaries. It has no presence in India, and explicitly state that this is due to labour market characteristics which are not conducive to its preferred mode of organisation.

Case 3 show a very different internationalisation strategy, with extensive acquisition-based FDI in all three core areas; technology, market and services. The respondent says that for many of the daughter companies (like the one in Bangladesh), being part of a large multinational company, works as a door opener towards other business partners and knowledge milieus in their region/country. The daughter companies are relatively autonomous and innovation efforts and initiatives in the regional units have their own rationale and trajectory, however relating to the overall enterprise strategy in the specific areas. The daughter companies often have strong regional connections and networks; this is also motivated from the HQ. The trend in the company has been that more and more research are carried out in the different units outside of the HQ in Norway, entailing that "the research activities at the HQ continuously must legitimize its existence". It must be stressed that this company is very large, and has a tradition for extensive technical R&D in Norway. It must also be stressed that this pattern of internationalization, although containing clear elements of technology sourcing, is largely driven by the search for opportunities in diverse markets.

For case 2, the main driver of internationalisation is "access to competences and resources at an acceptable price". Its activities abroad are polarised between production and assembly activity in China, and basic R&D in the US. Activities in Norway are held at a constant level, and the underlying knowledge base continues to evolve base at the intersection between these different international activities, and external value chain (customers & suppliers) interaction. The core innovations are developed at "home", based on competences accumulated in-house in this organisation. With regard to learning and knowledge accumulation activities in these foreign locations, the respondent believe that the position of the Chineese units in the value chain will change as more and more development work is relocated to China. The foreign units will start to see opportunities at the interface between different products and

technologies that actors in the "North" who are specialised in certain niches (technologies and products) do not necessarily see. The technologies that subsidiaries are exposed to and conduct may seem simple, but the variety of different development tasks can trigger opportunities for learning no longer available to specialised firms in the North. According to the respondent, Chinese operations and industrial regions may become "...melting pot for processes which each on their own may seem very simple...but nobody else sees the whole picture like they do".

Summary 5: The GIN embeddedness of the Norwegian ICT sector

The Norwegian ICT sector source a relatively low proportion of its total R&D from actors abroad. Further, the geographical scope of the innovation collaboration network of the average Norwegian ICT firm is well below other sector averages. This reflect the combined effects of a lower overall propensity to engage in contract R&D (in favour of in-house knowledge development), and a lower propensity to engage in collaboration altogether (again, in favour of in-house knowledge development). In addition, it may also reflect how informal linkages. Once ICT firms have decided to engage in formal collaboration, the geographical scope of the collaboration network is well above country averages.

Combined this point back to the importance of understanding how specific *knowledge and opportunity conditions* impact on R&D sourcing and collaboration propensities in general, and thus affiliation with GIN networks by means of these linkages.

Table 27: GIN affiliation and location factors, NOR INGINEUS case firms

	Innovation Search		Innovation Collaboration		Innovation Sourcing		R&D location factors	
	Domestic	**International**	**Domestic**	**International**	**Domestic**	**Abroad**	**Domestic**	**Abroad**
Case 1	Very limited use of domestic information sources. Electronic user community to front/search consumer markets?	Broad use of international information sources; programming communities, customers & competitors. Electronic user community to front consumer markets?	No significant domestic collaboration partners.	Dense within-group linkages; subsidiaries abroad collaborate with business customers. Electronic user community to front consumer markets?	Weak, although some use of national science system. Strategy of avoiding sourcing.	Weak. Strategy of avoiding sourcing.	"Sticky" competences in HQ are continuously reproduced. Supply limitations in regional/ national labor market	Customer proximity, Access to qualified personnel (labor markets) most important determinant for R&D activity.
Case 2	Weak.	Transparent international sector community ease market search. R&D activities in the US front research communities.	Traditionally strong collaboration with research and national champion telecom company, now very weak due to reorientation of attention towards international activities.	Respondent do not want to discuss linkages outside group in detail. But strong linkages internally, in particular towards research in the US and production in China.	Weak/no linkages beyond labor market.	Modular components.	"Sticky" in-house competences which are reproduced due to cumulativeness.	Access to qualified labor and research communities. Expect increasing emphasis on China because of 'melting pot' effect from technology transfer and the strong linkage between production and knowledge development.

Case 3	Advanced consumer & business markets have traditionally been important drivers of application & service development.	Broad international market search, in particular Asian markets through subsidiaries. Strong emphasis on predicting future consumer trends. Also increasing emphasis on the creation of internal "corporate search spaces" which diffuse information & ideas across locations. Has implemented electronic "platforms" for external application developers.	With lead users & research communities. The latter has weakened with reorientation of core activity away from technical innovations to services & applications.		Sourcing of complementary technical capabilities.	Active contractual sourcing of complementary technical capabilities (infrastructure, components & hardware, etc). Acquisition-based sourcing of firms with key complementary services (e.g. a bank).	"Sticky" in-house competences reproduced due to cumulativeness and HQ roles as gravitation centre/coordinator of international activities.	Expected market opportunity – combined effect of expected growth and willingness to absorb new services. In one case (Malaysia) also proximity to ICT research community.

Case 4	Domestic customer base important information source.	International communities are searched actively through parent group network.	Domestic customer base. No research system linkages.	Other units in parent group network.	No relationships of significance	Intense sourcing of technology embodied in parent group supply, Strong parent group emphasis on sourcing technology in the form of small firms & patents.	Markets.	Markets.

1.8 Subject 6: coordinating and communicating in GINs

ICT software development does not involve suppliers in the traditional sense, the identification and coordination of which on a global scale is one of the challenges (and sources of network complexity) for traditional manufacturing firms. Further, it does not involve "production" in the traditional sense, which in turn removes challenges related to value chain design, production planning and logistics. And last, it is commonly argued that modularity and industry standards on the *technology* side reduce the challenges related to GIN communication and coordination.

Table 28: Factors which represent a challenge of barrier to international innovation collaboration, NOR INGINEUS survey sample (q11).

	Share stating moderate or higher barrier	Extreme barrier	Serious barrier	Moderate barrier	Small Barrier	No barrier	Response count
Finding relevant new knowledge	58,5 %	0,0 %	13,8 %	44,7 %	28,7 %	12,8 %	94
Overcoming organisational barriers	47,9 %	0,0 %	16,0 %	31,9 %	35,1 %	17,0 %	94
Changing the current location and related costs	56,0 %	4,4 %	22,0 %	29,7 %	29,7 %	14,3 %	91
Managing globally dispersed projects	60,9 %	6,9 %	24,1 %	29,9 %	25,3 %	13,8 %	87
Harmonising tools, processes, etc	58,9 %	1,1 %	15,6 %	42,2 %	33,3 %	7,8 %	90
Answered							95
Skipped							87

In the Norwegian case we have already seen that this latter assumption does not hold, as this modularity and standardisation has translated into a shift in innovation strategies towards activities dominated by other forms of knowledge, the development and transfer of which is not subjected to codification & standardisation. Geographical scope and broad network linkages still lead to problems of co-ordination, communication and integration between and of its constituent element, as Table 28 above clearly reveal: It is only overcoming organisational barriers which is perceived as a small barrier or not a barrier at all by more than than 50 per cent of the sample firms. Barriers related to finding relevant new knowledge on a

global scale (i.e. search) are perceived as a moderate or more serious barrier by over 58 per cent of the sample, but even more challenging is the subsequent process of managing globally dispersed projects. Almost 17 % of the sample finds this to be a serious or extreme barrier, which brings the total share of firms stating this as a moderate or higher barrier up to 61 per cent.

These findings are not surprising against the background of ICT sector opportunity and knowledge conditions. The larger the degree of openness and the more diverse actor groups involved, the more problems of knowledge system compatibility and relative absorptive capacity emerge. These problems are reinforced substantially when involved knowledge is not "stable" and changes occur to too fast for codification and standardisation to keep pace, and when rapidly changing technological landscapes necessitate broad, explorative innovation search processes (which by definition are riddled with uncertainty and thus cannot be predesigned).

This has implications for coordination and communication within and outside the company. Cases 1, 3 & 4 all stress the importance of internal information and knowledge diffusion on a broad basis, as a foundation for exploration beyond the initial point of entry or conceptualisation. Case 1 in particular stress the importance of controlled, organic growth combined with 'socialisation' as the basis for control and communication without excessive administrative systems. "We do it simple, build a common culture by way of osmosis, this creates communication channels across the different countries" and "we move around people a lot". To enable the establishment and maintenance of internal communication channels, new subsidiaries are established through greenfield investments, with key Norwegian personnel on site during the early stages. This strong emphasis on socialisation entail that inter-unit communication is perceived as functioning well, but the respondent explicitly stress the importance of the organic growth strategy applied.

The respondents report of massive information flows and a huge amount of information available for anyone. In general, more and more communication occurs through different electronic channels. Respondents agree that on the one hand, face-to-face contact does stimulate communication. But on the other hand, electronic communication is much cheaper and more flexible, meaning that one can "meet" far more often. Increased frequency is compensating for the lost "richness" per meeting, compared to face-to-face. This seems to works impressively well, in part because of modularity and shared "basic competences" within the companies, but in many cases (i.e. Case 1, 3, 4) it is stressed that the underlying social basis (corporate culture) is of equal importance as the characteristics of the technologies per se.

This in turn generates challenges of information filtering and selection. As GIN linkages create extensive amounts of knowledge, the respondent says: "It is vital that you can access the 'important' knowledge or information, but how do you separate out the important knowledge or information from not so important input?" One of the respondents suggested that having a strong HQ is essential in order to manage and direct the knowledge flow that runs through the enterprise. The gravity of this company has over the years changed, as mentioned; most of the companies' activities are placed outside of Norway. Yet, it argues that the increased emphasis placed on the creation of electronic platform for information sharing may increase this gravitation role of HQ. Similarly, case 3 is part of a multinational group

headquarter outside Norway. It points to the present decentralized decision making structure of the company, which is combined with a strong emphasis on maintaining the socio-organizational basis for rich information diffusion and use by means of electronic communication. At the same time, it questions the extent to which new (or former) gravitation points will form (or remerge) within the group network, as a result of this same decentralized structure. Taken together with the strong HQ orientation of case 1, we can therefore conclude that increased decentralization of decision making, and the 'flattening' of information distribution within these corporate groups, is not necessarily an inevitable outcome of their emphasis on decentralized decision making and information diffusion. As put by one respondent (case 3), increasing centralisation of core activities may follow when the company increasingly position itself as the link between mass consumer markets and external developers of modular applications.

Yet, one of the respondents felt that in the future one would see more distributed innovation than today and that the strongholds of today will be less distinct. He also mentioned that some of the activity taking place in Silicon Valley is downsized somewhat, and that the activity in Bangalore is similarly increased, suggesting a shift in strategic location. However, this respondent do not see new strongholds emerging out of this since the product portfolio of the company is too broad and the need for physical presence in markets is to high.

Summary 6: coordinating and communicating in GINs

Modularity, standardisation and generic codes for communicating technical knowledge are not sufficient for ICT industry firms to overcome challenges of coordination and communication in GINs. ICT firms still experience problems with respect to identifying relevant knowledge on a global scale. Yet, once firms have internationalised, they gain access to much more diverse information and knowledge. They are then forced to work actively with establishing the internal communication channels which are necessary to diffuse this across locations. Those who (due to necessary absorptive capacity and financial strength) manage to overcome these challenges of search, internationalisation and subsequent integration are amply rewarded with innovation inputs.

Information flows in international corporate networks often require, or result in, the establishment of particular strongholds. These remain being the HQ of the enterprise group.

1.9 Subject 7: prospective, impact from crisis

Table 29: How have you reacted or planning to react to the current global economic crisis? NOR INGINEUS survey sample (q14)

	Percent	Count
Few or no changes	69,2%	72
Increasing effort at innovation on our part	30,8%	32
A serious reduction of innovative activities	5,8%	6
Relocation abroad of innovative activities	6,7%	7
Relocation of innovative activities to you from abroad	1,9%	2
Answered		104
Skipped		78

The impact from the financial crisis was felt differently among the interviewed firms, ranging from "little if any impact", to "increase in outsourcing motivated by lower costs" and in form of weaker consumer demand and that larger projects have been postponed. In general, there is however little evidence that the crisis will have a substantial impact on the GIN affiliation of the sector, or on its innovation activities more broadly. This is consistent with other recent surveys, of bordering sectors in Norway (Herstad & Brekke, 2010).

Summary 7: Financial crisis impact on GIN formation in Norwegian ICTs

The large proportion of ICT sector firms which are small and serve domestic markets have been sheltered from the crisis by its weak impact on this market. Consequently, most firms report that the crisis will not impact their innovation efforts.

1.10 Subject 8: looking forward, implications for policy

Table 30 below indicate simultaneously the importance of different location factors and different areas in which public policy may intervene. As would be expected, two-thirds of the sample state that more public economic support for innovation activities would be desired. More importantly and directly reflecting the picture of the industry portrayed above, almost as many firms state that higher skills in the labour are of moderate or high importance. Similarly, less than 1/3 state that better access to international research networks is of moderate or higher importance, and factors such as IPR and FDI regulations & enforcement considered important by fewer than ¼. This means again that the availability of qualifications in the

labour market, as determined by the combined effect of public education efforts *and* the existing industrial structure of different places, will remain to interact with market characteristics in influencing the location patterns of the industry. Policy can intervene in this at the margins through the research and education system, and by providing funding, but it is – based on the Norwegian case - very unlikely that such intervention may achieve more than either reinforcing broader positive logics of industrial revolution (the ICT industry customer base and the labour market), or slow down negative processes of evolution, both which are contingent on factors outside the domain of policy.

Challenges perceived by our individual firms span the full range from increasing the ability to appropriate the commercial value of advanced technical knowledge (case 1), to the much broader issue of how telecom operators can set themselves apart from each other in a landscape of increasing standardisation and emphasis on external application development. With respect to globalisation, few if any of the companies see their international operations as a direct threat to the domestic knowledge development; and several of the cases rather see the two as mutually reinforcing each other. With this follows oscillating movements of centralisation and decentralisation, processes which may create new gravitation points but also tend to reinforce those points which have the strongest absorptive capacity to begin with. With respect to outsourcing, the respondent believes that the phenomenon is highly exaggerated and that there are very strong limitations to the use of contracting out. “It can only be done successfully when the knowledge is outside your core activity, or it is stable. But we don’t do anything which is outside our core activity, and knowledge is not stable”. In this sector the innovation processes needs to be rapid and efficient and build on and contribute to the core competence base of the company. This becomes complicated, slow and costly if outsourced says the respondent. Further, outsourcing entail large knowledge transfers out of the company, raising the competence level of partners resulting in less knowledge accumulation within the company, hence reducing the cumulative impact of the development work.

Table 30: Considering your future innovation activities, please assess the need for improving the following factors (degree of need).

	Moderately or very high	Very high	Moderately high	Moderately low	Very low	Not needed	Response
Practical support from centres for the internationalisation of innovation and technology transfer	36,1 %	14,4 %	21,6 %	18,6 %	12,4 %	33,0 %	97
More public incentives and economic support	66,0 %	33,0 %	33,0 %	12,4 %	6,2 %	15,5 %	97
Better access to international research networks	29,5 %	7,4 %	22,1 %	25,3 %	14,7 %	30,5 %	95
Higher skills in the labor force	65,6 %	24,0 %	41,7 %	14,6 %	7,3 %	12,5 %	96
More stringent IPR	19,1 %	4,3 %	14,9 %	27,7 %	17,0 %	36,2 %	94

regulations/enforcement							
Better and cleares rules regarding FDI and trade	20,2 %	4,3 %	16,0 %	21,3 %	8,5 %	50,0 %	94
More open and flexible migration policy for employing experts from abroad	23,2 %	9,5 %	13,7 %	22,1 %	13,7 %	41,1 %	95
Greater availability of risk capital for innovation activities with an international dimension	41,7 %	22,9 %	18,8 %	15,6 %	9,4 %	33,3 %	96
Answered							98
Skipped							84

The main challenge at the economy level, and thus on policy, is to support the development of 1) territorially embedded knowledge bases upon which individual firms may feed; 2) ensure that 'internal' system dynamics does not translate into lack of external input, and 3) ensure that strong external linkages does not translate into constraints on the degree of domestic 'embedding' (see Herstad et al, 2010, for a discussion). In this perspective, the low degree of internationalisation in the Norwegian ICT sector may be perceived as indicating a future challenge related to dimension number 2. At present, the industry is highly polarized between a very limited number of large & internationalised actors, and a very high number of small actors. This polarisation reflects the specific opportunity and knowledge conditions of the industry the last decades, combined with the inherently high degree of user-orientation in ICT services industries which has enabled numerous small firms to establish and compete based on domestic knowledge externalities upstream and specialised demand downstream. The big question seems to be the extent to which these companies are able to develop the internal resources necessary to eventually become larger, domestically embedded but globally linked actors.

In this context, the Norwegian system of industrial & innovation policy may have certain weaknesses. First, it is strongly oriented towards creating linkages between industry and the science system, normally in the form of sourcing rather than collaborative relationships. As we have seen and explained, sourcing of R&D services is not a preferred mode of network affiliation for ICT software firms, and the science system is by far not the preferred partner. Second, firms need to identify and tap into relevant knowledge *wherever* it is located, and this challenges search and coordination capacity more on an international scale than domestically. Yet, Norwegian policy schemes directed towards R&D and innovation often discriminates towards 'global knowledge' and the support of foreign milieus in R&D projects. The respondents says: "Knowledge development must be carried out where the knowledge is", and for some core knowledge areas these developments are located outside of Norway, and Norwegian schemes do not support or finance activities where most of the development is carried out outside of Norway even if "Norway as a nation will gain by this" as the respondent says. In this company each researcher has its own competence network, representing the most knowledgeable milieus in the world in their specific field. In order to receive finance for an R&D project it is often required that the company uses a Norwegian university - and as such neglecting where the best knowledge for specific projects are located.

Other aspects mentioned with relation to R&D schemes that could be of relevance for the sectors was that R&D programs only support projects that will develop something concrete (physical) that you know what is in advance of the project, which is hard when you engage in and R&D project in the ICT field! These schemes also insist that the use of R&D grants are to be specified in advance and that the granted money can be seen as essential for the development of the project. These are parameter you often cannot assure before the start of a research project. The respondent mentioned one project that was near by getting an R&D grant, but the company neglected it due to strict detailed statements given in advance from the research council. The respondent says that a motivation to make use of R&D schemes is that these are projects where the company wants to take a risk – to find something radically new - they want to test out ideas where the outcome is uncertain. It seems that the Norwegian R&D schemes are not willing to take enough risk in such projects.

One respondent is also keen on warning against excessive emphasis on very long education programs; the challenge from the industry side is access to people in large enough quantities who have the basic competencies necessary to engage in industry-specific knowledge development. Locking larger proportions of the labour force to the education system for prolonged periods of time may therefore work contrary to intentions. In general the company need to develop and accumulate competences internally in their own organisation, and conduct innovation processes fast and efficient, suggesting that the innovation policy funding tools and schemes should give industry more control over the project as such, and allow it to conduct development work without numerous requirements as to collaboration with the science system. The importance of internal industry competence development and accumulation seem to be an overall neglected issue in Norwegian innovation policy, according both to respondents and to previous research.

Outside the domestic economy, one of the respondents point out that “emerging economies” fairly rapidly will cease to be “low cost” countries, and that this will result either in companies seeking out to new low-cost countries or in shifting emphasis (“roundtrip”) back towards home-base or north operations. Further the respondent emphasise that many companies are underestimating the costs related to establishing and coordinating activities in low-cost countries, further the respondent is critical to outsourcing parts of the value chain as a lot of the “innovation capacity” and “thinking power” is located in processes of “doing” and as such emphasising the need to maintain complete value chains to avoid hollowing out of this innovation capacity. “If too much is outsourced, very little will remain”. Implicitly warning against the idea that academic research – in itself - can sustain industrial development in the North. On the other hand, the respondent also warn against (a Norwegian) tendency to consider the international business environment in general, and low cost economies in particular, as only a threat.

Summary 8: Prospects & policy implications for Norwegian ICTs

The most important localization factors at play in supporting the ICT industry is a) access to competent labor (and thus knowledge developed by other ICT or non-ICT sector firms), and b) the demand base. In addition, firms the sector point to c) funding constraints, which are likely to influence not only their innovation activity in Norway but also their ability to

internationalize. Consequently, policy can support innovation through education effort. The government can also directly influence the demand drive so important in the sector by acting as a lead customer; and indirectly by means of regulation. However, as such efforts serve to 'contain' the sector at home, it is important that complementary policies seek to support the internationalization of the industry.

1.11 Conclusions

Taken together, this all suggests that the Norwegian ICT sector is caught between strong domestic centripetal forces, (the domestic demand base, competences embedded internal to ICT sector organizations, small average actor size with related lack of organizational resources necessary to establish and exploit international linkages); and on the other centrifugal forces related to the diversity of international markets and the availability of specialised competences in the labour markets of specific places.

In between these centrifugal and centripetal forces we find a process of internationalization which is not only polarized between (a few) large firms and (many) small, but also characterized by oscillating movements within the large-firm segment. This entails that one should be careful when interpreting present movements in either one direction as a clear indicator of the future status quo. For instance, as clearly pointed out by case 2, offshoring of activities may require attention to be allocated away from domestic linkages during the early establishment and consolidation phases; but these domestic linkages may be established at a later stage, once foreign operations require less management or researcher attention. Similarly, both cases 3 & 4 have developed (case 3) or is part of (case 4) relatively decentralised corporate organisational structures, the purposes of which are to ensure that each unit embed well in their respective external economies. Yet, according to case 3, this present organisational structure may be followed by more standardisation of procedures and platforms for sourcing ideas and applications from those external contexts, partly because this is necessary to ensure their use on a broader basis, in other markets. This in turn may require a higher degree of centralisation, enabled partly by technologies developed by the sector itself.

Summary

Contrary to common assumptions, the Norwegian ICT sector operates based on knowledge which is sticky and contextual. As a result, it has comparably weak linkages to global innovation networks. This is partly due the mentioned knowledge conditions, combined with strong opportunities for innovation in domestic markets and an apparent inability overcome the initial barriers to internationalization. To some extent, this reflects the immaturity of a sector which as expanded very rapidly during the last 15 years, based on such domestic opportunity conditions. Once these barriers have been overcome and subsequent coordination and organization challenges have been met; ICT firms are able to link up to and capitalize on the wide range of external information and knowledge inputs which then become available. This results in the polarization of the sector which we can observe at present.

Table 31: Innovation drivers & strategy in Norwegian case firms

	Opportunity conditions		Knowledge conditions		Innovation strategy	GIN affiliation
	Input (knowledge)	**Output (market)**	**Composition**	**Cumulativeness**		
Case 1	Relatively high technological opportunity due predominantly to strength of internal knowledge base & routines.	Low in domestic and medium in international. High opportunity with respect to incremental changes in design and user interface, but does not translate into profit due to appropriability problems.	Engineering-based; relatively narrow, centered around advanced programming. Based on R&D originally conducted by case 3.	Moderate.	To be best on their core technology; fastest (technically best) browser. Low appropriability on the design & application side combined with (perceived) weakness of capabilities reproduce focus on technical product features.	Sales presence in proximity to customers, R&D subsidiaries in selected contexts. Strong emphasis on internal communication. Strong emphasis on 'socialization' of employees into corporate routines and 'tacit' components of the knowledge base.
Case 2	Medium. Cumulative development of specialized internal competencies.	Low to medium in international markets. Constrained by conservative infrastructure investment market.	Engineering-based, multi-disciplinary, tacit & complex. Highly firm-specific.	Very high.	To continuously anticipate & define incremental changes in market demand, cut production costs & maintain/increase quality.	Off shoring of "basic" R&D to the US, production to China (own subsidiaries).
Case 3	High - induce entrepreneurial activity, acquires external knowledge as well as building own capacity to innovate.	High in domestic & international markets	Engineering-based knowledge originally at the core, now more and more broad, multi-disciplinary core competence base related to service development and provision in different markets.	Relatively low with respect to modular "hardware" and products with high rate of turnover. Medium to high at service-provision side.	Combine internal and external strategies. Use existing internal capabilities as a platform to identify capitalize on external ideas & technology.	Internal creative accumulation and offset external creative destruction

Case 4	High, due partly to intense small-firm based experimentation with new technologies.	High in domestic & international markets. Enormous parent group expansion supported by market.	Engineering-based knowledge originally at the core, now more and more broad, multi-disciplinary core competence base related to service development and provision in different markets.	Low at engineering side. Extensive sourcing of technology. High at the level of 'organizationally embedded' competences.	Combine internal and external strategies. Use existing internal capabilities as a platform to identify and capitalize on external ideas & technology.	

References

Asheim, B., Ebersberger, B., & Herstad, S. (2010). MNCs between the global and the local: Knowledge bases, proximity and globally distributed knowledge networks. *Conference paper, DRUID Summer Conference 2010, London June 16th-18th.*

Hauknes, J., & Knell, M. (2009). Embodied knowledge and sectoral linkages: An input-output approach to the interaction of high- and low-tech industries. *Research Policy, 38*(3), 459-469.

Herstad & Brekke, 2010. "Globalization, modes of innovation and regional innovation systems". Paper presented at the 5th International Seminar on Regional Innovation Policies October 14th-15th Grimstad, Norway

Hollanders, H., (2007). Innovation modes. Evidence on the sector level. Europe Innova Sectoral Innovation Watch deliverable WP4. European Commission, Brussels.

ANNEX 2 – COUNTRY SECTOR REPORT: ICT AND AUTOMOTIVE IN SWEDEN

Author: Cristina Chaminade (cristina.chaminade@circle.lu.se), University of Lund (ULUND, Sweden, participant no.13)

2.1 Introduction

The objective of this report is to understand the specific dynamics of two industries: the ICT industry and the Autoparts industry in Sweden, with regards to the access to Global Innovation Networks. This report is the contribution of ULUND to WP9.

Global innovation networks are defined in this report following Archibugi and Michie (1995)27 who proposed to distinguish between three forms of globalization of innovation: the global exploitation of innovation, the global research collaboration and global generation of innovation. The global exploitation of innovations refers to the international commercialization of new products or services and has its economic equivalent in the export of new products or services or in the international licensing of patents. The global research collaboration alludes to the joint development of know-how or innovations with the participation of partners from more than one country. This collaboration can take a variety of forms, including R&D joint-ventures, R&D alliances, contractual R&D, etc. and can involve a variety of actors, including firms, research centers, universities or the government, among others. Finally, the global generation of innovations refers mainly to the location of R&D activities in a different country and it is associated with R&D related foreign direct investment. Additionally to this, we consider the *Global Sourcing of Technology* as a fourth form of globalization of innovation and engagement in global innovation networks.

Innovation is defined in this report in very broad terms, including product and process innovation as well as radical and incremental innovation. In terms of networks, we consider both internal as well as external networks, that is, the linkages between the headquarter and its subsidiaries (internal networks) as well as the collaboration with external actors in the research and innovation process.

[27] Archibugi, D. and J. Michie (1995). "The globalisation of technology: A new taxonomy." Cambridge Journal of Economics 19(1): 121.

The report is based on empirical data from a) the dedicated INGINEUS survey, b) firm-based case studies and c) desktop research.

Within the INGINEUS consortium, Sweden was the only country that conducted the survey in two industries: Autoparts and ICT. This allows us to systematically compare the different behavior of two industries that are embedded and affected by the same national innovation system.

2.2 Method

2.2.1 INGINEUS survey

The dataset used to identify the survey universe was from Statistic Sweden. We selected all the firms that operate in ICT and Automotive sector specifically in Telecommunication equipment and software (for ICT) and Autoparts, for automotive. These sub-industries corresponded to the following NACE 2 codes: 26.30 Manufacture of communication equipment; 62.01 Computer programming activities; 62.02 Computer consultancy activities; 62.03 Computer facilities management activities; 62.09 Other information technology and computer service activities; 29.31 Manufacture of electrical and electronic equipment for motor vehicles; 29.32 Manufacture of other parts and accessories for motor vehicles.[28]

The data base lists small, medium size and large organization. In order to ensure the comparison with other INGINEUS countries, we only considered firms above 5 employees.

In the original dataset there were listed 2181 companies but not all had contact details. We ended up with a final set of 1830 companies (1662 ICT; 168 Automotive). The final completed responses in the Swedish survey are 195. The partial respondents are 426. We conducted a non-response test to check the robustness of our survey, comparing selected questions with data from Statistics Sweden and the survey was robust.

The survey was conducted in three steps. First we did a pilot survey to test the validity of the questionnaire. The questionnaire was subsequently changed. In a second stage, we sent the questionnaire to the 1830 firms in our data set, using an electronic-based survey (survey monkey). To increase the response rate, we contacted the firms a second and a third time by email. With these consecutive interactions, we were able to raise the response rate to

[28] The term ICT will be used in this report to refer exclusively to Telecommunication equipment and software, which are the focus sub-industries in INGINEUS.

approximately 10%, this is considered to be high for an electronic-based survey. Table 32 next deploys the number of firms and the response rate.

Table 32: Swedish INGINEUS survey

26300 (Telecom. Equip)			
n. of firms	49	6	53
% on group tot.	92,45	11,32	100
% on ICT sample tot.	2,89	0,36	3,12
62010-90 (Computer services)			
n. of firms	1477	165	1642
% on group tot.	89,95	10,04	100
% on ICT sample tot.	87,13	9,73	96,87
29310&29320 (Autoparts)			
n. of firms	152	24	176
% on group tot.	86,36	13,63	100

2.2.2 Cases

The cases were identified in close collaboration with the other partners in INGINEUS. The main objective was to identify companies that had locations in both North and South, to be able to grasp the dynamics of GINs and the interactions with innovation systems with very different institutional frameworks. For ICT, the selected companies had locations in at least 4 of the following 5 countries: Sweden, Norway, Estonia, China, India and South Africa. For the automotive industry, the selected companies had locations in at least 2 of these 4 countries: Sweden, Brazil, Germany and South Africa.

The interviews took place in 2010 and 2011. The person interviewed in each firm was at a very high level – Company's CEO-. We used semi-structured interviews, with an interview guide that covered almost all critical questions for every work-package in which ULUND participated[29].The list of interviewed companies is summarized next.

[29] WP4: Regions and GINs, WP5: offshoring, WP6: Competences and GINs, WP9: sectors and WP10: Policy and GINs.

Case 1, 2 and 5 will be used in this report to illustrate some of the issues that emerge from the INGINEUS survey. These three cases are the most complete ones and the ones that offer better insights into the sector dynamics.

	Industry	HQ	Size of unit in Sweden	Locations in INGINEUS countries
Case 1 "TELEQUIP"[30]	Telecom. Equipment and software	Sweden	Large	Sweden, Norway, South Africa, China, India
Case 2 "SOFTNOR"	Software	Norway	Medium	Sweden, Norway
Case 3 "SOFTUSA"	Telecom. software	USA	Medium	Sweden, Norway, India, Estonia and China
Case 4 "SOFTUSA2"	Telecom software	USA	n.a.	Sweden, Norway, India, Estonia and China
Case 5 "AUTOSWE"	Autoparts	Sweden	Large	Sweden, China, South Africa

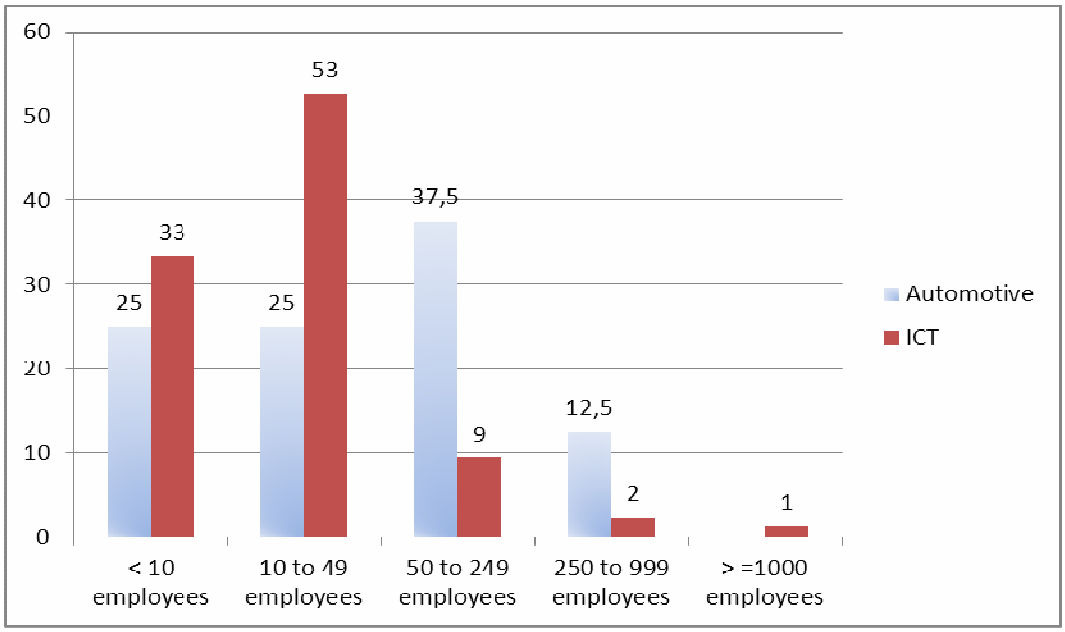
2.3 Present nature of sector activities in Sweden

Both ICT and Automotive are considered to be strategic industries in Sweden. According to VINNOVA (2007) the ICT industry is responsible for a 12% of the Swedish industrial production and 15% of the exports. With regards to innovation activities, the ICT industry is responsible for almost a third of all business R&D and it performs near 70% of all the ICT-business related R&D. It is very difficult to estimate the number of employees in the ICT industry, as they are very ill classified by the current NACE code-based statistics but it was estimated in about 180000 employees (2003). In terms of employment, the Swedish automotive industry is not so far behind, with an estimated 140000 employees in 2003 (Vinnova, 2007).

[30] The names of the firms are fictitious. The real name of the firm is kept secret for reasons of confidentiality.

The INGINEUS survey may provide a more accurate picture of the type of firms in the Swedish ICT and Autoparts industry. In terms of size, a majority of ICT firms are small firms with less than 50 employees. In contrast, Autopart firms are larger in average size, although still most of the firms are under 250 employees, as Figure 1 shows.

Figure 1: Distribution of sample by size



Source: Swedish INGINEUS survey

Most of the companies in both samples are standalone companies. Only a 2,35 percent of ICT and a 4,17 percent of Autoparts are multinationals, as next table shows. In terms of the most important market, both industries are mainly targeting the domestic or regional market. However, a high proportion of Autopart firms are also targeting international markets. Autopart firms either work for large assemblers that, with few exceptions (Volvo and Saab) are from outside Sweden or to module assemblers, which may be located in Sweden. When they do export, both ICT firms and Autopart firms target mainly the European market or the US market (for Autoparts). The proportion of exports that go to other Asian countries or other parts of the world (where we find Brazil, China and India) is still marginal, at least as compared to the other markets.

Table 33: Type of firm Swedish INGINEUS survey

	ICT (n=194)	Autoparts (n=24)
Stand alone	87,65%	83,33%
Subsidiary	10,00%	12,50%
MNC	2,35%	4,17%

Source: Swedish INGINEUS survey

Table 34: Location of largest market

	ICT	Autoparts
Count	164	24
Internal to enterprise	1,20%	0,00%
Regional	31,10%	20,80%
Domestic	53,70%	41,70%
Export	14,00%	37,50%

Source: Swedish INGINEUS survey

Table 35: If an export market was selected, please indicate most important destination (multiple answer possible)

	ICT	Autoparts
Count	164	24
North America	11,70%	45,80%
South America	3,50%	25,00%
Western Europe	52,60%	83,30%
Central & Eastern Europe	17,00%	45,80%
Africa	0,00%	0,00%
Japan and Australasia	4,10%	12,50%
Rest of Asia	12,30%	4,20%
Rest of the world	4,10%	4,20%

Source: Swedish INGINEUS survey

2.4 Nature of knowledge and innovation in the sector

2.4.1 Type of innovation

About half of all the firms surveyed indicated that they have a significant R&D activity. This percentage is high both in the Autopart firms (54,2 % of the Autopart firms say that they have significant R&D activity) as well as the ICT firms (45,8%).

This high effort in R&D is reflected in the number of innovations as well as in the degree of novelty. As Figure 2 shows, about 16% of the ICT firms have introduced new to the world innovations. Again this percentage is much higher in the Autoparts firms where approximately one third of the firms have introduced new to the world innovation.

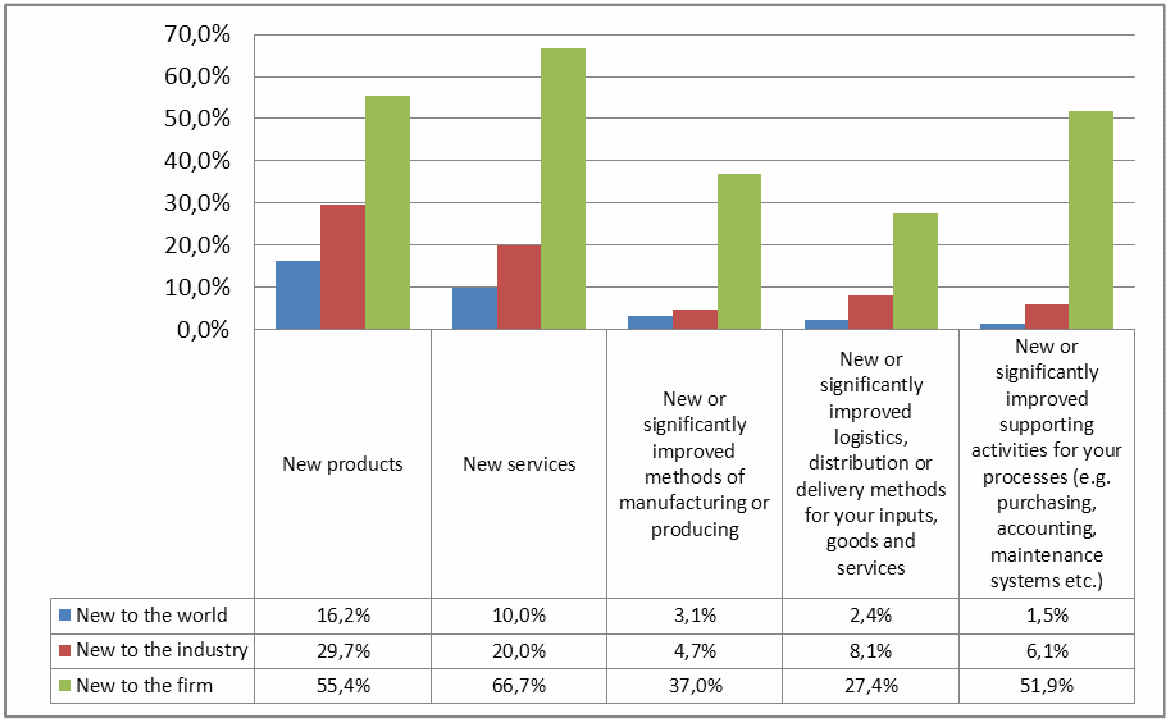
Both the high R&D expenditure as well as the high degree of novelty in innovation products and services, may be an indication that Sweden is specialized in high-added value activities, even in industries that are considered as medium to low tech by the OECD, like the automotive industry. The types of products in which Swedish Autopart firms are specialized are electrical and electronic equipment, pressing and stamping, safety accessories, like airbags, etc. They are usually first tier suppliers and their technology and research centers are usually located in very close proximity with the final customer, usually large car assemblers. Case 5 is a world-leading Autopart company, specialized in automotive safety. It is also a very research-intensive company. Their product development process consists of four phase's research, development, engineering and operation (start of production) and it is a process that can last 10 years. The first stage consists of 4-6 years before production, second stage needs 3-4 year and engineering 2 years. As can be seen there is a process of 10 years at least before the production can be started and launched in the market. The most important innovation in the company was developed 10 years ago and is still the innovation that sustains the main growth of the company and it is, still today, considered a new to the world innovation. This innovation is still determinant for growing particularly in emerging economies (China, Brazil and India) where there is a growing demand for more sophisticated cars. The rest of the innovations introduced later by the company are more of an incremental nature, mainly following the company strategy of improving the technology and the prize of the products.

In almost all cases conducted in Sweden, firms follow an innovation strategy that is both a combination of technology push and market demand but in four out of the five cases, the core research is being done with few external collaborators. This is also reflected in the Swedish INGINEUS survey. As Table 36 shows, 79,19% of the Autopart firms produce most of their technological inputs in-house. This percentage is a little bit lower for ICT firms- 68,35%. What the cases seem to suggest is that the most basic research (the one that is still several years before production) relies heavily on the skills and technological competences of the

firm. It is more in the development phase that the inputs from the market become more important. TELEQUIP and AUTOSWE can illustrate this point. As indicated by the interviewee in TELEQUIP "One of the most important innovation in the last years a protocol for data transmission. The first version of the 3G was still not ready for the protocol of data so 2 persons who were working at our firm came up with the idea to change the protocol (how to transmit the data). This innovation permitted to increase for example the speed of data. Now this innovation has leaded to 400 millions of subscribers. The core has been developed in Sweden while incremental improvements of the innovation (implementation of the idea) came from the different subsidiaries (e.g. in Europe and partly also in China)".

In AUTOSWE the engineering is carried out on location, in close interaction with the final car assemblers. Although the products are initially developed for a local market, they can also be spread out worldwide. As the interviewee states "If it is a very good innovation and design that has been mainly developed for example for the Chinese market but it is good, then we learn about it in the rest of the group and of course it could be spread around".

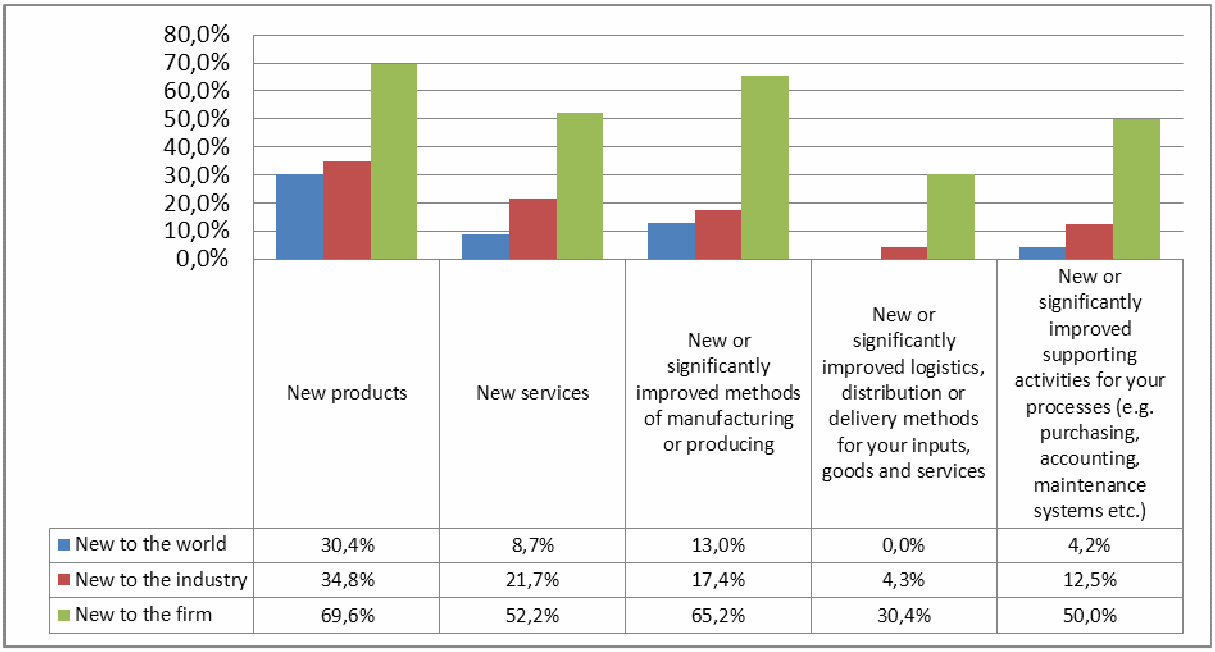
Figure 2a: Type of innovation and degree of novelty – Swedish ICT firms



	New products	New services	New or significantly improved methods of manufacturing or producing	New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services	New or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems etc.)
New to the world	16,2%	10,0%	3,1%	2,4%	1,5%
New to the industry	29,7%	20,0%	4,7%	8,1%	6,1%
New to the firm	55,4%	66,7%	37,0%	27,4%	51,9%

Source: Swedish INGINEUS survey

Figure 2b: Type of innovation and degree of novelty – Swedish Autopart firms



Source: Swedish INGINEUS survey

Table 36: Most important source of technology for the enterprise

		We produce most technological inputs in-house	We buy most of our inputs from other branches of our own MNC	We buy most of our technological inputs from non-MNC firms	We buy most of our inputs from MNCs with which we are not formally connected	Total
Autoparts	Count	19	3	1	1	24
	% within Autoparts	79,17%	12,50%	4,17%	4,17%	100%
ICT	Count	108	10	17	23	158
	% within ICT	68,35%	6,33%	10,76%	14,56%	100%

Source: Swedish INGINEUS survey

What the cases seem to suggest, is that the drivers of innovation as well as the geographical spread of the innovation activities is highly contingent to the nature of innovation. Core basic research is done mostly internally or in collaboration with a handful of very strategic

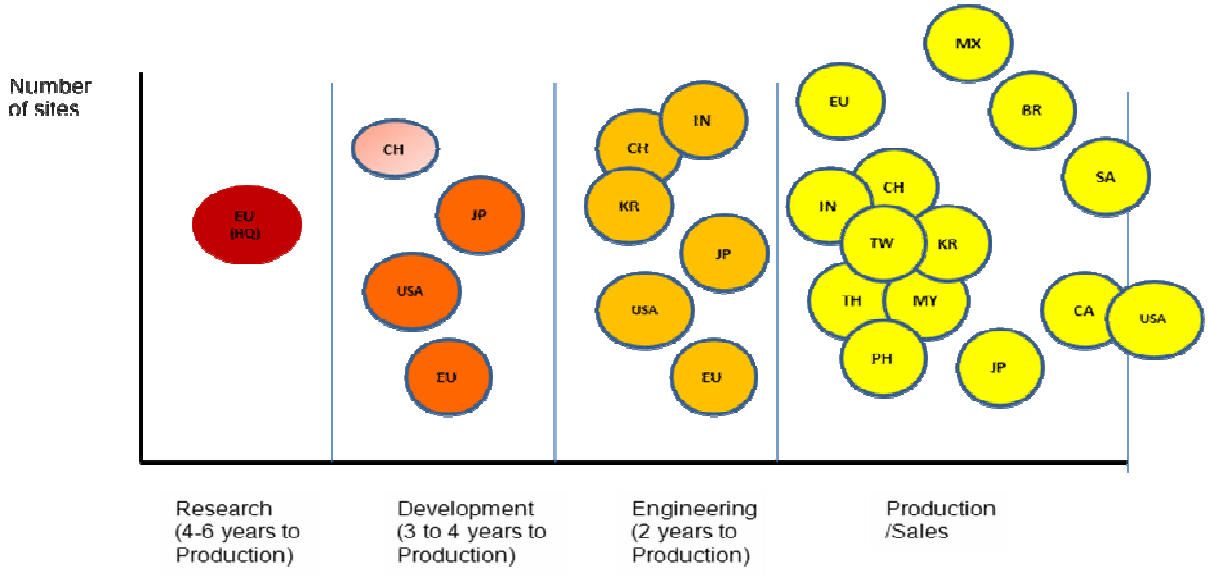
customers, while applied research and development can be done with a larger number of partners. Geographically, core research is close to the HQ and not spread in different locations worldwide although the ideas can come from subsidiaries, while applied research and development take place in many different locations around the world in close proximity with the market. AUTOSWE has different R&D centres around the world; each of them is specialized or responsible for one or various phases in the product development cycle. Only the HQ is doing the research (basic research, 4-6 years to production). The HQ, together with the subsidiaries in Japan, US and other European countries can do the development of the products (3-4 years to Market) while there are a larger number of subsidiaries that do only engineering or production. TELEQUIP indicates that "the development of new ideas involve often not only the HQ. Different subsidiaries teams participate for example in specific sections of pre-development where the ideas are shared). If instead an idea is developed in a subsidiary it is usually sent to the HQ where the core research is. The HQ takes therefore the control".

This relationship between the nature of the innovation and its geographical spread can be clearly seen in Case 1 "Telequip" and Case 5 "Autoswe". Graphs 1 and 2 plot the geographical spread of the R&D centers, according to the type of innovation conducted.

Graph 1: Geographical spread of the R&D centers of TELEQUIP

Source: Own based on interview

Graph 2: Geographical spread of R&D centers of AUTOSWE



Source: Own based on interview

In both cases, it is interesting to see that the types of innovation activities conducted in China are becoming more strategic for the company. In the case of TELEQUIP, the center in China is considered to be key in the area of radio based stations and, although its main tasks continue to be the development of incremental innovation for the Chinese market, TELEQUIP foresees that the Chinese center could conduct more core-research activities in the near future. In the case of AUTOSWE, the center in China has recently been engaged in the development stage that before, was only performed in centers located in the triad (US, Japan and Europe).

The linkages between innovation, internationalization and the decisions for location will be discussed in the next section.

2.5 Internationalization and location

In the previous section we have already discussed how Swedish ICT and Autopart firms engage in the exploitation of innovation as well as in the sourcing of technology. In this section, we will be discussing the other two forms of internationalization: the research collaboration as well as generation of innovation.

2.5.1 Global research collaboration

In general Swedish firms have a high propensity to collaborate with external partners as compared with other EU firms, being the most important ones the suppliers (78%) and clients (64%). Interestingly, there is a very high proportion of innovative firms that collaborate with China and India, even within small firms.

Table 37: Percentage of firms that cooperate in innovation by size and location of the partner.

	Total innov	**Sweden**	**Other Europe**	**USA**	**China and India**	**Other**
Below 10 employees	40	94	63	30	18	22
10-49 employees	37	94	58	28	16	21
50-249 employees	43	96	69	29	20	23
More 250 employees	65	95	83	43	31	28

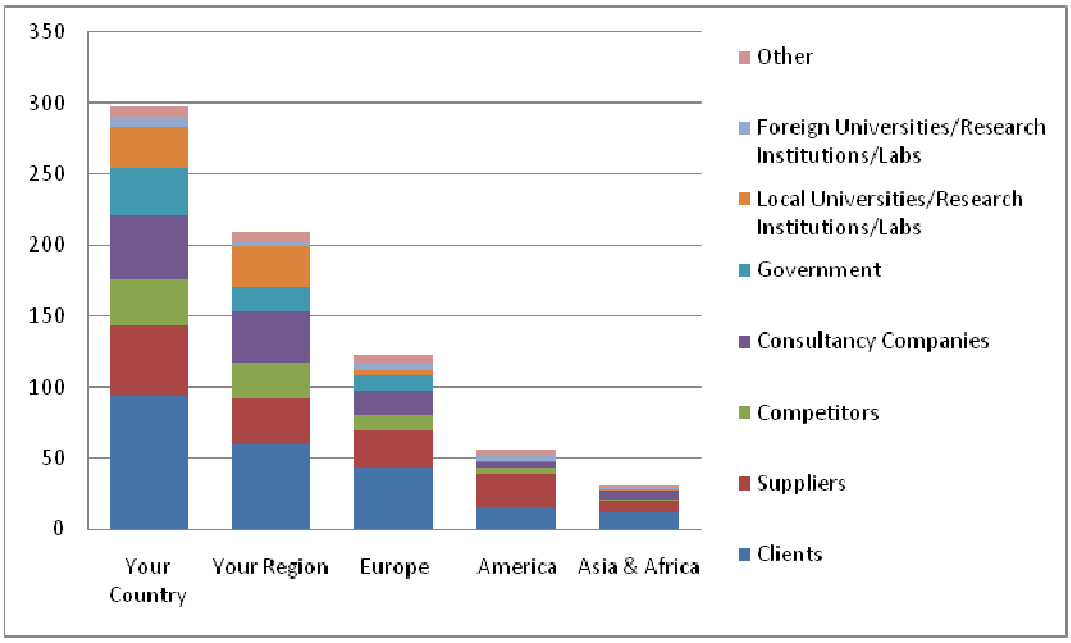
Source: Authors' own elaboration with CIS data (Eurostat, 2007)

In the INGINEUS survey, firms were inquired about their main partners for innovation, as well as the geographical location of those partners (regional, domestic, Europe, Asia&Africa and America). A simple analysis of the data shows that most linkages are at domestic level, both for Autoparts as well as ICT firms. However, there are significant differences in the international geography of the networks between the two industries. Contrary to what we would have expected, the research collaboration network of ICT firms is more contended geographically than the Autopart firms.

ICT firms collaborate less than Autopart firms but, when they collaborate, they use a larger variety of partners both in Europe and internationally. In this respect, the research network of ICT firms is more diverse and also more geographically dispersed than that of Autopart firms. This is highly coherent with the kind of knowledge that is dominant in the ICT industry which is highly codifiable and then more likely to be transferred across geographical distances and across different partners.

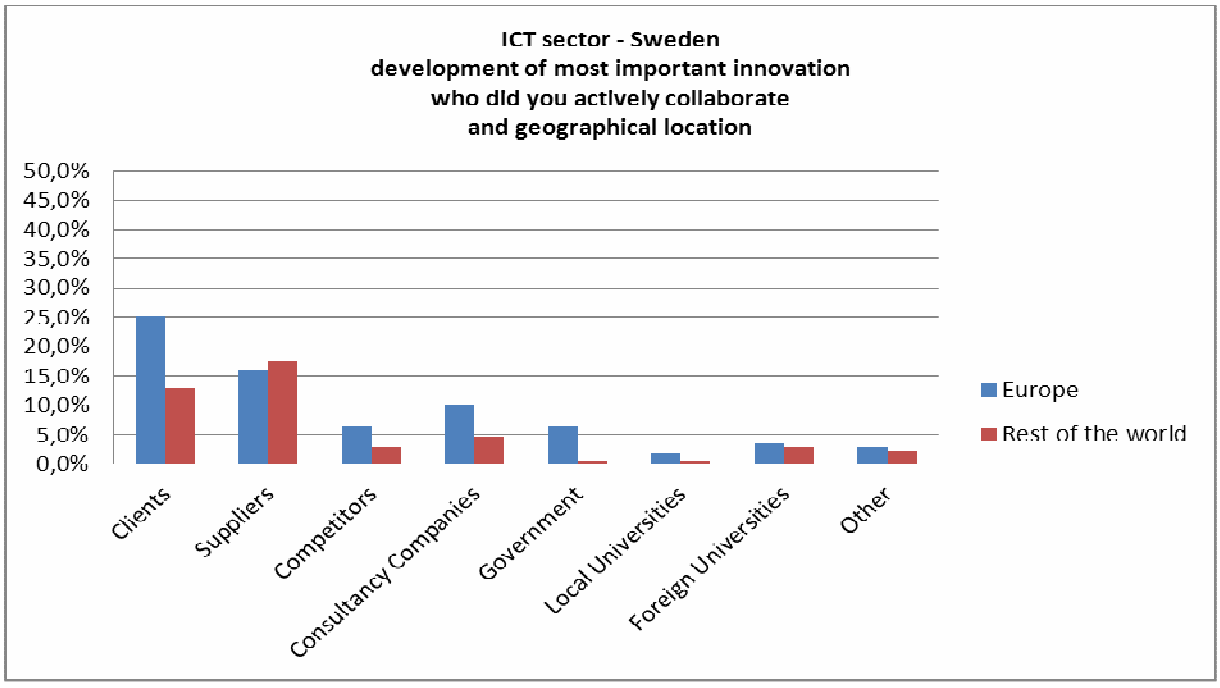
On the other hand, Autopart firms innovate in collaboration with the clients and suppliers and their network is more confined to Europe. In this respect, one could say that Swedish Autopart firms are more engaged in European networks with other organizations in their value chain.

Figure 3a: Collaboration for innovation in Swedish ICT firms



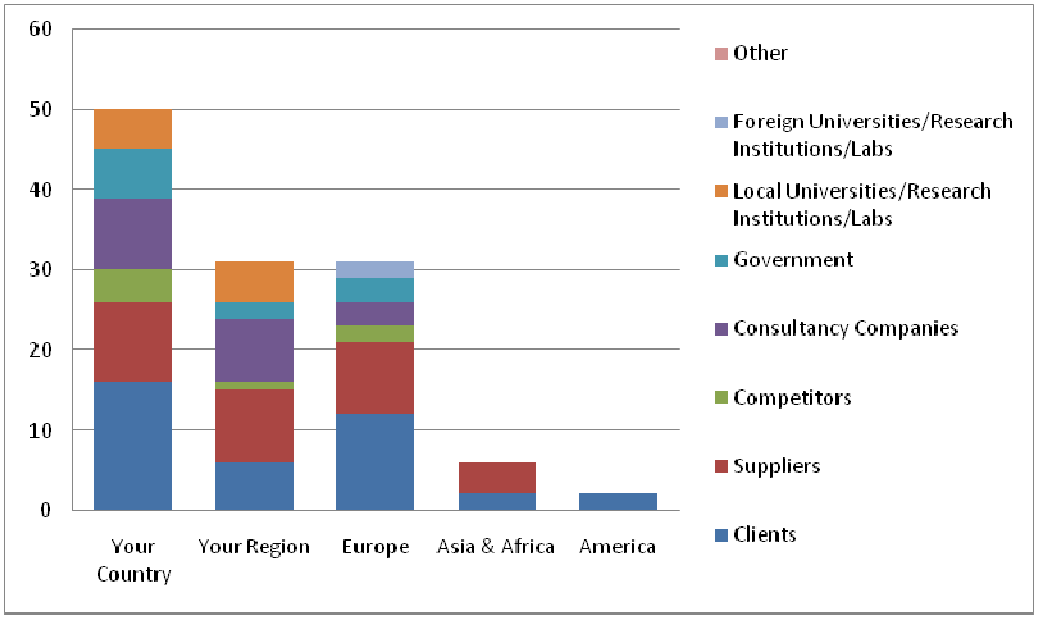
Source: Source: Swedish INGINEUS survey

Figure 3b: Collaboration for innovation in Swedish ICT firms



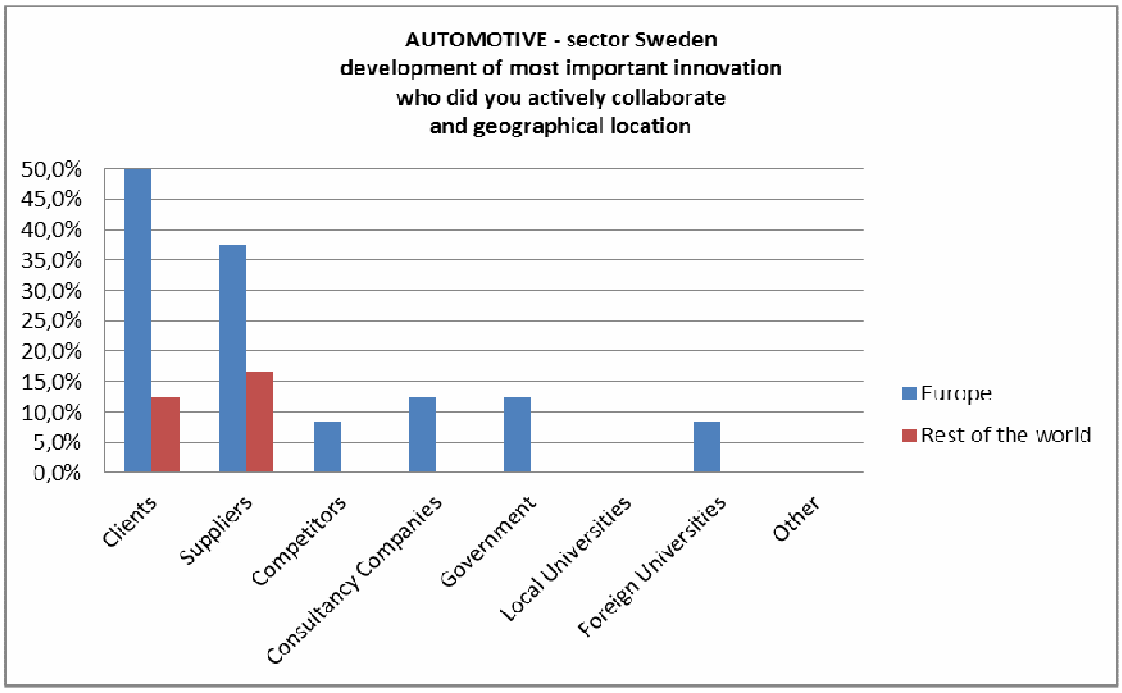
Source: Swedish INGINEUS survey

Figure 4a: Collaboration for innovation in Swedish Autoparts firms



Source: Swedish INGINEUS survey

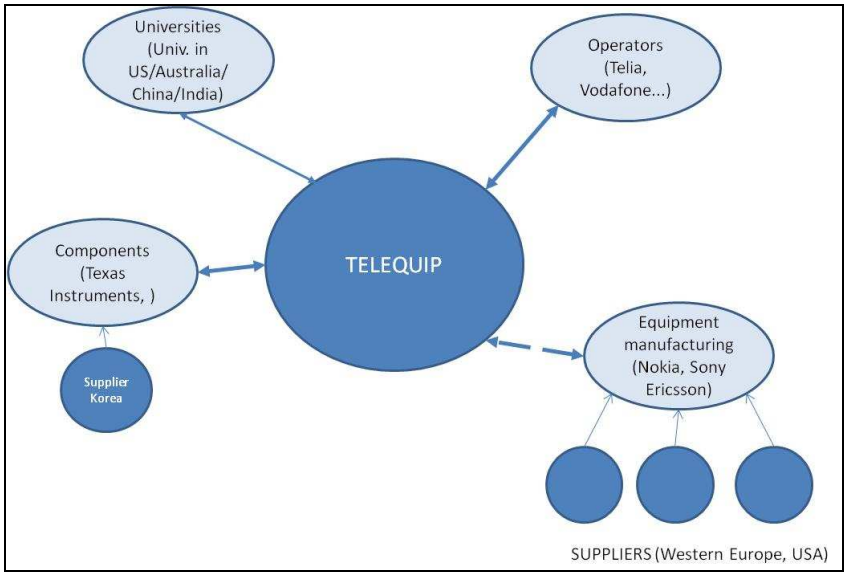
Figure 4b: Collaboration for innovation in Swedish Autoparts firms



Source: Swedish INGINEUS survey

TELEQUIP can help to illustrate how a typical network for collaboration in innovation can look like. As illustrated on the map the collaboration takes place with different actors. The universities represent an importance source of innovation. The collaboration happens mainly for accessing generic and high scientific knowledge but it is not related directly to the product that needs to be developed. For example TELEQUIP develops internally the algorithm that is necessary for the technological innovation (CORE RESEARCH) and lets the universities solve specific broader theoretical questions (GENERIC RESEARCH). The cooperation with universities happens both at local but also at global level (important is the cooperation with some American and Australian and in the last period Chinese universities). The main collaboration takes place with operators (who in turn have the networks with the equipment manufacturers) and component suppliers. In a typical project, the main partners will be located in Western Europe and USA, although some less important collaboration may also take place at local level.

Graph 3: Global research network of TELEQUIP



Source: Own based on interviews

The differences between Autoparts and ICT firms in terms of collaboration of innovation is also reflected in the proportion of firms that have developed formal or informal linkages with other organizations (not necessarily with innovation purposes). As Table 38 summarizes, a larger proportion of Autopart firms engages in formal and informal linkages with suppliers and competitors, while this proportion is higher for ICT firms when it comes to other

organizations, like competitors, consultants, government (only formal) or universities and research labs.

Table 38: Collaboration for innovation by nature of linkages

ICT (N=171)	Formal	Informal	No linkage
Customers	23,39%	30,99%	25,73%
Suppliers	25,73%	25,73%	26,90%
Competitors	7,60%	11,70%	47,37%
Consultants	23,98%	17,54%	34,50%
Government	9,4%	3,5%	49,1%
Universities/research labs	6,4%	9,9%	48,0%
Autoparts (N=24)	**Formal**	**Informal**	**No linkage**
Customers	37,50%	33,33%	12,50%
Suppliers	29,17%	37,50%	20,83%
Competitors	0,00%	12,50%	50,00%
Consultants	16,67%	20,83%	29,17%
Government	8,3%	8,3%	37,5%
Universities/research labs	4,2%	8,3%	45,8%

Source: Swedish INGINEUS survey

2.5.2 Global generation of innovation

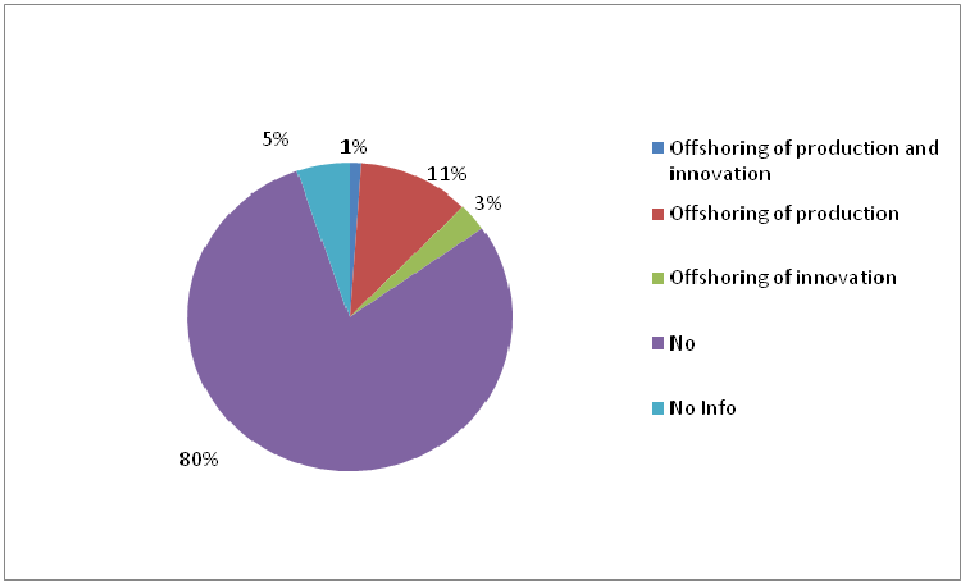
We have already seen that Swedish ICT and Autopart firms tend to keep basic research activities in the headquarters (HQ) or in very close proximity with the HQ. As we move towards more applied research and development, Swedish firms are more likely to decide to outsource or offshore innovation.

The INGINEUS survey asked the firms if they outsource or offshore innovation and, when they did, what was the main motivation of offshoring production and innovation. Once again, the results for the ICT industry and for Autoparts are quite different. The majority of ICT firms do not outsource or offshore production or innovation activities (80%) but there are some firms that offshore only innovation (3%) or innovation and production (5%). In contrast, the proportion of Autoparts firms that do not outsource or offshore is slightly lower (71%). Autopart firms offshore production more but very seldom they offshore only innovation. Innovation follows production and thus, the innovation network overlaps with the innovation network. As AUTOSWE indicates the firm locates innovation centers “following suppliers that are operating worldwide and locating its production and innovation facilities where the car makers have located their activities…. The global innovation network came after the

global production network (the technical centers and the developing centers are facilities that follow in steps the production facilities in a place."

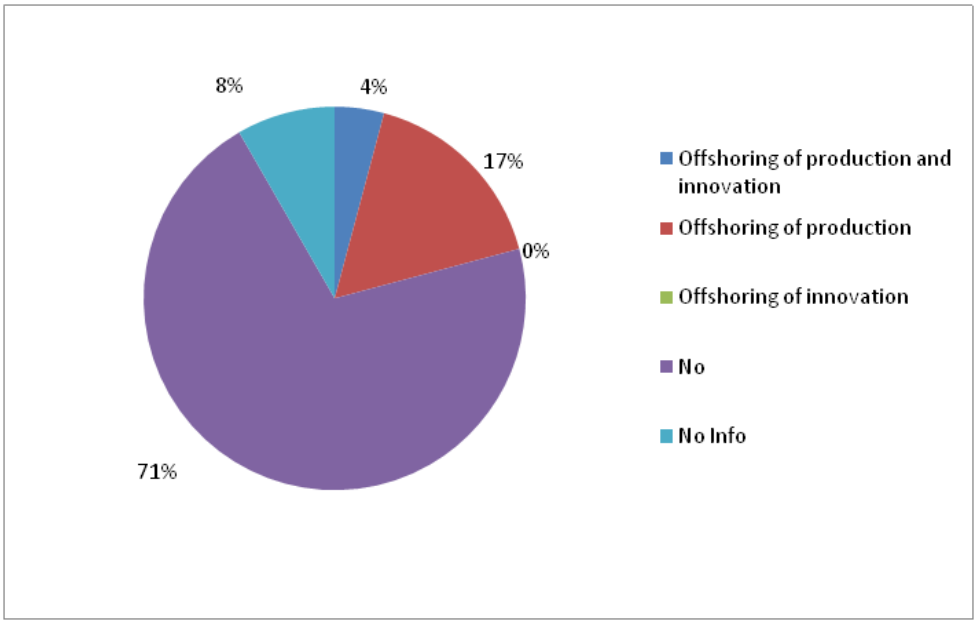
In the case of ICT, innovation networks may not overlap with production networks. Firms may locate innovation centers around the world to tap into specific competences. For example, SOFTNOR decided to locate an R&D center in Easter Europe to tap into a pool of qualified human capital that was available in that specific location after a large MNC in the ICT industry had closed down their facilities. TELEQUIP, on the other hand, decided to open an R&D facility in Bangalore to tap into software development skills.

Graph 4a: Offshoring of production or innovation in Swedish ICT firms



Source: Swedish INGINEUS Survey

Graph 4b: Offshoring of production or innovation in Swedish Autoparts firms



Source: Swedish INGINEUS Survey

In terms of the motivation for offshoring or outsourcing production and innovation activities, for ICT firms the main motivation is the access to qualified human capital at a lower cost, both for offshoring of production and innovation, followed by the availability of specialized knowledge in the host region as well as access to other infrastructure and new markets. Autopart firms share most of the motivations with the ICT firms, being the main difference the fact that the existence of specialized knowledge in the host region is not important for Autopart firms, while for ICT is (both for production as well as for innovation). This reinforces the idea that ICT and Autopart firms may follow different strategies: ICT firms offshore to access knowledge and may offshore innovation in places where they have no production just to tap on pools of specialized knowledge. Autopart firms, on the other hand, tend to follow production facilities and tend to be located where the clients are located.

Table 39: Reasons for offshoring production or innovation activities in Swedish ICT firms

ICT	Offshoring of production	Offshoring innovation
Qualified human capital at a lower cost	76,9%	15,4%
Specialised knowledge in the host region	26,9%	15,4%
Access to other infrastructure or cheaper resources	19,2%	15,4%
Access into new markets	19,2%	7,7%

Ethical standards and trust	11,5%	7,7%
Access to knowledge infrastructure	7,7%	7,7%
Incentives for the location of activities in the host region	7,7%	7,7%
Enforcement of intellectual property rights	7,7%	7,7%
Following clients who are outsourcing i.e. 'follow sourcing'	7,7%	7,7%
Efficient financial markets (including Venture Capital)	0,0%	3,8%

Table 40: Reasons for offshoring production or innovation activities in Swedish Autoparts firms

Autoparts	**Offshoring of production**
Qualified human capital at a lower cost	60,0%
Access to other infrastructure or cheaper resources	60,0%
Access into new markets	40,0%
Access to knowledge infrastructure	20,0%
Efficient financial markets (including Venture Capital)	20,0%
Following clients who are outsourcing i.e. 'follow sourcing'	20,0%
Specialised knowledge in the host region	0,0%
Incentives for the location of activities in the host region	0,0%
Level of ethical standards and trust	0,0%
Enforcement of intellectual property rights	0,0%

Source: Swedish INGINEUS survey

2.6 Embeddedness in GINs

Table 41 summarizes the similarities and differences between Swedish ICT firms And Autopart firms with regards to their engagement in GINs, taking into consideration the different forms of globalization of innovation. The picture that emerges is of GINs being only marginal for both industries- most of the innovations are commercialized domestically, most sourcing of technology is still internal to the firm, and the majority of firms do not collaborate for innovation or do not offshore innovation or production.

However, in both industries, there is a number of firms that do engage in different forms of GINs. When they do, we can observe important differences between the two industries. GINs in the ICT industry are more global and involve a larger variety of partners than GINs of Autopart firms. GINs in Autoparts usually involve clients and suppliers -that is, organizations in the value chain- and are more confined geographically to Europe. Furthermore, GINs in the ICT industry may or may not overlap with GPNs. On the other hand, Autopart firms tend to locate R&D centers close to production centers and, as a result, GINs tend to overlap with

GPNs. So, despite the potential advantages of engaging in GINs, the majority of firms still maintain the development of their innovation in house and, when they collaborate, they do it in cooperation with a handful of actors, usually located in close proximity. The next section discusses why this may be so.

Table 41: Embeddedness in GINs of Swedish ICT and Autopart firms

	Global exploitation of innovation[31]	**Global sourcing**	**Global research collaboration**	**Global generation of innovation**
ICT	The most important market is domestic or regional. Internationally, firms target mainly European markets but the proportion of firms that target asian markets is also very high	About 68% of the firms produce technological inputs inhouse. The main source of technology is internal to the firm.	ICT firms collaborate less than Autoparts in the development of their innovations, but when they do, their research networks is wider in terms of variety of partners as well as more global.	ICT firms have less propensity to outsource or offshore abroad. When they do, they may locate innovation centers in different places than production centers. In this respect GPN and GIN do not always overlap.
Autoparts	The most important market is domestic or regional. Internationally, around 83% target European markets and about half North American markets.	About 79% of the firms produce technological inputs inhouse. As with ICT, the main source of technology is internal to the firm.	Swedish Autopart firms collaborate mainly with suppliers and clients located in Europe. In this sense, their GIN is less networked and less global than ICT.	Autopart firms offshore production more but very seldom offshore only innovation. When they do, innovation follows production.

2.7 Barriers for collaboration

Collaborating with foreign partners may have some advantages in terms of access to specialized knowledge or competences that the firm is lacking but it is also costly for firms, as there are important transaction costs associated with the collaboration. There are a number of barriers that may hamper the possibilities or willingness of firms to collaborate with external partners for the development of new product or services. Table 42 summarizes the results.

[31] The proxy used for the global explotation of innovation is the market distribution.

Table 42: Barriers for collaborating in innovation

	Share stating moderate or higher barrier	Extreme barrier	Serious barrier	Moderate barrier	Small Barrier	No barrier	Response count
ICT							
Finding relevant new knowledge	42,28%	3,25%	13,82%	25,20%	29,27%	28,46%	123
Overcoming organizational barriers	50,00%	2,46%	13,93%	33,61%	26,23%	23,77%	122
Changing the current location and related costs	53,45%	7,76%	12,93%	32,76%	18,97%	27,59%	116
Managing globally dispersed projects	52,54%	4,24%	17,80%	30,51%	24,58%	22,88%	118
Harmonizing tools, processes, etc	53,39%	1,69%	18,64%	33,05%	26,27%	20,34%	118
Autoparts							
Finding relevant new knowledge	50,00%	0,00%	22,22%	27,78%	38,89%	11,11%	18
Overcoming organizational barriers	38,89%	0,00%	27,78%	11,11%	44,44%	16,67%	18
Changing the current location and related costs	66,67%	5,56%	27,78%	33,33%	16,67%	16,67%	18
Managing globally dispersed projects	66,67%	0,00%	27,78%	38,89%	22,22%	11,11%	18
Harmonizing tools, processes, etc	50,00%	0,00%	22,22%	27,78%	44,44%	5,56%	18

Source: INGINEUS Swedish survey

There are not significant differences between Autopart firms and ICT firms with regards to the main barriers: changing the current location and related costs as well as difficulties managing globally dispersed projects are considered to be important barriers for firms in both industries. As SOFTNOR indicates, one of the main barrier for the internationalization of innovation involving emerging countries is represented by culture distance and by time differences in the different zones. Another barrier for the type of high tech activities in which the company is specialized is represented by the nature of knowledge (tacit and that require frequents interrelationships). Face to face communication is crucial, even in an industry in which knowledge is highly codified. High tech functions that require tacit knowledge and experience as demonstrated in this case are difficult to globalize (so globalization is not so much depending on the sectors but on the type of activities in the sector in which the companies are specialized).

In TELEQUIP the decision to coordinate projects from the HQ or delegate it to the subsidiary depends on the nature of the innovation. In the pre-development activities the coordination between the headquarter and subsidiaries has a special process. In this company, if an idea is small and incremental like changing the design of a product then the decisions on how to proceed with the production is made at a local level by the expert committees. However the larger and more radical technological ideas should be sent to the product council in Sweden where the product development decisions will be made.

On the other side, finding relevant new knowledge is considered to be easier for ICT firms than for Autopart firms. One possible explanation to this is that the knowledge required for ICT is more generic – for example, computing engineering skills- than that of Autopart firms. AUTOSWE can illustrate this point. As indicated by the interviewee "the competences in developing countries are still low. There is need to increase the quality of the competences of HQ to be able to approach better the internationalization of innovation activities in these new regions". The fact that the company is very specialized in a narrow field – security- makes it difficult to find the required competences. In other words there is no formal education within the engineering field for the design of seat belts for example. Therefore -as emphasize by the interviewee- there is a need for training the local pool of engineers with the specific education required for AUTOSWE products. In the words of the interviewee: "building up the experience which we need to have for people in order to protect what we think is essential for our brand is not easy". The expats going to global sites for some months is the main way of transferring the required knowledge in AUTOSWE. One of the main barriers with regard to local skilled people in locations like China and India is the ability to retain them within the company as once confronted with a better proposition they intend to leave the current working position. Although limited but the Chinese and Indian engineers are also given an option to have some short stays in Sweden. The interviewee in China also has similar reasoning, he states that they have had training programs for their employees in the last five years both by having expatriates in China and also by sending local people to other AUTOSWE subsidiaries in Europe and Japan.

2.8 Impact from crisis

At the time when the INGINEUS survey was concluded (2009) most of the firms had not modified their efforts in innovation as a consequence of the crises, as Table 43 shows. The majority of firms reported few or no changes in their innovation effort or even increasing efforts. This somehow surprising result could be explained by the fact that the crisis has impacted Sweden much less than other countries in Europe. Although growth stagnated in 2008 and was negative in 2009, the country recovered much faster than Southern countries.

Table 43: Impact of the global economic crisis on innovation strategies

	Few or no changes	Increasing efforts at innovation on your part	A serious reduction of your innovative activities	Relocation abroad of your innovative activities	Relocation of innovative activities to you from abroad	Total
Autopart						
Count	7	10	3	1	0	21
% within Autoparts	33%	48%	14%	5%	0%	100%
ICT						
Count	94	43	14	1	1	153
% within ICT	61%	28%	9%	1%	1%	100%
Total						
Count	101	53	17	2	1	174

Source: INGINEUS Swedish survey

2.9 Policy

Both in the survey as in the cases we asked the firms what policies could facilitate or hamper a higher integration in global value chains. In the survey we asked both about factors that had influenced the firm in the past 3 years as well as factors that may be of relevance in the future. In this section, we considered only the first ones, as they refer to real challenges that the firms faced, as not on expectations about the future.

As Table 44 shows, one of the factors that impacts more positively on the internationalization of innovation activities for both ICT and auto part firms is the qualification of human resources. On the other side, the factors affecting negatively are almost all related to the higher costs of internationalization (availability of risk capital and economic support) and, in the case of ICT, the lack of stronger IPR regulations or enforcement or, even more important, the harmonization of different regulations and standards, as the cases show.

TELEQUIP, for example, indicated that what was important at policy level is the harmonization of different regulations at international level (like, for example) standardization or radio frequencies in different part of the world).

Following the same idea, AUTOSWE indicated that even when IPR protection is important for the company is not one of the main obstacles for the internationalization of innovation. Some patents have been copied by other companies but the strategy of the firm has been to ask them to buy the license (turning the disadvantage in benefit). Moreover, the advantage of the company is based also on the long experience as global leader, its know-how and the well-

known brand. On the other hand, in terms of policy, the company thinks that it is the standardization of rules at international level (safety rules for example) what constitutes today one of the main obstacles for the internationalization of innovation activities.

Table 44: Factors affecting internationalization of innovation activities

ICT	**Highly Positive**	**Moderately Positive**	**Moderately Negative**	**Highly Negative**	**Response**
Practical support from centers for the internationalization of innovation and technology transfer	0,00%	72,22%	22,22%	5,56%	36
More public incentives and economic support	15,38%	53,85%	20,51%	10,26%	39
Better access to international research networks	10,00%	70,00%	16,67%	3,33%	30
Higher skills in the labor force	26,09%	50,00%	21,74%	2,17%	46
More stringent IPR regulations/enforcement	12,50%	37,50%	32,50%	17,50%	40
Better and cleares rules regarding FDI and trade	2,86%	45,71%	42,86%	8,57%	35
More open and flexible migration policy for employing experts from abroad	6,45%	54,84%	32,26%	6,45%	31
Greater availability of risk capital for innovation activities with an international dimension	0,00%	41,94%	35,48%	22,58%	31
The corporate governance environment	15%	48%	25%	13%	40
Auto	**Highly Positive**	**Moderately Positive**	**Moderately Negative**	**Highly Negative**	**Response**
Practical support from centers for the internationalization of innovation and technology transfer	0,00%	75,00%	25,00%	0,00%	4
More public incentives and economic support	28,57%	28,57%	14,29%	28,57%	7
Better access to international research networks	22,22%	55,56%	22,22%	0,00%	9
Higher skills in the labor force	45,45%	36,36%	9,09%	9,09%	11
More stringent IPR regulations/enforcement	10,00%	70,00%	20,00%	0,00%	10
Better and cleares rules regarding FDI and trade	25,00%	62,50%	12,50%	0,00%	8
More open and flexible migration policy for employing experts from abroad	28,57%	57,14%	14,29%	0,00%	7
Greater availability of risk capital for innovation activities with an international dimension	28,57%	28,57%	42,86%	0,00%	7
The corporate governance environment	0%	67%	22%	11%	9

Source: INGINEUS Swedish survey

2.10 Summary of main findings and concluding remarks

Swedish Autoparts and ICT firms are specialized in highly added value activities in the value chain. They are also very knowledge intensive activities, of high-tech intensity, even in the case of low-medium tech industries like automotive or Autoparts. As a consequence Swedish firms in both industries are research intensive and very specialized. They rely strongly on their own internal research capabilities. As indicated in several of the interviews, core research is of very strategic nature and high-tech activities rely heavily on tacit knowledge and face-to-face interaction. This explains why most of the firms develop their own technological inputs inhouse and, more often than not, at the Headquarter.

Outsourcing, offshoring and collaboration of innovation takes places more often when dealing with applied research or development for local markets.

In general most Swedish firms do not engage in global exploitation of innovation (main market is domestic), global sourcing of technology (technological inputs are mainly developed in-house), global research collaboration or global generation of innovation (70-80 % do not offshore production or innovation). But when they do, there are significant differences in the way that ICT and Autopart firms engage in GINs.

In terms of their *Globalness*, ICT firms tend to collaborate more in research with global partners than Autopart firms. In terms of *Innovativeness* both industries are highly innovative, with an extremely high proportion of new to the world innovation. Finally, in terms of N*etworkness* ICT networks for innovation are wider in terms of variety of partners and broader in terms of geographical spread. Autoparts network mainly with suppliers and clients and mainly in Europe, but they seem to do it more than ICT firms.

What these results seem to suggest (in line with Barnard and Chaminade, 2011) is that engaging in GINs is a costly process and that there have to be very clear advantages – in terms of costs, access to markets or access to very specialized knowledge- for the firm to make the decision to participate in GINs. When firms have the technological resources and capabilities, they tend to develop their innovations in house or with very limited interactions with other actors. Additionally, as the Swedish innovation system is quite strong, interactions tend to be regional or domestic rather than international. And when they interact, is usually not for core and basic research but for more development and applied research.

A final note on the limitations of this research, particularly with regards to the number of responses. Although the response rate is high for a web-based survey and the number of responses in the ICT industry is acceptable, it is rather low for Autoparts. Most of the analysis is based on 24 questionnaires and thus, the results presented in this paper should be taken with caution.

ANNEX 3 - COUNTRY SECTOR REPORT: ICT IN ESTONIA

Authors: Tarmo Kalvet (tarmo@ibs.ee) and Marek Tiits (marek@ibs.ee), Institute for Baltic Studies (IBS, Estonia, particpant n.5)

3.1 Introduction

Estonia is frequently considered one of the most, if not the most, successful Eastern European catching-up economy. Estonia experienced very rapid economic growth for most of the 2000s. The high ratios of exports and inward FDI to GDP seem to indicate that through its Nordic neighbours it has integrated well into the global production networks (GPN). According to the World Economic Forum's annual Global Competitiveness Reports Estonia has retained a relatively stable position on the border of the 25 most competitive economies in the world throughout the last decade.

However, this is only a part of the story. The very rapid economic growth experienced by Estonia and led by foreign finance has not been sustainable. In fact, in terms of the contraction of GDP in 2009, Estonia was among the worst hit economies in the world. With this a number of weaknesses have been revealed in the national innovation system, especially in relation to participation in the global innovation networks (GINs) (Kalvet and Tiits 2010; Tiits et al. 2008).

The Estonian economy is better described according to the "doing, using and interacting" mode of innovation than the "science, technology and innovation" mode of innovation (see Jensen et al. 2007). More specifically, Estonian industry is dominated by low and medium-tech industries, which are, by the very nature of these industries, not very R&D intensive. Innovative activities in Estonian companies are largely related to inward technology transfer – the acquisition of equipment and machines. When looking at technologically innovative enterprises and the high importance of their information sources for innovation activities for 2006–2008, not only are the most widely practiced innovation activities intramural, but these are also considered the most important next to suppliers and clients. Direct R&D and innovation co-operation with universities or other higher education institutions is considered to be important only among a relatively small number of respondents (Statistics Estonia 2011).

Theory suggests that successful entrance into the global production networks does not necessarily lead to the automatic upgrading of the local nodes (subsidiaries, affiliates, but also independent suppliers and sub-contractors) into the nodes of the global innovation system

(e.g. Ernst and Kim 2002). Estonian attempts and achievements in internationalising its economic system since the early 1990s have mostly been related to the attraction of foreign capital and foreign direct investments, resulting in entrance into the GPN. The emergence of the GIN on top of the GPN is, however, foremost about greater specialisation and gradual upgrading of the value chain relationships. As individual enterprises might acquire new capabilities and enter new markets, their basic production and maintenance activities might be complemented with more knowledge-intensive activities, such as applied research and product development, management of multi-site production and supporting facilities, global brand development and marketing. The transformation of the GPN into the GIN is, thus, primarily about an increase in the quality of innovative activities among the enterprises involved. The mode of and the barriers to innovative activities in catching-up economies are, presumably, different from those in advanced industrialised nations.

The objective of this article is to analyse the dynamics of the formation of GIN more specifically within the Estonian ICT sector[32]. We also analyse whether there are different GIN patterns forming within the sub-sectors of the Estonian ICT industry. We assess the extent to which these trends are influenced (driven, constrained) by contextual conditions specific to Estonia and what impacts this has had at the national economic level.

The method of the current study consists of a thorough literature analysis regarding the Estonian ICT sector. To fill in the missing gaps, various empirical data sets were analysed in addition: a) Community Innovation Survey for 2006–2008 and other data available from Statistics Estonia, b) the dedicated INGINEUS survey (2010), c) patenting data for 2000–2009. Also, d) altogether twelve major private sector actors were analysed in depth over the period of August 2009 to December 2010. They were interviewed in order to gather first-hand information on their R&D base and strategic interests, especially in relation to the

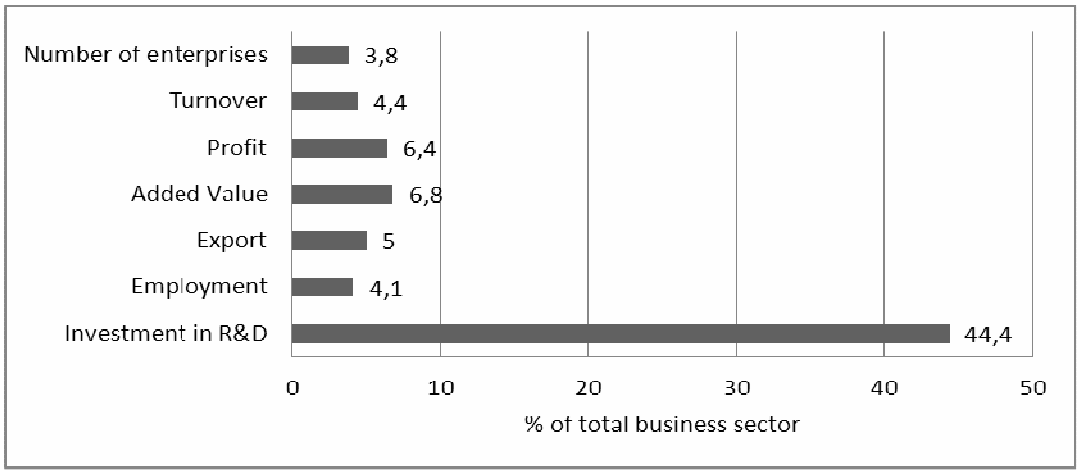
[32] The OECD Working Party on Indicators for the Information Society has defined the economic activities of the ICT sector, and this definition usually serves as the basis for various international comparisons. According to the OECD, the following manufacturing and service industries belong to the ICT sector (based on NACE Rev.2 classification): 261 manufacture of electronic components and boards; 262 manufacture of computers and peripheral equipment; 263 manufacture of communication equipment; 264 manufacture of consumer electronics; 268 manufacture of magnetic and optical media; 465 wholesale of information and communication equipment; 582 software publishing; 61 telecommunications; 62 computer programming, consultancy and related activities; 631 data processing, hosting and related activities; web portals; 951 repair of computers and communication equipment (see, e.g. OECD 2008). In the current paper, depending on the availability of data, slight deviations from the above standard definition have also occasionally been allowed. Also, in some of the following figures and tables, data for the financial services sector have been presented, as this is one of the most intensive industries in terms of ICT and ICT R&D outside the ICT sector itself.

participation (and limits on participation) in the international R&D and innovation activities (see also Tiits and Kalvet 2010). Also, the report draws on e) the case studies of two companies – Elcoteq and Skype (see also Tiits and Kalvet 2011).

3.2 Subject 1: a (short) history and the present nature of sector activities in Estonia

Currently, the share of the ICT sector in the whole economy is rather small: varying between 4–7% for value added, profits, exports, employees and turnover (Figure 1). The total number of ICT sector employment is approximately 15 thousand. The largest sub-sectors, measured in terms of the number of employees, are computer programming, consultancy and related activities (5,900 employees), manufacture of communication equipment (3,200), manufacture of electronic components and boards (2,500) and wired telecommunications (2,200) (Table 45).

Figure 1: Estonian ICT sector in the Estonian economy, 2007

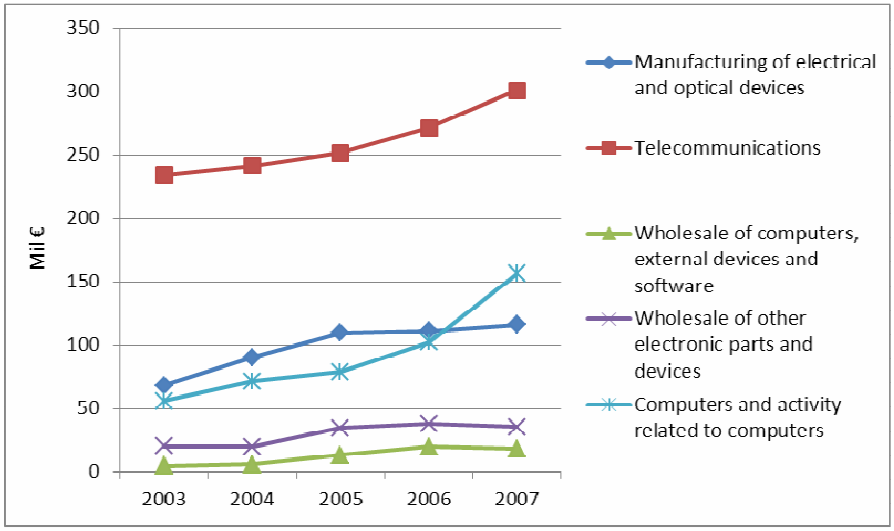


Source: Statistics Estonia, 2010.

The largest sub-sector according to net sales is, however, wireless telecom activities (Table 45). This sector has also been the highest according to value added generated – counting for 50% of the total value added generated in the Estonian ICT sector (Figure 2). It is also interesting to notice that in the manufacture of electronic components and boards, the value

added generated per employee has been below the Estonian average for private companies for 2003–2007 (Rozeik and Jürgenson 2009: 18).

Figure 2: Value added generated by ICT sub-sectors, 2003-2007



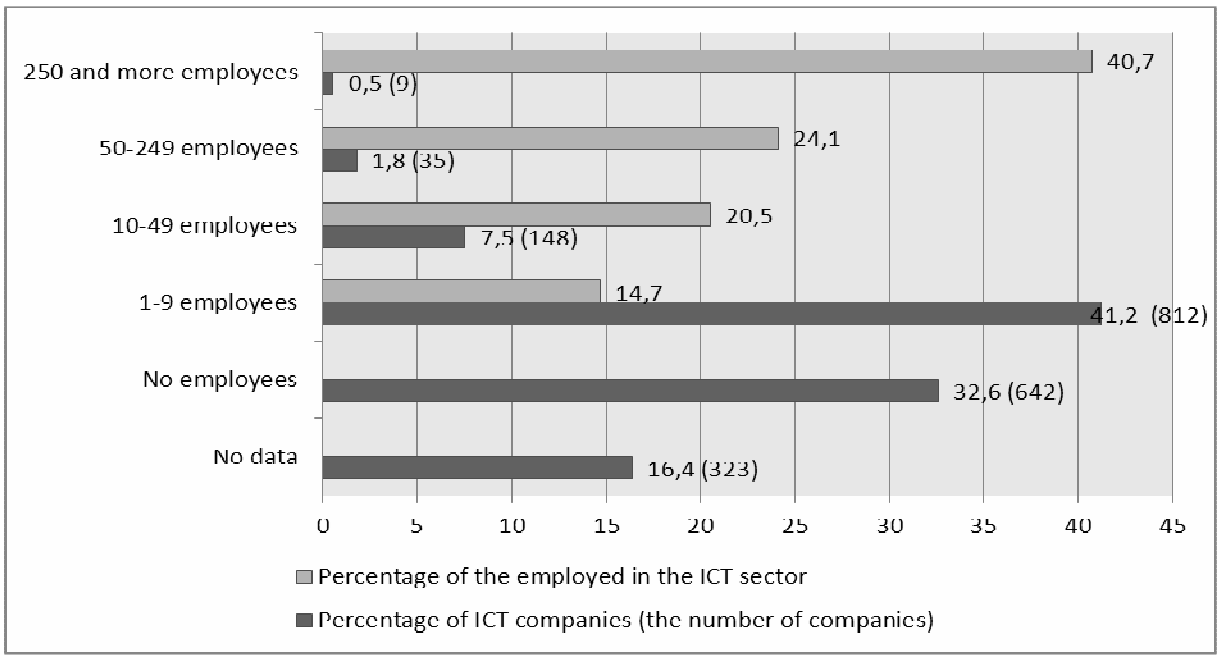
Source: Statistics Estonia, 2010.

Table 45: Key figures on Estonian ICT sector enterprises, 2008

	Number of enterprises	Number of employees	Net sales, mEUR	Sale to non-residents, mEUR	Personnel expenses, mEUR	Operating profit (loss), mEUR	Net profit (loss), mEUR
Manufacture of computer, electronic and optical products	112	6434	432,7	365,7	70,1	6	2,9
Manufacture of electronic components and boards	37	2464	207,4	188,3	27,6	8,3	5,8
Manufacture of computers and peripheral equipment	19	204	34,9	2,2	2,7	0	-0,7
Manufacture of communication equipment	15	3198	152,8	142,2	33,8	10,1	9,8
Manufacture of measuring, testing, navigating instruments; watches and clocks	22	381	15	12,1	3,7	-13,4	-13,6
Telecommunications	107	3357	757,1	118	72	173,7	159,3
Wired telecommunications activities	58	2201	282,1	56,3	42,4	44,9	34,1
Wireless telecommunications activities	11	958	424,4	31,7	26	124,6	120,9
Computer programming, consultancy and related activities	1103	5872	316,5	129,3	129	24,7	8,6
Total economic activities in Estonia	**55654**	**461750**	**44648,6**	**12435,2**	**5617,9**	**1765,4**	**1365,8**

Rozeik and Jürgenson (2009) undertook an in-depth analysis based on business registry data – they analysed the performance of 1,969 ICT sector companies registered in Estonia as of 2007. They discovered that approximately 33% of them had no employees and another 41% were microenterprises; the nine largest ICT companies employed 41% of the employees of the sector (Figure 3). The turnover statistics reveal a similar tendency: 60% of the enterprises (mostly found in the field of computer services) have an annual turnover below EUR 64,000; 45 of the largest companies that each have an annual turnover above 6.4 million EUR generate 75% of the turnover of the ICT sector's total (Rozeik and Jürgenson, 2009: 13).

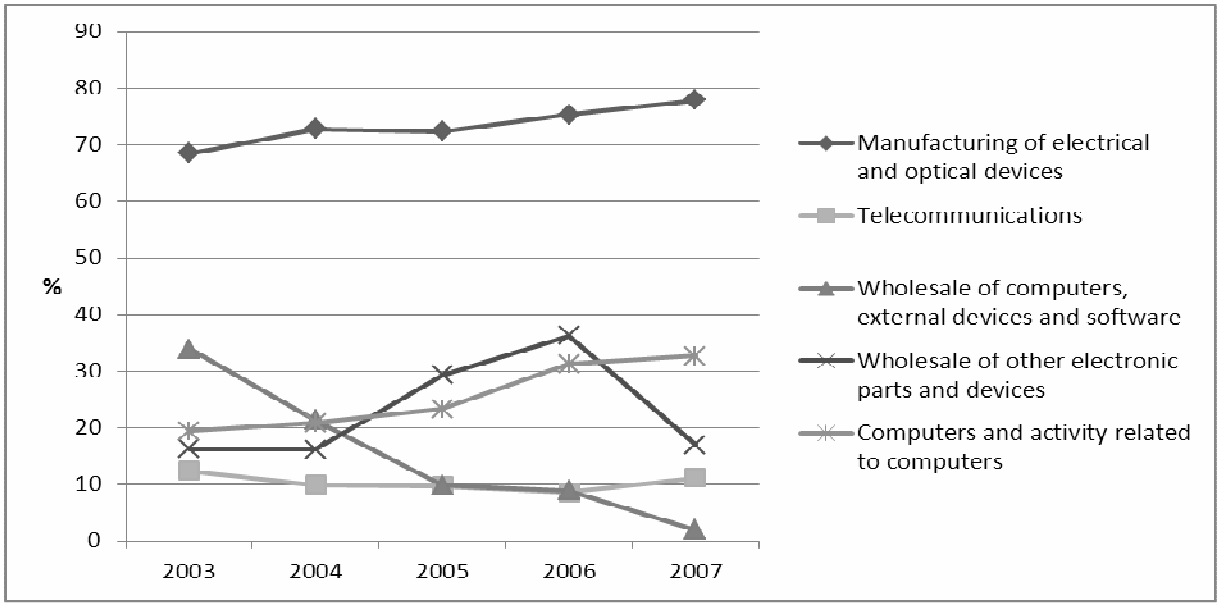
Figure 3: ICT companies



Source: Rozeik and Jürgenson, 2009: 10.

Most of the ICT exports are generated in Estonia in the field of manufacturing electrical and optical devices. This sub-sector is responsible for 80% of Estonian ICT exports (Figure 4). By contrast, 52% of Estonian ICT companies do not have any exports at all. The number of companies with export volumes above 640 000 EUR is 97. The largest 18 exporters (companies with exports above 6.4 million EUR) export 67% of total ICT exports (Rozeik and Jürgenson, 2009: 14-15).

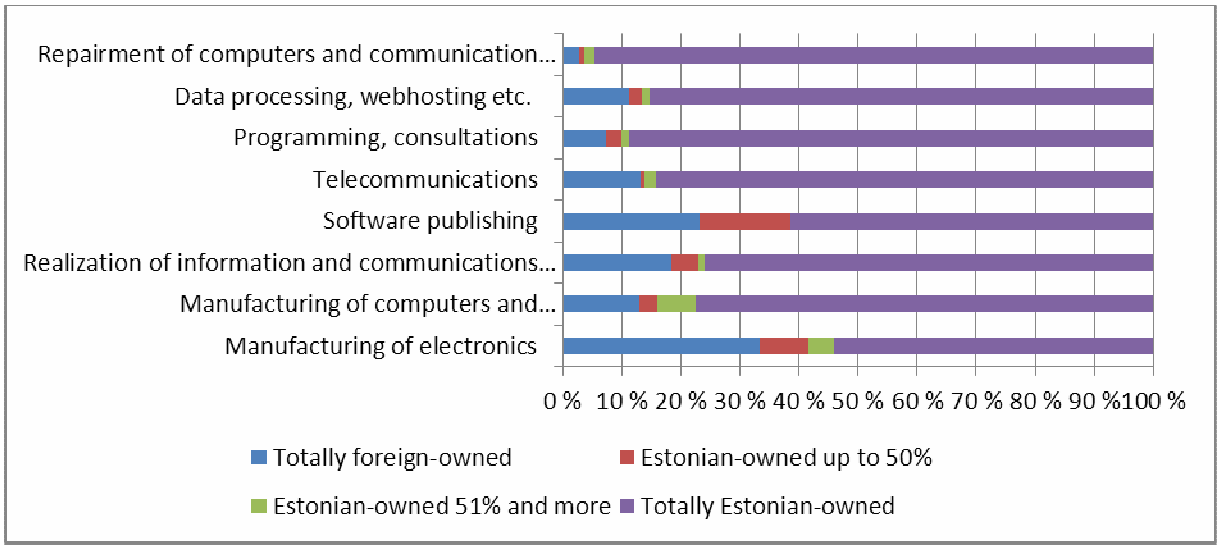
Figure 4: Share of exports in turnover, 2003-2007



Source: Statistics Estonia, 2010.

When we look at the sector as a whole, domestic ownership is rather dominant – 84% of the companies have only local owners, some 1.5% of ICT enterprises have foreign owners with the share of local owners above 51%. Joint ownership with dominant foreign owner(s) is recorded in 58 cases (2.9%) and 201 (10.2%) companies are fully under foreign ownership. Totally foreign-owned companies can mostly be found in the fields of programming and consultancy (84 companies), sales of ICT (51) and telecommunications (20) (Figure 5). The largest companies providing telecommunications services, the most profitable part of the Estonian ICT sector, are completely foreign-owned.

Figure 5: Ownership of Estonian ICT companies, 2007



Source: Rozeik and Jürgenson, 2009: 12.

As of 2007, of the 18 largest exporting companies, 13 were under foreign ownership; of these, seven were ICT manufacturing companies. Integration of the Estonian ICT manufacturing sector into the global production networks has been recorded earlier. Empirical evidence (exports-imports, ownership, FDI, value added, etc.) shows that the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster. The main branches of the Estonian ICT manufacturing industry are exactly the same as those of Finland and Sweden. ICT manufacturing network flagships generally consist of Finnish and Swedish companies, which have subsidiaries, affiliates and joint ventures in Estonia. Empirical evidence does not support the widely held view that Estonian ICT manufacturing has been gradually moving from low value-added manufacturing towards higher value-added production (Kalvet 2004).

The Estonian ICT sector is important, though, in the national innovation system. Already in 2002 it was concluded that of domestic industries, manufacturing, the telecommunications sector, banking, wholesale and retail trade, and governmental structures are important drivers of an emerging Estonian ICT cluster, as they demand most of the production generated by the ICT sector. Evidently, the rapid development of the Estonian banking sector and the high-tech solutions elaborated by the banks' own product development departments have reinforced the need for quality software, and trustworthy secure products; thus, also having positive effects on generating innovative solutions. Positive signs can be observed in the telecommunications sector, which has started to build strong links with universities and research groups, and also pursues research activities in-house. Collaborative activities undertaken by the banks and telecommunications operators have established strong links between these two sectors, paving

the way for future m-commerce related activities. However, in this context, the relations with content providers are insufficient, meaning that these relations have to develop towards a more active involvement of external content service providers in order for large-scale functioning m-business or m-leisure to appear. Government structures are important users of telecommunications equipment and services, office machinery, computers and software, whereas the government's affection for novel techno logical solutions has had a positive effect on a number of public sector initiatives (Kalvet et al., 2002; see also Kalvet, 2012).

3.3 Subject 2: the nature of innovation in the sector

Estonia ranks highly in the various international comparisons that benchmark the development of the information-society, not only among Central and Eastern European countries, but also among the original European Union member states and other leading ICT countries. For example, the Global Information Technology Report 2008–2009 (Dutta and Mia, 2009), which uses a comprehensive tool for measuring the progress of and identifying the obstacles to ICT development worldwide, has ranked Estonia 18th among the observed 122 countries. Similarly, the United Nations e-government survey (United Nations Department of Economic and Social Affairs, 2008: 81) ranks Estonia 13th, describing it as a country "reinventing itself from the confines of the previous Soviet era into a Baltic catalyst for digital adoption and innovation".

Indeed, results of the latest Community Innovation Surveys (Statistics Estonia, 2011), which represents data on 4,023 enterprises and on their activities for 2006–2008[33] show that compared to other surveyed economic activities, where the share of innovative enterprises is 56% of the 4,023 surveyed companies, in the fields related to ICT, the share of innovative enterprises is much higher (Table 46). In the manufacture of computer, electronic and optical products, three-quarters of the companies are involved in technological innovation, mostly process innovation. Process innovations are generally the most dominant form of innovation to increase productivity and improve the flexibility of production and the provision of services. A high share of both process as well as product innovations is also visible for

[33] The statistical survey "Innovation Survey of Enterprises" for the years 2006–2008 is the implementation of European Community survey (Community Innovation Survey — CIS) in Estonia. The survey is carried out in all European Union Member and candidate States simultaneously. The frame of the survey covered all enterprises with at least 10 persons employed in industry (excl. construction) and selected economic activities in services. The Survey was total for enterprises with at least 50 persons employed, and in the case of enterprises with less than 50 persons employed the random stratified sampling was applied if a stratum consisted of more than 30 enterprises.

telecommunication services, but here marketing innovations are also very important. The latter is related to the fact that there is strong competition between the telecommunications companies in Estonia for the local market. For computer programming, consultancy and related companies, innovation consists mainly of product innovations. Although financial and insurance activities are not “classical” ICT fields, innovations in such companies both in general as well as in Estonia are largely based on ICT (Kalvet 2006), and while product and process innovators are also compared to other sectors, they actively apply organisational as well as marketing innovation

Table 46: Innovativeness of enterprises, 2008

	Total enterprise (no)	Innovation (%)	Tech. innovation (%)	Product innovation (%)	Process innovation (%)	Product as well process innovation (%)	Non-tech. innovation (%)	Organis. innovation (%)	Marketing innovation (%)	Organis. as well marketing innovation (%)
Surveyed economic activities total	4023	56.4	47.8	26.7	37.5	19.1	35.2	25.5	23.2	13.6
Manufacturing	1908	59.8	52.8	30.9	42.1	22.5	34.1	20.9	24.2	10.9
Manufacture of computer, electronic and optical products	39	74.4	74.4	44.9	66.7	37.2	40.8	37.4	22.8	19.5
Telecommunications	21	93.3	86.7	68.6	75.2	63.8	75.2	39.0	70.5	34.3
Computer programming, consultancy and related activities	105	72.5	62.1	50.1	27.1	25.1	50.4	39.8	29.3	18.8
Financial and insurance activities	81	83.0	73.0	55.3	47.9	37.5	64.8	56.8	48.8	40.9

Source: Statistics Estonia, 2011.

While there are some radical technological and business model innovations among Estonian ICT companies (e.g. Skype), R&D investment in most ICT enterprises remains miniscule in global terms, and, not surprisingly, most ICT related innovations in Estonia are by nature incremental. This is clearly illustrated by the turnover of product innovators (Table 47). Even in the most innovative branches of the Estonian ICT sector, most of the turnover in product innovations comes from those that are new only for the enterprise (i.e. consist of solutions already applied elsewhere) and thus provide only a short-term competitive edge. It is also noteworthy that turnover generated from innovative products new to market is especially low in the manufacture of computer, electronic and optical products. Computer programming, consultancy and related activities are exceptions here, though. Although the turnover of the sector is smaller compared to other sub-sectors, 70% of turnover comes from products new to the market; that is, given the market orientation of Estonian ICT companies, new to the local market in most cases.

Table 47: Turnover of product innovators, 2008

	Total turnover (m EUR)	**Turnover of innovative products (m EUR)**	**Turnover of products new to market (%)**	**Turnover of products new only for enterprise (%)**
Surveyed economic activities total	10,147	2,363	39.8	60.2
Manufacturing	4,550	1,142	40.1	59.9
Manufacture of computer, electronic and optical products	254	97	25.0	75.0
Telecommunications	841	155	38.6	61.4
Computer programming, consultancy and related activities	131	70	70.3	29.7
Financial and insurance activities	1,397	176	32.4	67.6

Source: Statistics Estonia, 2011.

Analysis of the objectives of technological innovations shows that improved quality in goods or services and increased range of goods or services are both very important goals for all sub-sectors in question; for the telecommunications sector, increasing market share also stands out as a very important objective (Table 48).

Non-technological innovations implemented by companies through 2006–2008 are more frequent among ICT companies in comparison with the overall sample or manufacturing companies. For example, new methods of organising work responsibilities and decision-

making are much more often introduced (**Errore. L'origine riferimento non è stata trovata.**).

It might, however, come as a surprise that in an era of open innovation, new methods of organising external relations with other firms and institutions has a rather low priority when compared to other organisational innovations (**Errore. L'origine riferimento non è stata trovata.**). The main co-operation partners for innovative enterprises are other enterprises within a group, suppliers and clients. So, one can conclude that – both generally as well as in the ICT sector – the majority of co-operation takes place within the relevant value chains (production networks), while only a fraction of companies co-operate directly with research institutes in the public sector. The main link with public research and higher education is the supply of labour rather than co-operation in R&D or product development.

The fact that manufactures of computer, electronic and optical products are mostly co-operating with other enterprises within the enterprise group, suppliers of equipment, materials, components, or software, and with clients or customers has to do with the fact that these are supplier-dominated industries, where the majority of basic technological inputs are imported. While such co-operation is also important for telecom companies, in this industry co-operation with universities or other higher education institutions and with other enterprises in same sector is also more vivid; telecom companies as well as financial and insurance companies are also co-operating with consultants, commercial labs or private R&D institutes. For companies in computer programming, consultancy and related activities, co-operation with clients or customers is most important, and this is typical in knowledge-intensive economic sectors.

.

Table 48: Objectives of technological innovations for technologically innovative enterprises (%)

	Increased range of goods or services	Replacement of outdated products or processes	Entering new markets	Increased market share	Improved quality in goods or services	Improved flexibility of production or service provision	Increased capacity of production or service provision	Improvement of work conditions and safety	Reduced labour costs per unit output
Manufacture of computer, electronic and optical products	52.1	45.9	22.8	34.1	63.8	35.5	35.2	27.6	26.2
Telecommunications	55.0	31.7	36.7	62.2	62.2	43.9	13.3	0.0	11.1
Computer programming, consultancy and related activities	48.8	51.8	31.7	50.8	52.3	32.0	27.5	13.8	15.7
Financial and insurance activities	48.6	45.4	23.6	42.5	69.0	45.8	47.6	12.5	19.8

Source: Statistics Estonia, 2011.

Table 49: Non-technological innovations 2006–2008, % of total

	Organisational innovations			Marketing innovations			
	New business practices	New methods of organising work responsi-bilities and decision-making	New methods of organising external relations with other firms and institutions	Significant changes to the design or packaging of products	New media or techniques for product promotion	New methods for product placement or sales channels	New pricing methods
Surveyed economic activities total	13.3	18.7	12.0	12.2	10.6	11.4	9.3
Manufacturing	11.7	15.9	8.8	14.2	9.1	10.9	8.0
Manufacture of computer, electronic and optical products	18.7	34.9	7.7	16.9	14.4	16.2	11.0
Telecommunications	28.1	22.9	16.7	46.7	34.8	29.5	39.0
Computer programming, consultancy and related activities	22.5	37.1	15.0	11.8	17.0	17.9	15.6
Financial and insurance activities	40.4	50.1	18.5	28.5	33.1	30.7	24.6

Source: Statistics Estonia, 2011.

Table 50: Co-operation in technologically innovative enterprises, 2006-2008

	Enterprises involved in co-operation total	Other enterprises within enterprise group	Suppliers of equipment, materials, components or software	Clients or customers	Competitors or other enterprises in same sector	Consultantscommercial labs, or private R&D institutes	Universities or other higher education institutions	Research institutes in public sector
Surveyed economic activities total	48.6	23.0	24.3	22.3	12.2	9.7	7.1	3.0
Manufacturing	44.8	18.5	24.5	21.1	10.0	8.4	5.8	1.5
Manufacture of computer, electronic and optical products	51.4	36.5	27.2	31.0	5.9	12.8	7.9	0.0
Telecommunications	69.2	42.8	52.7	45.0	34.6	20.3	25.8	7.7
Computer programming, consultancy and related activities	49.5	30.5	18.6	37.1	18.3	15.2	8.0	4.8
Financial and insurance activities	62.6	44.0	30.3	38.7	21.3	20.1	5.2	3.6

Source: Statistics Estonia , 2011.

3.4 Subject 3: the nature of knowledge – sector activities in your country

Limited R&D co-operation with external partners is also confirmed when looking at R&D and innovation expenditures. Extramural R&D expenditures in the manufacture of computer, electronic and optical products amount to only 130 thousand EUR. The same figure is considerably higher for telecommunications (2 Mil EUR) and for financial and insurance activities (2.4 Mil EUR), but significantly lower when compared with intramural innovation expenditures or the acquisition of machinery, equipment and software.

Table 51: Innovation expenditures in technologically innovative enterprises, 2008

	Intramural research and development activities	Extramural R&D	Acquisition of machinery, equipment and software
Surveyed economic activities total	88.1	21.7	400.6
Manufacturing	23.9	6.4	167.3
Manufacture of computer, electronic and optical products	2.3	0.1	8.3
Telecommunications	10.0	2.0	14.6
Computer programming, consultancy and related activities	27.5	0.8	1.8
Financial and insurance activities	12.6	2.4	2.7

Source: Statistics Estonia, 2011.

Indeed, if we look at technologically innovative enterprises and the high importance of information sources for them for innovation activities through 2006–2008, it follows that not only are intramural innovation activities most widely practiced, but they are considered the most important sources for innovation next to suppliers and clients (Table 62). Universities, other higher education institutes and public research institutes were considered to be important co-operation partners by a relatively small number of technologically innovative enterprises; interestingly, other sectors in the economy find them more valuable compared to the ICT sectors. In other words, higher education institutions have a very important role to play in providing high quality labour, but their direct involvement in the innovative activities of enterprises is far less significant.

Table 52: Technologically innovative enterprises indicating the high importance of information sources for innovation activities through 2006–2008 (%)

	Surveyed economic activities total	Manufacturing	Manufacture of computer, electronic and optical products	Telecom.	Computer programming, consultancy and related activities	Financial and insurance activities
Sources within the enterprise or enterprise group	33.0	31.4	67.2	48.3	60.3	39.9
Suppliers of equipment, materials, components, or software	27.4	27.9	29.6	37.3	20.2	17.1
Clients or customers	15.6	14.5	36.5	17.6	27.3	24.5
Competitors or other enterprises in same sector	8.3	8.6	11.4	31.3	8.4	10.8
Consultants, commercial labs or private R&D institutes	4.6	4.1	3.4	5.5	3.4	5.1
Universities or other higher education institutes	2.8	1.7	0.0	0.0	1.5	0.0
Research institutes in public sector	1.0	0.3	0.0	0.0	1.5	0.0
Conferences, trade fairs, exhibitions	6.9	7.8	5.9	6.6	5.2	4.2
Scientific journals and trade/technical publications	4.2	3.3	10.3	5.5	8.0	3.4
Professional and industry associations	2.7	3.3	3.4	0.0	4.8	1.7

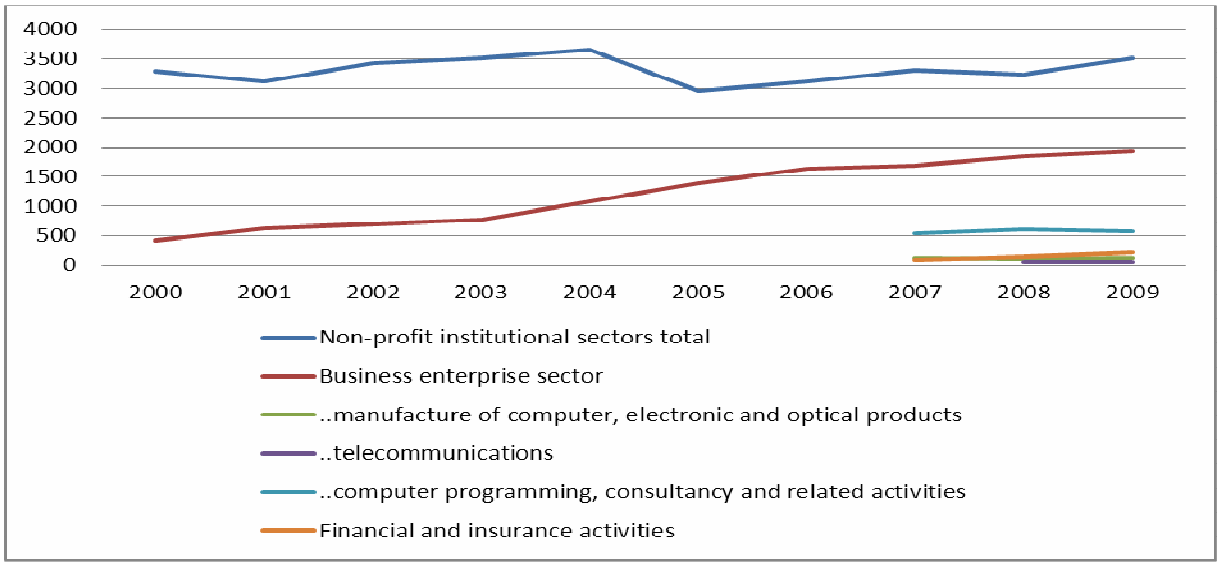
Source: Statistics Estonia, 2011.

Earlier, it was argued that innovations in the Estonian ICT sector are mostly incremental. This is also confirmed by patenting activity – one of the key indicators used internationally for detecting and analysing the outputs of R&D efforts, although in the ICT sector, quite a significant proportion of private sector R&D players choose not to apply for patents, but to secure their competitive advantage by simply keeping their inventions secret.

When analysing patents and utility models issued internationally in the field of ICT[34] for 2000–2009 where Estonian inventors have been involved, we identify a total of 285 records. This includes a substantial number of patents issued to the various foreign organisations where Estonian inventors have been involved. For most of the domestic actors, however, patenting activity remains fairly low (see also Table 54 below). This confirms the earlier observation that we have a relatively small number of large enterprises in the Estonian ICT sector that dominate the industry both in terms of sales, but also in terms of their ability to invest strategically in medium and longer term developmental activities, including formal R&D. Although the number of R&D personnel in the private sector has increased very rapidly through 2000–2009 (Figure 6), public universities continue to perform the majority of the R&D activities in Estonia. The vast majority of the public research takes place at the University of Tartu and Tallinn University of Technology, while other organisations play a substantially smaller role (Allik, 2008).

Figure 6: R&D personnel in FTE in Estonia, 2000–2009

[34] ICT patents were defined for the purposes of this patent search according to the recent OECD definition. However, the analysis of individual patents reveals that those having been classified as ICT patents belong to the fields of electrical engineering, physics, chemistry and even biotechnology rather than ICT.



Source: Statistics Estonia, 2010.

It is also interesting to note that in the private sector, the R&D personnel employed in computer related and financial intermediation activities accounted for 49 percent of the total business-sector R&D personnel in 2009 (Statistics Estonia, 2010): 572 R&D personnel (in FTE) in computer related activities and 118 in the manufacture of electric and optical equipment. Also, the ICT sector accounted for 44.4% of the investments in R&D (Figure 1). Software and computer services is the most R&D intensive branch of the Estonian enterprise sector, where a noteworthy 6% of income from sales is spent on R&D; for the manufacture of medical and optical instruments and of communication equipment, the respective ratios are 1.4% and 1.2%. Still, both the number of R&D personnel and the expenditures are subject to overestimation as not only R&D personnel (as defined by OECD and Eurostat, 2005), but also the personnel engaged in more routine activities are likely to be reported.

Official sources provide us with no figures for the ICT researchers in the public sector, but the Estonian Research Portal, which is the official interface for national R&D funding applications, lists altogether 410 people who are active in the field of computer science as their field of research as of 2009. However, 162 of them have at least one publication in the ISI Web of Science, and 127 of them have a PhD. On similar vein, a recent study based on Google Scholar has identified that there are 131 computer scientists in Estonia who have at least one citation of their research paper (Lipmaa, 2011). Thus, we estimate that there are no more than 150 reasonably active and productive ICT researchers in the Estonian public sector. The major ICT R&D units are Cybernetica Ltd., Tallinn University of Technology (especially the Department of Computer Engineering, Department of Informatics and Institute of Cybernetics), and the Institute of Computer Science at the University of Tartu. They are

responsible for most of the public R&D expenditure in Estonia, and also publish the majority of academic research papers (Tiits and Kalvet, 2010).

3.5 Subject 4: locations and internationalisation

According to Statistics Estonia (2011) and to the INGINEUS survey (2010), most of the co-operation in the introduction of technological innovations occurs either domestically in Estonia or with the various European partners. Usually, Estonian innovative companies import their basic technological inputs from the various Scandinavian or European (regional) offices of the respective enterprises, and export their production once again to (neighbouring) Baltic or Scandinavian countries. Essentially, the Scandinavian countries act in many ways as a regional gateway to the world market for Estonia. Direct imports from or exports to far away countries are relatively rare. While co-operation with the United States is not that common, it is much more prevalent in the field of ICT, especially in the manufacture of computer, electronic and optical products and in telecommunications. The same ICT sub-sectors are also more active in innovation co-operation with Indian and Chinese companies than Estonian innovative enterprises in general (Table 53).

Table 53: Location of co-operation partners for innovative activities for technologically innovative enterprises (%)

	Estonia	Europe[35]	USA	China or India	Other countries
Surveyed economic activities total	34.0	33.3	2.7	1.4	3.2
Manufacturing	28.8	34.6	2.4	1.2	3.0
Manufacture of computer, electronic and optical products	25.2	51.4	12.8	6.9	3.4
Telecommunications	58.9	56.7	13.9	5.6	7.2
Computer programming, consultancy and related activities	37.5	34.0	8.0	1.5	7.8
Financial and insurance activities	56.8	40.8	8.6	1.7	1.7

Source: Statistics Estonia, 2011.

[35] Europe is considered to refer to member and candidate countries of European Union (excl. Estonia) and EFTA countries.

An interesting pattern of technology co-operation emerges from the analysis of those internationally held patents and utility models in the field of ICT for 2000–2009, where Estonian inventors have been involved. Half of the 285 records have been assigned to various entities in Estonia, while the rest belong mostly to entities based in Germany, the United States, Finland, Ireland and so on. Further content analysis of the patenting activity reveals that the above patenting activity is very concentrated. Less than 10% of the set of assignees involved have more than two patents or utility models, while the list of assignees with three or more items is very short(Table 54). [36]

Table 54: List of assignees active in the field of ICT RTD, who have more than two patents involving Estonian inventors

Assignee	Number of items
SKYPE LIMITED (IRELAND)	18
TALLINN UNIVERSITY OF TECHNOLOGY (ESTONIA)	14
AS LASER DIAGNOSTIC INSTRUMENTS (ESTONIA)	7
ERICSSON TELEFON AB L M (SWEDEN)	7
PLAYTECH SOFTWARE LIMITED (UNITED KINGDOM)	6
NOKIA CORPORATION (FINLAND)	6
ELISA / RADIOLINJA EESTI AS (ESTONIA)	4
AS EMT (ESTONIA)	4
UNIVERSITY OF TARTU (ESTONIA)	4
LINUXPROBE CO. (JAPAN)	3
CURONIA RESEARCH LTD. (ESTONIA)	3
ELEKTROBIT TESTING OY (FINLAND)	3

Source: Authors based on Thomson Reuters, 2010.

The list of assignees is remarkably revealing in regard to the innovative activities of some of the ICT enterprises in Estonia. The cases of Skype and Playtech are particularly interesting.

[36] It appears from the textual analysis of the patent descriptions retrieved from the U.S. Patent and Trademark Office, European Patent Office and WIPO databases that some of the abovementioned patents are connected to ICT R&D activities only remotely. We would, ourselves, categorise a number of the above patents as physics, chemistry or drug discoveries and so on, rather than ICT.

For example, Skype is headquartered in Luxembourg, while the main sales office is actually located in the United Kingdom. The Skype global development headquarters are in Estonia, and secondary development sites in the Czech Republic, Sweden and the United States. It is a true global company that relies on the development of their services in ICT RTD and product development that is, for the most part, undertaken in Estonia, while the Irish branch of Skype takes responsibility for intellectual protection (see Barnard et al., 2012). Playtech Ltd, the world's largest publicly traded online gaming software supplier, follows a similar pattern. They build on Estonia as one of their software development sites, but the patenting is taken care of in the United Kingdom.

We also note that Swedish Ericsson has built on some inventions of Estonian origin. Yet, we see no direct link to the Ericsson branch in Tallinn in Ericsson's patenting activity. Instead, we find indications in the relevant patent descriptions of the involvement of Estonian inventors who are currently based abroad. The same is true for Nokia.

We also find that Cybernetica Ltd has some international patenting activity. There are also some indications of related patenting that has taken place through other companies (e.g. Linuxprobe Co and Privador Ltd). Interestingly enough, the Estonian subsidiaries of competing Scandinavian mobile telephone operators demonstrate notable activity in using IPR protection.

The off-shoring of R&D and innovation activities, according to the INGINEUS survey, is not commonplace among Estonian ICT enterprises either. This has, first of all, to do with the general structure of the ICT sector in Estonia, where a fairly small number of relatively well known enterprises are responsible for the majority of the business R&D investment and/or independent product development activities. The list of such R&D intensive enterprises includes, for example, Cybernetica Ltd., Skype Technologies OÜ, EMT Ltd., Webmedia Ltd., Helmes Ltd. and Regio Ltd. as stated earlier. Also, when we take into account the R&D investment of individual companies in development activities, it becomes immediately apparent that the R&D activities of Estonian ICT companies are (as in the public sector) very concentrated.

So, the off-shoring of R&D and innovation activities occurs, given the general concentration of R&D activities in the Estonian ICT sector, in only a small number of enterprises. What is more, the motivation for off-shoring different business activities, including R&D, also varies significantly both in the ICT sub-sector and the ownership structure and strategy of the particular enterprise.

As expressed by interviewees, the standardised packaged products (incl. software, manufactured goods) that cater for a truly global market are relatively easy to export across

borders; therefore, the immediate presence on target markets is not always an absolute necessity for the designers and producers of such products. The export of services, however, often assumes a physical presence on target markets.

This is a general observation that applies to all industries, but is also vividly visible in the Estonian ICT sector. In software and telecommunication services, subcontracting of some of the software development (coding) takes place in lower cost locations (e.g. Russia, Ukraine and Belarus). Some companies; for example, Webmedia and Skype, have also established foreign affiliates to gain access to foreign markets and/or acquire additional workforce.

At the same time, the local telecommunications market is dominated by foreign telecommunications operators (TeliaSonera, Elisa, Tele2) that have acquired local companies to achieve a stronger presence. The motivation for internationalisation remains fairly low among Estonian subsidiaries of the above telecommunication service providers, as they are, almost by definition, to concentrate on the Estonian domestic market. While this is the case, the entry barriers remain high in this sub-sector due to the required high infrastructure investment, and the smaller domestic companies are not able to compete with larger multinational groups on this market.

The Estonian ICT manufacturing sector, as stated earlier, is largely part of a larger Nordic ICT cluster. The manufacturing of ICT goods is dominated in Estonia by foreign investment enterprises, who have in most cases off-shored into Estonia various manufacturing functions from the testing of product prototypes and the establishment of suitable production configurations to the actual manufacturing itself. The R&D that takes place in such cases in Estonia has first and foremost to do with process rather than product innovation (e.g. the case of Ericsson and Elcoteq). The off-shoring of certain specific product development related R&D functions is rather rare, and has to do with a certain unique knowledge and experience that was not available in the existing locations of the specific company (National Semiconductor Estonia, Artec Group). By contrast, most of the indigenous ICT manufacturers remain fairly weak in Estonia, they do comparatively little in-house R&D and the internationalisation of their R&D activities remains even more limited.

Accordingly, companies from Nordic countries have been moving towards more complicated business models and have overcome the limitations of small states. Evidence shows that such foreign expansion has clearly taken place in Estonia, as Nordic countries dominate as the sources for foreign direct investments in the largest ICT companies in Estonia, and has been driven by Estonia's proximity to the Nordic economies. It has been observed for Finland and Sweden that in recent years, an increase of R&D in foreign subsidiaries has taken place, especially in the case of the large manufacturing firms in the case of Finland and financial intermediation in the case of Sweden (Braunerhjelm et al. 2010). This is in line with the results with our understanding: R&D taking place in the foreign-owned financial

intermediation companies in Estonia has increased remarkably. For the manufacturing sector, the picture is more heterogeneous and rather seems to confirm that foreign ownership might not generate positive intra-industry spillovers for domestic firms. Several of the largest foreign-owned companies as well as companies with local ownership and with a subcontracting-only profile have little contacts with other companies or educational and R&D institutions. The insufficient or missing links between foreign-owned enterprises in Estonia and the indigenous actors continue, thus, to be a considerable problem.

3.6 Subject 5: sector embeddedness in GINs

As stated earlier, for the technologically innovative enterprises and the high importance of their information sources for innovation activities through 2006–2008, intramural innovation activities are the most widely practiced, and they are also considered to be the most important sources for innovation next to suppliers and clients. The main sources of knowledge for innovation are clients and customers (Table 52 and Table 53 above).

Two distinct conclusions can be drawn about the international links (including but extending) beyond intra-corporate networks on the basis of the INGINEUS survey.

First, the domestically owned enterprises do not, as a rule, have any specific units outside Estonia. Their strategic management and most of the other core functions are internalised within the enterprise. When it comes to expansion into foreign markets, Latvia and Lithuania tend to be their first and ‘natural’ choice.

Second, the strategy of the enterprises that have a notable foreign ownership tends to depend substantially on the foreign owners. They are typically either a subsidiary of a larger multinational enterprise that has been established specifically for the Estonian market, or a smaller production or development unit that caters mostly to foreign markets. In the case of the latter, the foreign owners tend to be the ones who ‘open the doors’ for exports in Scandinavia and beyond.

Some of the indigenous ICT enterprises; for instance, Webmedia and Regio, have been able to build on the presence of the multinationals, such as Microsoft and Ericsson, and use them as strategic partners in entering foreign markets. Most of the indigenous ICT enterprises continue, however, to serve predominantly the domestic market, so the actual extent of integration into GINs remains modest.

3.7 Subject 7: prospective impact from the crisis

Estonia's integration into the GINs has to do with the overall development context in Estonia. Therefore, in the following we discuss, based on the seminar with stakeholders, the main strengths, weaknesses, opportunities and threats both the specific local situation as well as the global entail for the development of ICT in Estonia.

The most significant strengths characterising the internal environment for ICT R&D in Estonia derive from the prioritisation of the adoption of ICTs by the government and end users. Also, a variety of instruments are in place that support excellence in ICT R&D. This includes both the national Centres of Excellence and Competence Centres programme, but also the generally competitive R&D funding system in Estonia, which prioritises high quality research. Estonia also has a good reputation in the international ICT landscape and there is a lot of enthusiasm in Estonia to develop and adopt ICTs in the best possible ways. The small size of the country allows for closer links between individual actors, and thereby also for greater dynamism. Interaction between higher education establishments is indeed quite close. Similarly, major ICT enterprises communicate quite closely. Still, the interaction between academia and industry remains weaker and more random. A limited number of local key players are very well integrated with the global innovation networks.

The primary weaknesses derive from the existing low number of R&D personnel and the weakness of the supply of additional qualified ICT specialists (both in terms of quantity and quality; see also Kattel and Kalvet, 2006). Estonia's current R&D funding system favours existing fields of research, and puts promising new research groups and new fields of R&D in a relatively unfavourable position. A number of the ICT R&D units have insufficient international technology and business management skills to advance their position in international R&D and innovation networks, and to manage (and co-ordinate) R&D projects. On a similar vein, entrepreneurs keep emphasising the lack of international sales skills as one of the most important impediments to increasing exports and growth. Overall, the sophistication of the business models of ICT companies remains low, and in most cases general software development services remain the main sales articles rather than more risky (and lucrative) local products or components. The small size of the country and thereby also the small size of the individual research groups, institutes and departments forces the universities and companies to cover a rather broad set of topics in their teaching, research and business activities. This makes international competition in any particular (narrow) field of ICT R&D quite difficult, compared to larger specialised units available elsewhere.

The global economic crisis is an important trigger for change and development, the power of which should not be underestimated. Also, the continued globalisation (and participation in international value chains) and the emergence of new fields of ICT R&D continue to exhibit major opportunities. The rapidly evolving globalisation of higher education (and attracting

teaching and research staff as well as students) is another driver that will also have a major impact on Estonia. The aspirations of the EU for the establishment of a well functioning European Research Area and the existence various R&D support instruments itself continue to present major opportunities for economies like Estonia. Estonia is also in the neighbourhood of some of the most advanced ICT nations in the world. At the same time, Estonia is located on the borders of two major trading blocks: the EU and the CIS. Given the geographic location, even closer ICT R&D and business co-operation with neighbouring countries in Baltic Sea Region would prove beneficial for Estonia. In particular, linkages with Nordic countries could be more actively used by Estonian researchers and entrepreneurs as a gateway that allows for joint access to far away markets (e.g. the Americas, Asia, etc.).

3.8 Subject 8: looking forward

As expressed above, the most significant threats are likely to derive from the lack of timely and sufficient action in meeting the challenges posed by the current crisis, and the excess complacency of the policy makers with the immediate stabilisation achieved in recent months. The demographic challenges and projected decline in the supply of labour force in Estonia continue to demand immediate action. While the emergence of global production and innovation networks is a good opportunity, in more established fields of ICT, international supply and R&D networks were already formed around larger players quite some time ago. Now, with the increasing concentration of the industry, the barriers to entry continue to mount. In order for new actors to be accepted into existing R&D and production networks, the benefits must be clear (and risks low). The limited specialised advantages of Estonian entities remain a considerable threat in this context.

3.9 Subject 9: policy implications

Based on the analysis above and supported by the results of the INGINEUS survey, it can be concluded that for Estonia to be successful in international ICT R&D, and related product and service development and exports, Estonia must considerably improve the supply of high quality ICT specialists – scientists and engineers and international business and technology management skills, including better utilisation of strategic R&D and business alliances.

Critical volumes and barriers to entry in global innovation networks

- The continued *globalisation of R&D* presents a major opportunity, especially right now, when the global financial and economic crisis has triggered a major wave of relocation and M&A decisions.

- Typically, major actors in Estonia consider that they *are generally visible* to potential national and international partners. Despite this, they should be more active in expanding their international outreach beyond the neighbouring countries in the Baltic Sea Region.
- .In more established fields of ICT, international supply and RTD *networks have already formed* around larger players quite some time ago. In order for new actors to be accepted into those networks, the benefits must be clear and risks low.
- Most of the ICT RTD centres in Estonia are relatively *small*, and cannot, therefore, compete with larger actors in India or elsewhere solely based on costs. Even if the emergence of global production and innovation networks might be considered a historic opportunity, the limited specialised advantages of Estonian entities remain a considerable weakness.

Need for deeper specialisation and development of more specialised knowledge

- Most of the Estonian ICT companies, especially those serving the domestic market, provide general software development and systems integration services. The development of *specialised knowledge or technology* remains limited.
- The discussion of the limited specialised technological capacities feeds directly into the discussion of the weakness of the *supply of qualified labour* and the related *public knowledge base* (i.e. the public education and research system in the field of ICT RTD in Estonia).
- The small size of individual research groups, institutes and departments forces universities, as with companies, to cover a rather *broad set of topics* in their research and teaching activities, making competing internationally in any of these difficult.
- The rather fragmented domestic funding environment for academic R&D that encompasses a large number of separate *support instruments* (e.g. Target Funding, Estonian Science Foundation grants, infrastructure and mobility grants, various smaller contracts, etc.) enforces the *fragmentation* of the public RTD base even further.[37]
- The recent efforts aimed at increasing opportunities for *international mobility*, including increasing the mobility of younger researchers and efforts at attracting foreign researchers to Estonia, have clearly been very beneficial both in terms of strengthening

[37] As a rather drastic illustration of fact, one of representatives of a major public RTD organisation indicated during the interview that the ratio of funding contracts to researchers is in his organisation currently 1:1. Obviously, such a fragmentation not only reduces significantly the productivity of researchers, but leads also to unnecessarily high administrative load in handling a very high number of contracts.

the local knowledge base and expanding professional networks internationally, and need to be continued.

Improvement of international business and technology management skills

- A number of the ICT RTD units have *insufficient technology management skills* to advance their position in international RTD networks, and to manage (and co-ordinate) RTD projects and thus need strategic-alliance-forming skills and capacities to manage the internal organisation in such a way that it is suitable for open innovation.

This is why, not surprisingly, several academic entities as well as companies admit the need to attract internationally renowned and networked specialists to increase their own capacities. This relates both to RTD and product development, but also international business development and marketing personnel.

3.10 Conclusions

The objective of this research was to analyse the drivers, the degree and patterns of integration of the Estonian ICT sector into global innovation networks. The research question was an intriguing one as Estonia is frequently considered a successful, if not the most successful Eastern European catching-up economy. Estonia has been ranked highly in international comparisons measuring information-society developments, not only among Central and Eastern European countries, but also among the original European Union member states and other leading ICT countries. Also, Estonia has taken great steps to internationalise its economic system and to attract foreign capital and foreign direct investments, resulting in entrance into the GPN. But, theory suggests that successful entrance into the global production networks does not lead necessarily to the automatic upgrading of local nodes (subsidiaries, affiliates, but also independent suppliers and sub-contractors) to the nodes of the global innovation system, and the current research fully supports this argument.

According to widely used classification there are key differences among sectors as sources of innovation and the appropriability mechanisms (patents, secrecy, lead time, learning curves, and complementary assets) differ (Pavitt, 1984). The ICT sector is widely labelled as a representative of a science-based regime – assumed to be characterised by a knowledge base firmly embedded in the life sciences and physical sciences. A more refined picture is provided in Malerba (2004), where it is concluded that in “telecommunications equipment and services a convergence of different technologies, demand and industries with processes of knowledge integration, combination and production specialisation has taken place” (466), and global networks among a variety of actors are relevant. Software, on the other hand, “has a highly differentiated knowledge base (in which the context of application is relevant) and several

different and distinctive product groups in which specialised firms are active. User-producer interaction, global and local networks of innovation and production, and the high mobility of highly skilled human capital are all present" (*ibid*, 466). Also, "Nowadays the three broad product groups in which software can be examined (global package, situated software and middleware software) require different types of knowledge and learning processes. Global package software products are characterised by the search for generic solutions and experience as a major input for innovation with process innovation playing a key role. Situated and embedded software, on the other hand, have knowledge related to specific contexts and specialised purposes. Middleware software and integrated software solutions – such as product data managers and enterprise resource planning – aim to reach many users but focus on situated specific applications" (*ibid*, 470).

The Estonian case study confirms that there are key differences within the ICT sector as sources of innovation and the appropriability mechanisms (patents, secrecy, lead time, learning curves and complementary assets) differ.

First, one part of the Estonian ICT industry – and especially lower value-added electronics manufacturing service providers – can be described as a supplier-driven OEM industry, where technical change comes largely from the suppliers of product specifications, machinery and other required inputs. The main task of the EMS innovation strategy is to use technology from elsewhere in order secure an efficient and effective production system. So, the focus is mainly on process innovations within the established global production network. Also, non-technological innovation is very important.

Second, the ICT sub-sectors where software is the source of competitive advantage can be described as knowledge-intensive industries where the main sources of technology are in-house software and systems integration departments, and suppliers of basic ICT hardware and software. The main purpose of this sub-sector is to design and operate complex systems for processing information, particularly in distribution systems that make the provision of a service or a good more sensitive to customer demands. Such software development is embedded rather strongly in the national innovation system, while the international linkages in the GINs are in most cases of lesser importance.

Third, there is a small number of internationally active specialised suppliers that are rather small in the global context, but provide high-performance inputs for complex systems of production, information processing and product development in the form of components, instruments and software. Such specialised suppliers benefit from the operating experience of advanced users, in the form of information, skills and the identification of potential modifications and improvements. Specialised supplier firms accumulate the skills to match advances in technology with user requirements which, given the cost, complexity and interdependence of production processes, put a premium on reliability and performance,

rather than price. The main tasks of an innovation strategy are to keep up with users' needs, learning from advanced users and matching new technologies to users' needs. For this group of enterprises, intimate integration into the GINs is crucial.

There are also companies that are succeeding with their own products on the world market. The case of the GIN built up around Skype is characterised by a truly global character, the engagement of a variety of actors from different countries and the existence of different linkage mechanisms. However, it remains a notable successful exception in the Estonian ICT landscape.

It is increasingly recognized (see Herstad et al., 2010) that the path-dependent nature of endogenous learning within territorial systems necessitates external links, and this to avoid locking in to diminishing return paths (see Bathelt et al., 2004). The forces of globalisation may necessitate that regional or national innovation systems deconstruct as sets of user-producer interaction. Depending on degree and direction of technology transfer within GPNs and GINs, as well as the relative position of regional nodes in global networks (see e.g. Ebersberger and Herstad, 2008), they may, however, reconstruct as gravitation and accumulation nodes within these networks. Thus, whereas the question of technology transfer has traditionally been linked to the activities of multinational enterprises, it must now be linked to GIN formation more broadly. In general, it is expected that GINs on average will develop more extensively in fields where knowledge is more readily codified (software) in a commonly accepted (scientific) language, less cumulative and consequently more distributed across organisations and individuals.

For most Estonian enterprises, international business is actually almost a synonym for regional collaboration in the Baltic Sea Region. Estonian innovative companies export to neighbouring European countries, and co-operation with clients is important within the co-operation involved in technological innovation. Suppliers of technologies or materials are again also largely from neighbouring European countries, and co-operation with them is important as well. In addition, due to the extensive presence of FDI in the Estonian economy, those foreign-owned companies are co-operating with other enterprises within enterprise groups. So, in general we are seeing the emergence of a cross-border supranational innovation network in the Baltic Sea Region rather than entrance into truly global innovation networks.

The modes of internationalisation are different, but some follow a pattern where firms start by using low-commitment modes and then move towards higher commitment modes, including foreign acquisitions. Some companies, however, have built successful internationalisation strategies by approaching leading multinational companies and providing specialised services to them.

Off-shoring of R&D and innovation activities occurs, given the general concentration of R&D activities in the Estonian ICT sector, only in a very small number of enterprises. What is

more, the motivation for off-shoring of different business activities, including R&D, varies significantly both in terms of the ICT sub-sector and the ownership structure and strategy of the particular enterprise. Standardised packaged products (incl. software, manufactured goods) that cater for a truly global market are relatively easy to export across borders; therefore, immediate presence on target markets is not always an absolute necessity for the designers and producers of such products. The export of services, however, often assumes a physical presence on the target markets. This is a general observation that applies to all industries, but is also vividly visible in the Estonian ICT sector. In software and telecommunication services, the subcontracting of some of the software development (coding) takes place in lower cost locations (e.g. Russia and Belarus). Some companies also use foreign affiliates to access foreign markets and acquire additional workforce (e.g. Webmedia).

The Estonian ICT manufacturing sector, as stated earlier, is primarily part of a larger Nordic ICT cluster. The manufacture of ICT goods is dominated in Estonia by foreign investment enterprises, who have off-shored in most cases into Estonia various manufacturing functions from the testing of product prototypes and the establishment of suitable configurations of production to the actual manufacturing itself. The R&D that takes place in such cases in Estonia has foremost to do with process rather than product innovation (e.g. the case of Ericsson and Elcoteq). The off-shoring of certain specific product development related R&D functions is rather rare, and has to do with certain unique knowledge and experience that was not available in existing branches of the specific company (National Semiconductor Estonia, Artec Group). By contrast, most of the indigenous ICT manufacturers in Estonia remain fairly weak; they do fairly little in-house R&D and the internationalisation of their R&D activities remains even more limited.

Accordingly, companies from Nordic countries have been moving towards more complicated business models, and have overcome the limitations of small states. Evidence shows that such foreign expansion has clearly taken place in Estonia, as Nordic countries are the dominant sources of foreign direct investment into the largest ICT companies in Estonia, and this has been driven by Estonia's proximity to the Nordic economies. Still, several of the largest foreign-owned companies as well as companies with local ownership and a subcontracting-only profile have little contact with other companies and educational or R&D institutions, where the missing positive feedback mechanisms is a considerable problem.

While the emergence of global production and innovation networks is a good opportunity, in more established fields of ICT, international supply and R&D, networks have already been formed around bigger players quite some time ago. Now, with the increasing concentration of the industry, the barriers to entry continue to mount. In order for new actors to be accepted into existing R&D and production networks, benefits must be clear (and risks low). The limited specialised advantages of Estonian entities remain in this context a considerable threat.

It has been proposed that the globalisation of innovation and the emergence of GINs means that public policy can no longer build territorial knowledge bases (at regional, national and EU levels) without accounting for the need to link such development processes to external knowledge, information and capabilities (Herstad et al., 2010).

Based on this analysis we can also conclude that the true large-scale Estonian entrance into the global innovation network (or rather the Nordic innovation network) from the current Nordic production network still remains to be seen, and, we would argue, is largely dependent upon public policies. While continued investment into the R&D system remains crucial for further capacity building, it is of utmost importance to maintain and increase the quality of higher education and achieve its contribution to the development of the absorptive capacities of local companies. It is already clear that research-intensive companies need senior (top-level) researchers and marketing specialists who must have excellent technical knowledge about research-intensive products, services and processes. Internationally competitive companies with a limited research but strong development capacity need internationally experienced managers and people with product- and technology-management competence. Those with limited development and no research capacity need internationally experienced managers, engineers, designers, innovation managers, international sales and other specialists.

References

Allik, J. (2008). Quality of Estonian science estimated through bibliometric indicators (1997–2007), *Proceedings of the Estonian Academy of Sciences*, 57 (4): 255–264.

Barnard, H., Kalvet, T. and M. Tiits (Forthcoming 2012). *Institutional voids as a trigger for the emergence of global innovation networks: The case of digital service firms*. Manuscript.

Bathelt, H., Malmberg, A. and P. Maskell (2004). Clusters and Knowledge: Local buzz, global pipelines and the process of knowledge formation, *Progress in Human Geography*, 28 (1), 31-56.

Braunerhjelm, P., Halldin, T., Heum, P., Kalvet, T., Pajarinen, M., Pedersen, T. and P. Ylä-Anttila (2010). *Large firm dynamics on the Nordic-Baltic scene. Implications for innovation and growth.* Bergen: Institute for Research in Economics and Business Administration

Dutta, S. and I. Mia (Eds.) (2009). *The Global Information Technology Report 2008–2009, Mobility in a Networked World*. Geneva: SRO-Kundig.

Ebersberger, B. and S. Herstad (2008). *Go abroad or have strangers visit? On organizational search spaces and local linkages*. GIPOL working paper. Oslo: NIFU STEP.

Ernst, D. and K. Linsu (2002). Global Production Networks, Knowledge Diffusion, and Local Capability Formation, *Research Policy*, 31, 1417-1429.

Herstad, S., Bloch, C., Ebersberger, B. and E. van de Velde (2010). National innovation policy and global open innovation: Exploring trade-offs, balances and complementarities, *Science and Public Policy*, 37 (2), 113-124.

INGINEUS survey (2010). Data collection, Estonia. Tartu: Institute of Baltic Studies.

Jensen, M. B., Johnson, B., Lorentz, E., B.-A. Lundvall (2007). Forms of knowledge and modes of innovation, *Research Policy* 36. 680-693.

Kalvet, T. (Forthcoming 2012). Innovation: a factor explaining e-government success in Estonia. *Electronic Government, an International Journal*, 9(1).

Kalvet, T. (Ed.). (2006). *Private Sector R&D in the New Member States: Case of Estonia*. Brussels: European Techno-Economic Policy Support Network.

Kalvet, T. (2004). *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*. Seville: Institute for Prospective Technological Studies-DG Joint Research Centre, European Commission.

Kalvet, T. and M. Tiits (2010). *Estonia.* In: Synthesis Report on the evolution of national innovation system and its relevance for the emergence of GINs. Impact of Networks, Globalisation and their Interaction with EU Strategies.

Kalvet, T., Pihl, T. and M. Tiits (2002) *Analysis of the Estonian ICT Sector Innovation System: Executive Summary*. Tartu: Archimedes Foundation.

Kattel, R. and T. Kalvet (2006). *Knowledge-Based Economy and ICT-Related Education in Estonia : Overview of the Current Situation and Challenges for the Educational System.* Tallinn: Praxis Centre for Policy Studies.

Lipmaa, H. (2011). Estonian Computer Scientists - Ordered by Citations, http://research.cyber.ee/~lipmaa/cites/cites.php?data=estonia.

Malerba, F. (Ed) (2004). *Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe*. Cambridge University Press.

OECD and Eurostat (2005). *Guidelines for Collecting and Interpreting Innovation Data, Oslo Manual*, 3rd ed. Paris: OECD Publishing.

OECD (2008). *OECD ICT Outlook 2008*. Paris: OECD.

Pavitt, K. (1984). Patterns of Technical Change: Towards a Taxonomy and a Theory, *Research Policy,* 13 (6), 343-373.

Rozeik, H. and A. Jürgenson (2009). Info- ja kommunikatsioonitehnoloogiasektori ettevõtete uuring (Study of the ICT Sector Companies). Tallinn: Praxis Center for Policy Studies.

Statistics Estonia (2010). On-line database, www.stat.ee.

Statistics Estonia (2011). *Community Innovation Survey (2006-2008),* www.stat.ee.

Thomson Reuters (2010). Delphion database.

Tiits, M. and T. Kalvet (2011). *Nordic small countries in the global high-tech value chains: the case of telecommunications systems production in Estonia,* INGINEUS.

Tiits, M. and T. Kalvet (2010). *Estonia - ICT RTD Technological Audit, Detailed Report*. Tartu: Institute of Baltic Studies.

Tiits, M., Kattel, R., Kalvet, T., and D. Tamm (2008). Catching up, forging ahead or falling behind? Central and Eastern European development in 1990-2005. *Innovation-the European Journal of Social Science Research*, *21*(1), 65-85.

United Nations Department of Economic and Social Affairs (2008). *United Nations e-Government Survey 2008: From e-Government to Connected Governance*. New York: United Nations.

Interviews

Aho Augasmägi, Swedbank

Tõnu Grünberg, AS EMT

Kristi Hakkaja, OÜ Oskando

Ülo Jaaksoo, Cybernetica AS

Teet Jagomägi, Regio AS

Arno Kolk, Elcoteq SE

Taavi Kotka, AS WebMedia

Andres Kütt, Skype Technologies OÜ

Rain Laane, Microsoft Estonia OÜ

Tarvi Martens, Sertifitseerimiskeskus, AS

Tarmo Pihl, Modesat Communications OÜ

Indrek Ruiso, ELIKO Tehnoloogia Arenduskeskus OÜ

Sten Tamkivi, Skype Technologies OÜ