WP 9 Report: Country Sector Report, Agro-Food in Denmark

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1 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

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[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.

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
- 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

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[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”.

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

- **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.

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.

Agro-processing 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.

2 SYNTHESIS REPORTS OF COUNTRY SECTOR REPORTS

2.1 SYNTHESIS REPORT ICT

The synthesis report on ICT is compiled on the basis of 5 country sector reports[4] by Heidi Wiig Aslesen, NIFU/BI.

2.1.1 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

[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.

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 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“.

2.1.2 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

[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.

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.

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).

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

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.

2.1.3 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 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

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[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.

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.)

2.1.4 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 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.

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[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.

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.

2.1.5 Conclusion – 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.

Conclusion Northern firms –Implication.

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.

Conclusion 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.

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2.1.7 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 Norwegian ICT firm is well below other sector averages. Challenges of coordination and communication	GINs being only marginal in the sector, when collaborating their research 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	Integration into GINs remains modest. Indigenous firms have very few external linkages. Few examples of MNC HQ being able to link up with MNC sub and their

	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	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.	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, 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,	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, 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?

	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.	

2.2 SYNTHESIS REPORT AGRO

Compiled by NIFU on the basis of 2 country reports[10].

2.2.1 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 attached[11]. 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.

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[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

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 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.

2.2.2 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.

2.2.3 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.

2.2.4 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

[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

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-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.

2.2.5 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

[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.

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 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.

2.2.6 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.

2.2.7 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.

2.2.8 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.

2.2.9 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.

2.3 SYNTHESIS REPORT AUTO

Compiled by NIFU on the basis of 4 country reports[14],.

2.3.1 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

[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.

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 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.

2.3.2 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.

[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.

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 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.

2.3.3 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.

2.3.4 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.

3.2. 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 (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 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.

3.3. International Orientation

[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.

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
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

[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.

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 %
headquarters of an MNC	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 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

[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.

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.

3.4. 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

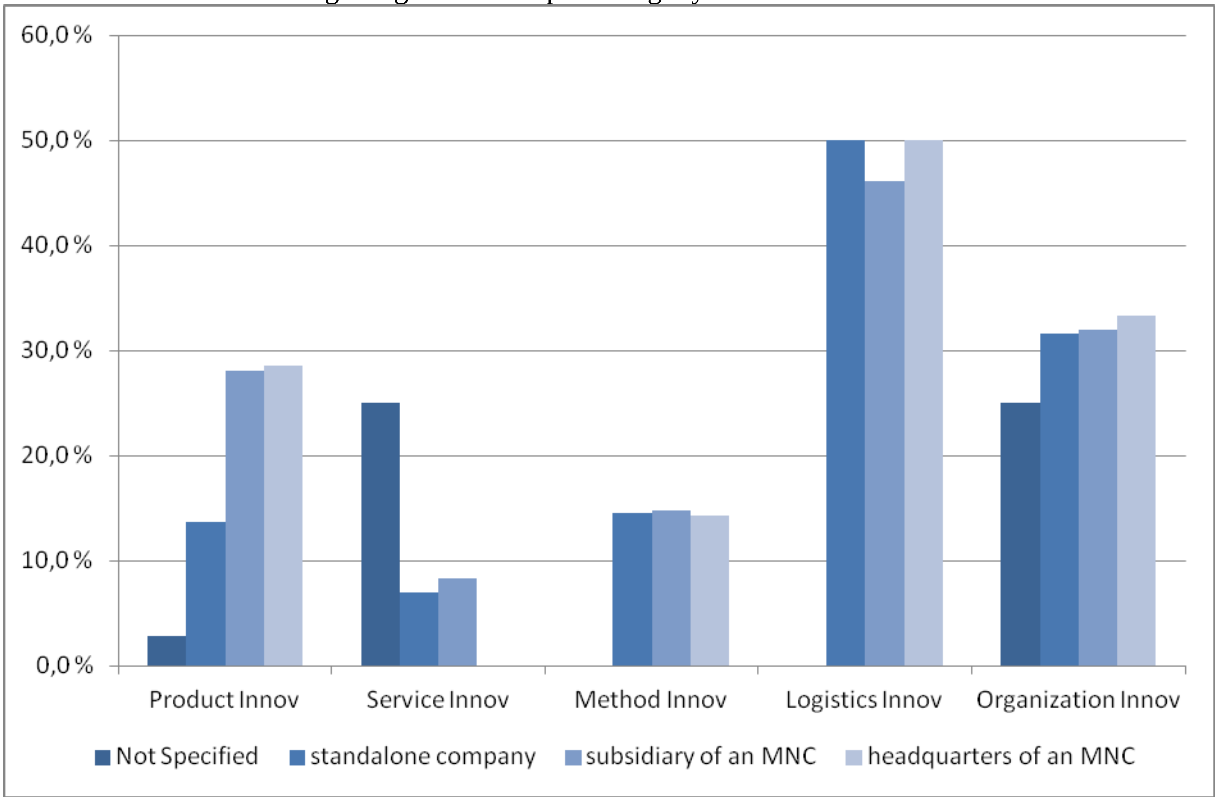
Company_Type	N	R&D Active	R&D Employees (mean)	Innovations (mean)
Not specified	36	5,6 %	0,6	1
standalone company	73	47,9 %	9,2	7
subsidiary of an MNC	32	62,5 %	17,1	7
headquarters of an MNC	7	57,1 %	27,0	8
Total	148	41,2 %	9,7	6

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.

2.3.5 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

[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.

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.

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.

4.1. 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 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

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[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.

[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.

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.

2.3.6 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.

[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)

Sweden

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%.

1 ANNEX 1: WP 9 COUNTRY SECTOR REPORT: ICT IN NORWAY

By Heidi Wiig Aslesen NIFU/BI and Sverre Herstad NIFU

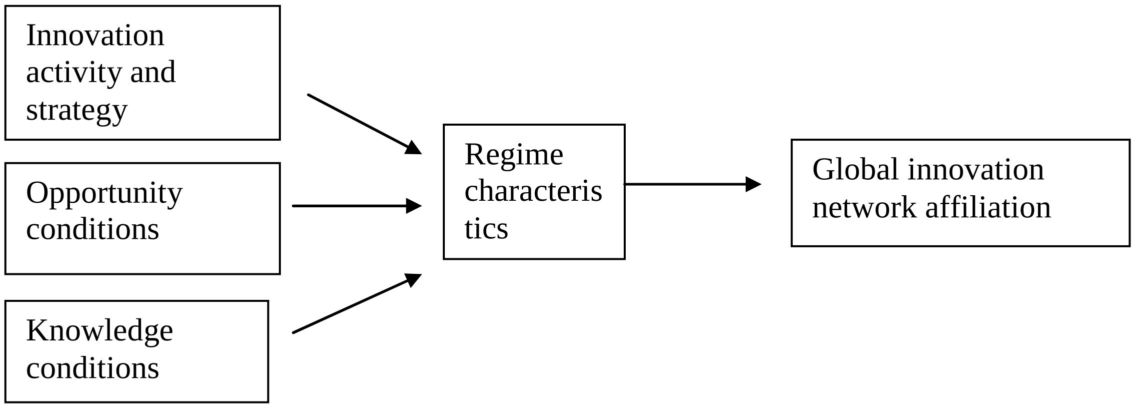
Introduction

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.



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.

1.1 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. Source: CIS2006.

	Number	Share (per cent)
All firms	1514	100
Innovation active	969	64
Present in foreign markets	640	42

[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

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
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.

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 Ingineous 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 Ingineous 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. CIS2006.

	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.

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. CIS2006

	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 & tobacco	7,02	2,00	8,44
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.

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.

1.2 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

[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

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 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.

1.3 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 stage it 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).

1.4 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. Source: CIS2006.

	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

Note: Based on CIS2006, weighted sample (N=25 628). Sourcing refer to contract R&D purchased from other units within own corporate group, or from external industrial or research system actors. If needed, the data can easily be broken down into R&D sourced from parent group units abroad (offshoring), and R&D sourced from external actors abroad (outsourcing). Data on foreign sourcing can also be broken down on world regions.

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 Ingineous 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 THEREFORE BE READ FROM LEFT TO 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	N America	S America	W Europe	E/C Europe	Africa	Japan Australaisa	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 constrain the GIN network affiliation of the sector.

1.5 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 Ingineous 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. Source: CIS2006

	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

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 Ingenious 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.

1.6 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 Ingineous 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.

1.7 Subject 7: Prospective, impact from crisis

Table 29 | How have you reacted or planning to react to the current global economic crisis? NOR Ingineous 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.

1.8 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.

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 regulations/enforcement	19,1 %	4,3 %	14,9 %	27,7 %	17,0 %	36,2 %	94
Better and cleares rules regarding	20,2 %	4,3 %	16,0 %	21,3 %	8,5 %	50,0 %	94

FDI and trade							
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

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.

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.

1.9 Conclusion

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 reflect 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	Implications
	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.		

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2 ANNEX 2: INTERRIM REPORT COUNTRY SECTOR REPORT ICT AND AUTO SWEDEN

WP 9 Country sector report:

ICT AND AUTOMOTIVE IN SWEDEN

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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

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

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.

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 organizations. 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 approximately 10%, this is

[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.

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.

	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

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.

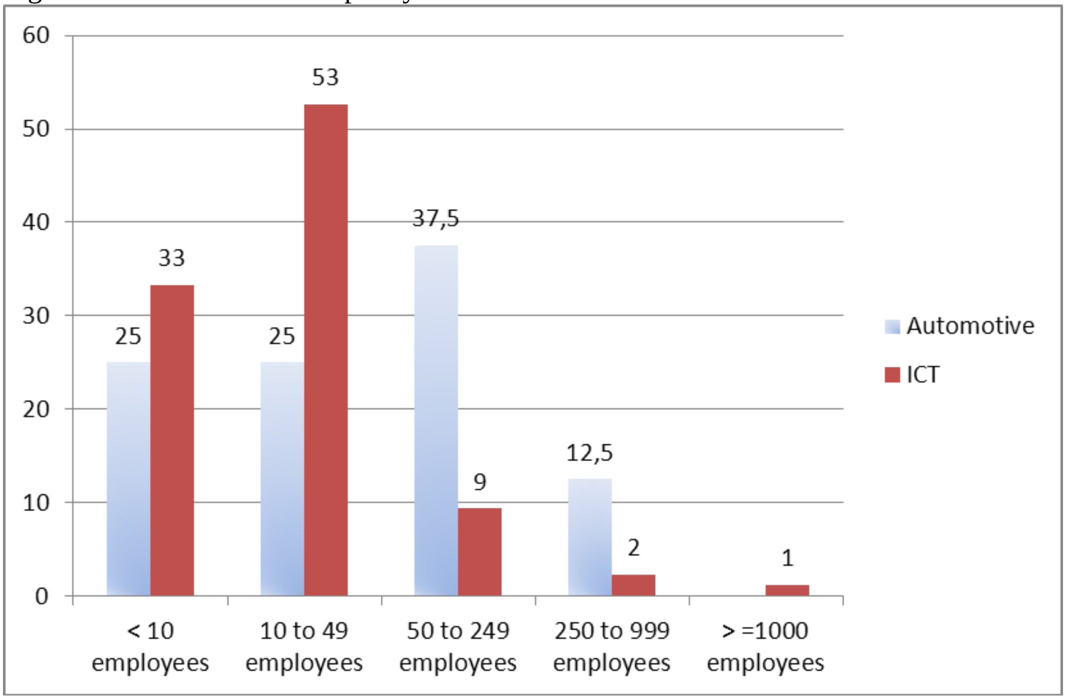
2.3 Present nature of sector activities in Sweden

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).

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.

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

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%).

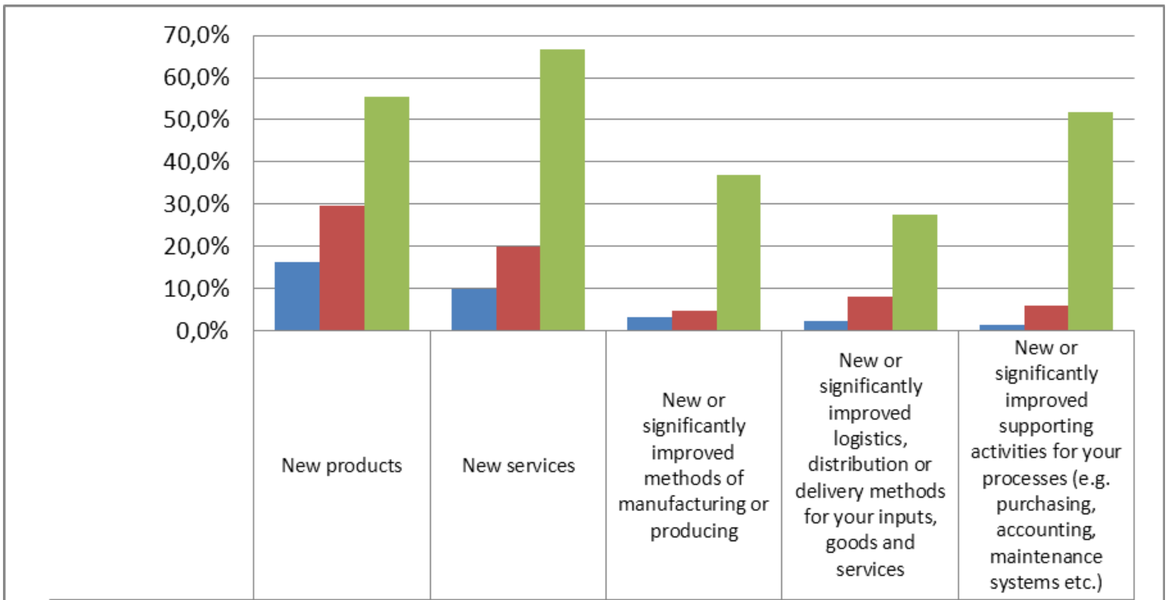
This high effort in R&D is reflected in the number of innovations as well as in the degree of novelty. As Figure 2 shows, about 16% of the ICT firms have introduced new to the world innovations. Again this percentage is much higher in the Autoparts firms where approximately one third of the firms have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

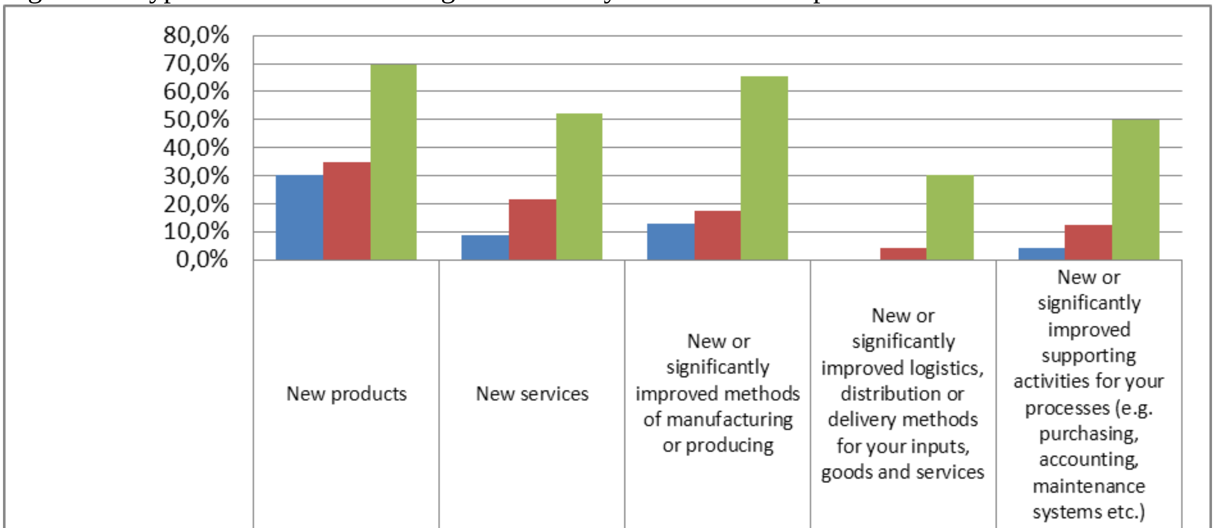
Figure 2a. Type of innovation and degree of novelty – Swedish ICT firms



	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



	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	30,4%	8,7%	13,0%	0,0%	4,2%
New to the industry	34,8%	21,7%	17,4%	4,3%	12,5%
New to the firm	69,6%	52,2%	65,2%	30,4%	50,0%

Source: Swedish INGINEUS survey

Table 36 | Most important source of technology for the enterprise

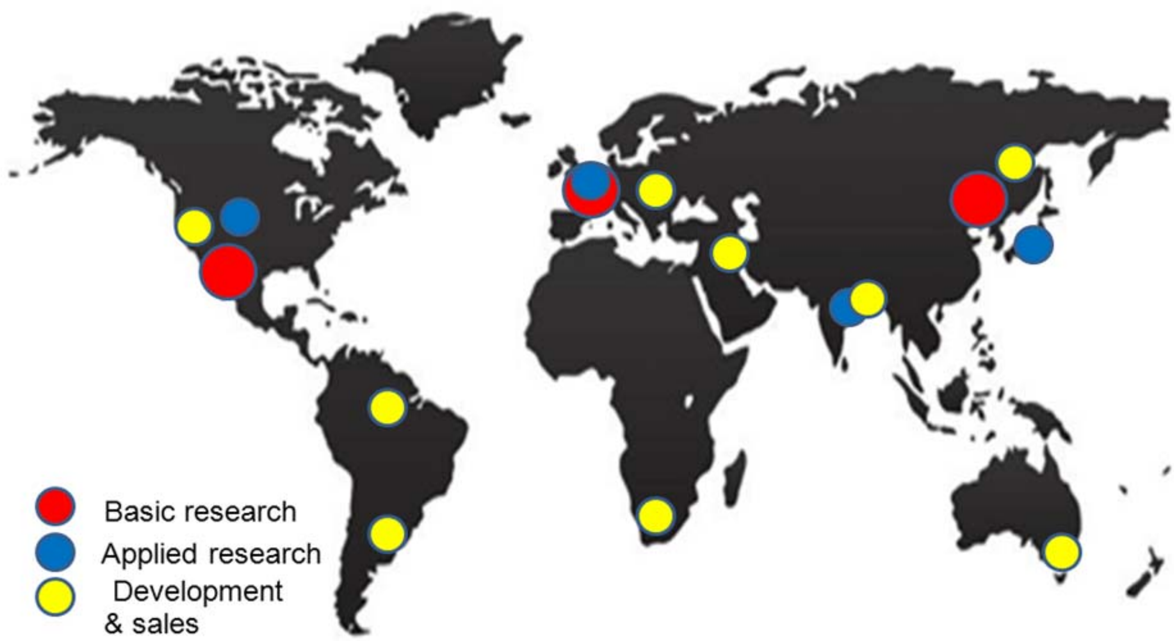
		We produce most technological inputs in-house	We buy most of our inputs from other branches of our own MNC	We buy most of our technological inputs from non-MNC firms	We buy most of our inputs from MNCs with which we are not formally connected	Total
Autoparts	Count	19	3	1	1	24
	% within Autoparts	79,17%	12,50%	4,17%	4,17%	100,00%
ICT	Count	108	10	17	23	158
	% within ICT	68,35%	6,33%	10,76%	14,56%	100,00%

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”.

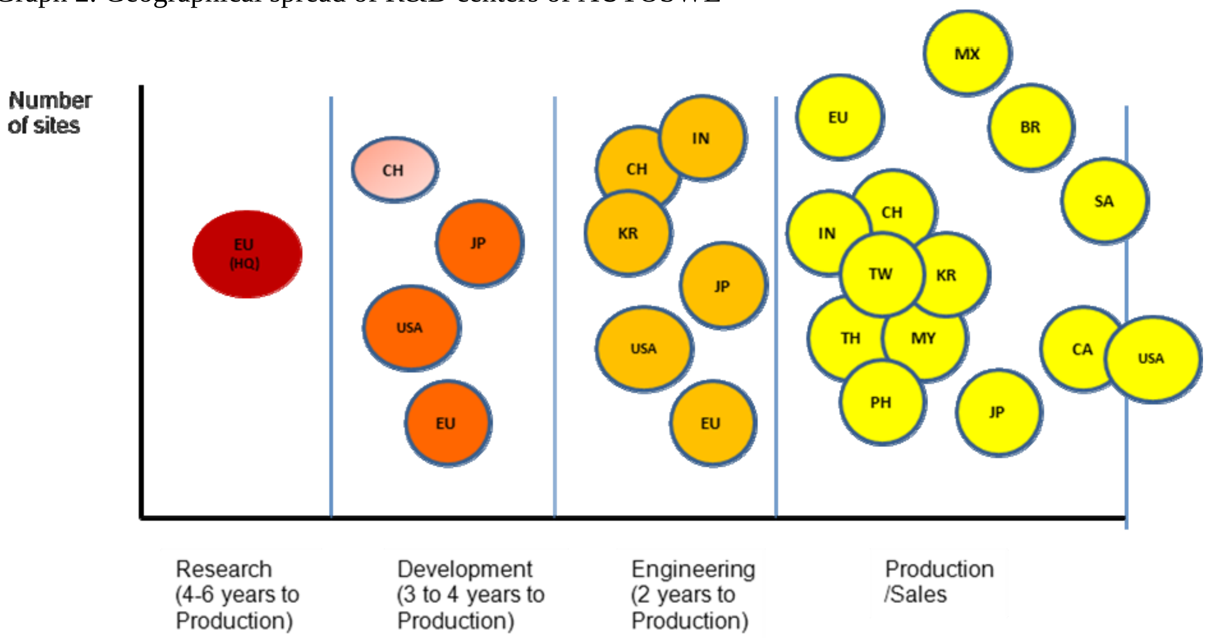
This relationship between the nature of the innovation and its geographical spread can be clearly seen in Case 1 “Telequip” and Case 5 “Autoswe”. Graphs 1 and 2 plot the geographical spread of the R&D centers, according to the type of innovation conducted

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

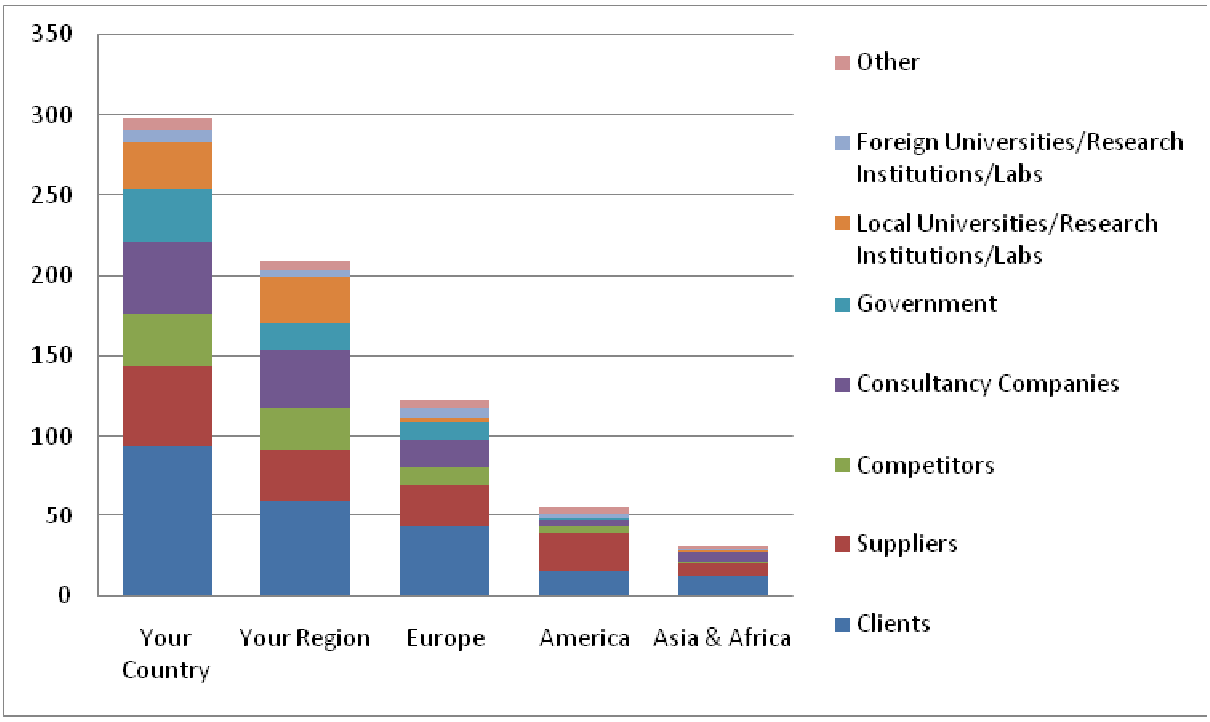
Source: Authors' own elaboration with CIS data (Eurostat, 2007)

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.

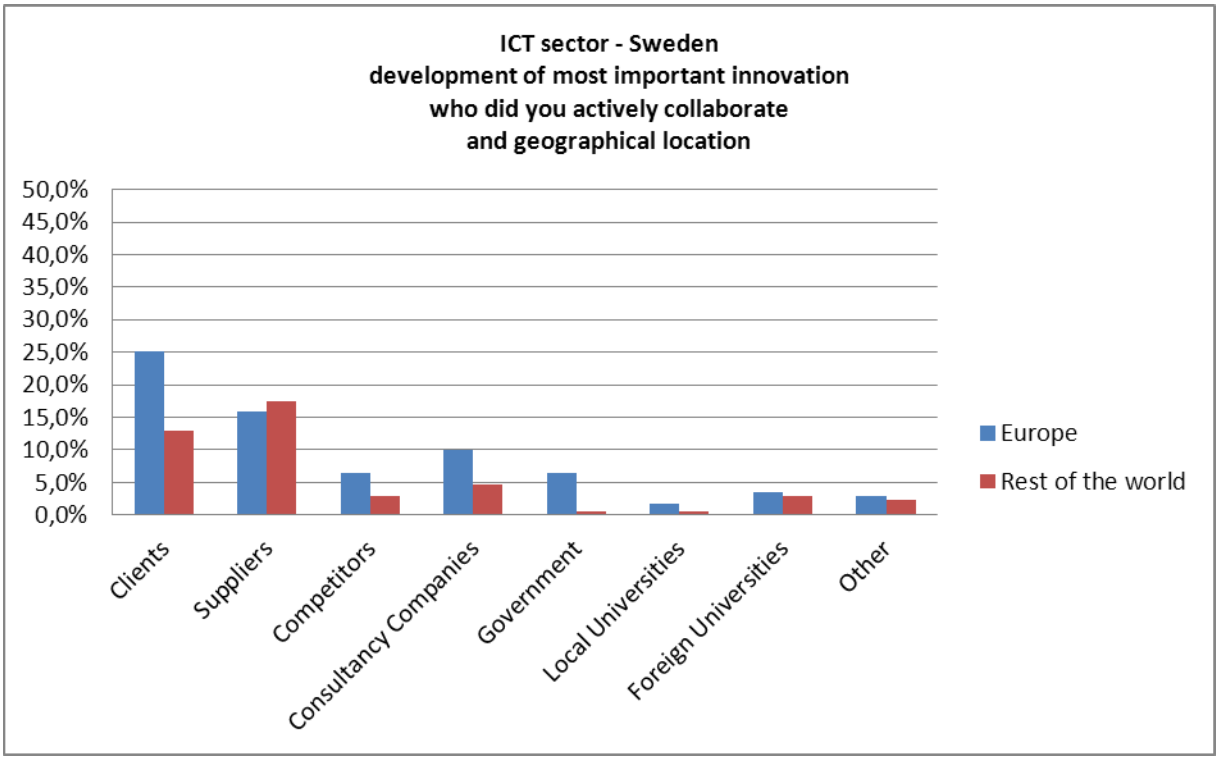
On the other hand, Autopart firms innovate in collaboration with the clients and suppliers and their network is more confined to Europe. In this respect, one could say that Swedish Autopart firms are more engaged in European networks with other organizations in their value chain.

Figure 3a. Collaboration for innovation in Swedish ICT firms



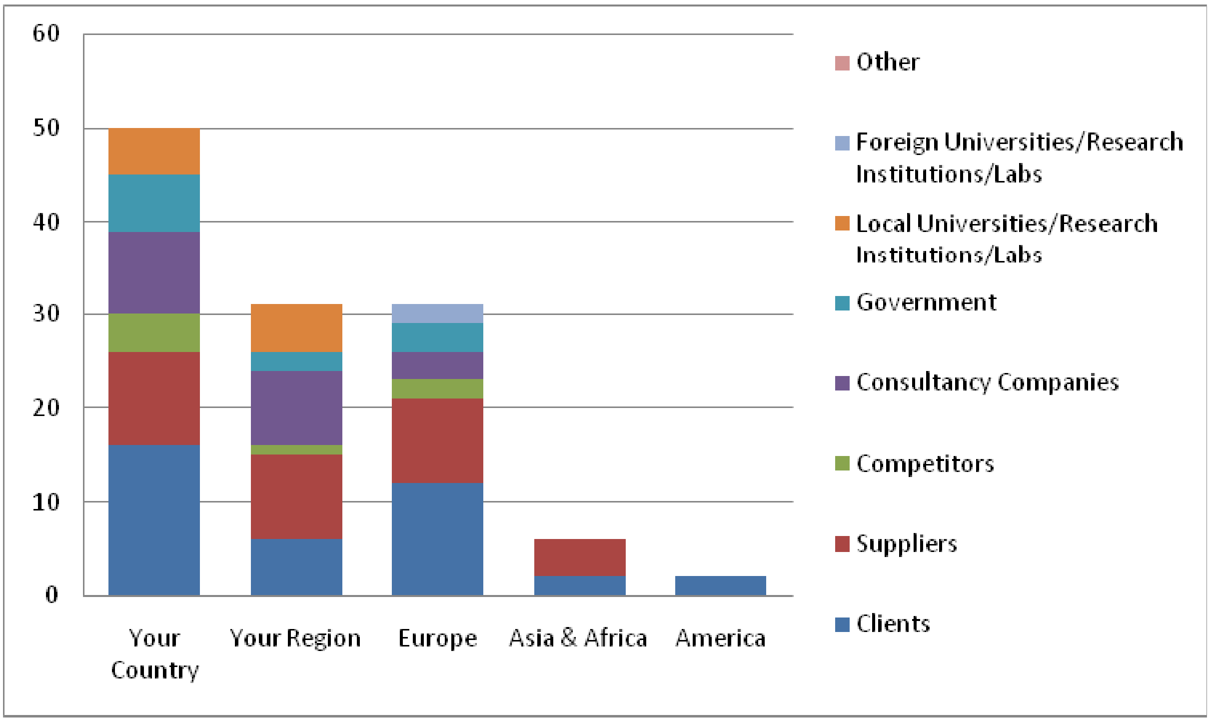
Source: Source: Swedish INGINEUS survey

Figure 3b. Collaboration for innovation in Swedish ICT firms



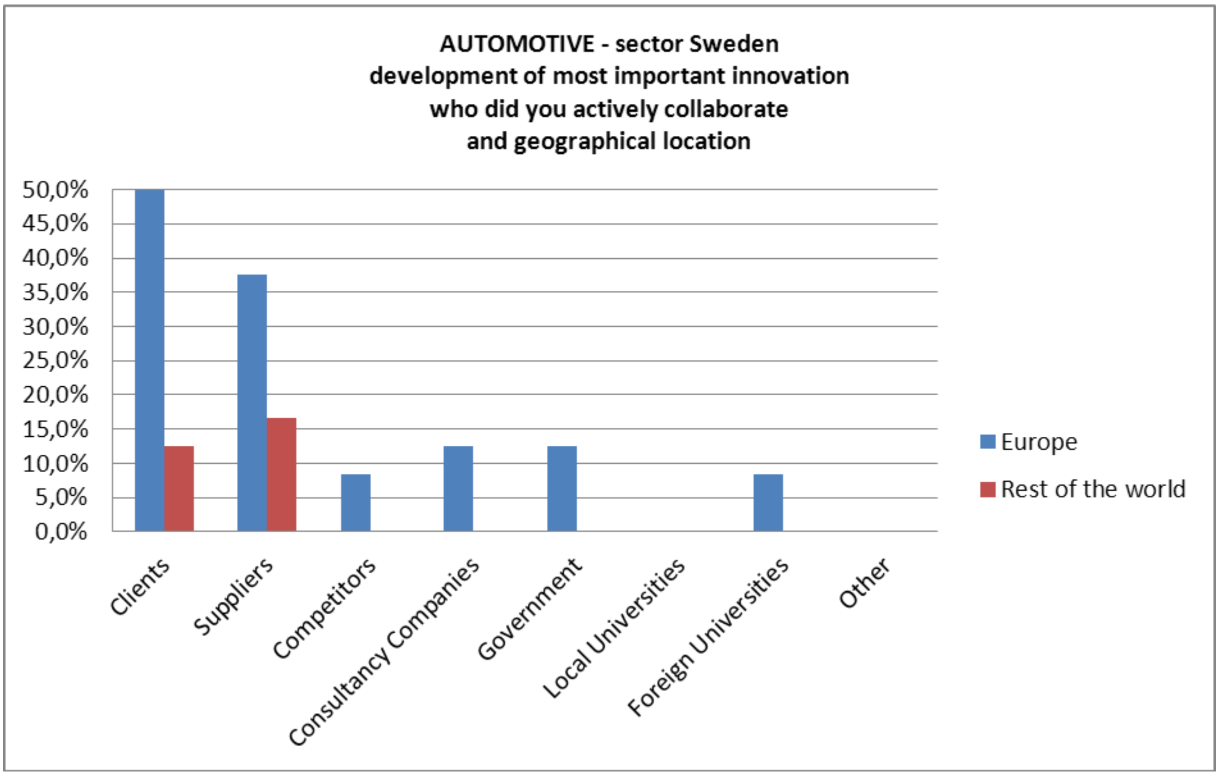
Source: Source: Swedish INGINEUS survey

Figure 4a. Collaboration for innovation in Swedish Autoparts firms



Source: Swedish INGINEUS survey

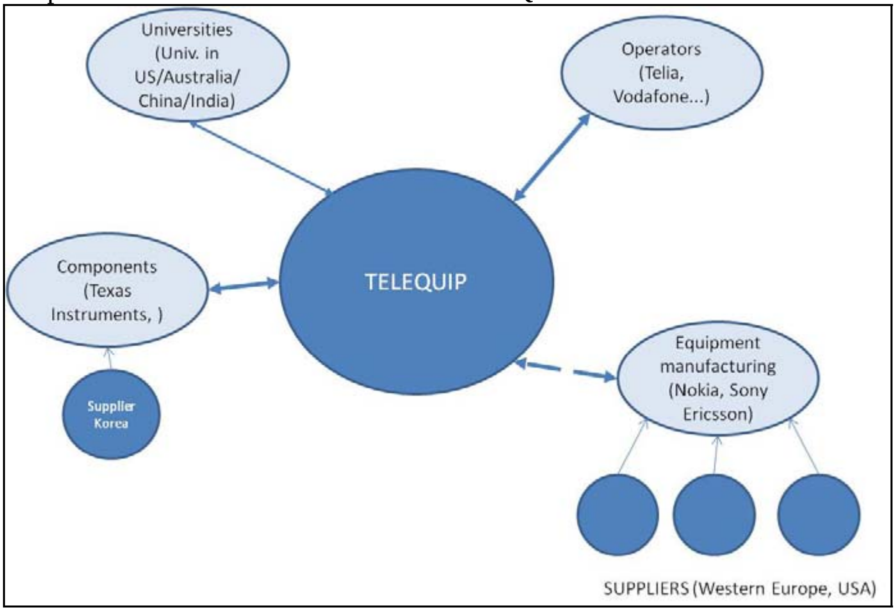
Figure 4b. Collaboration for innovation in Swedish Autoparts firms



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 7.

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

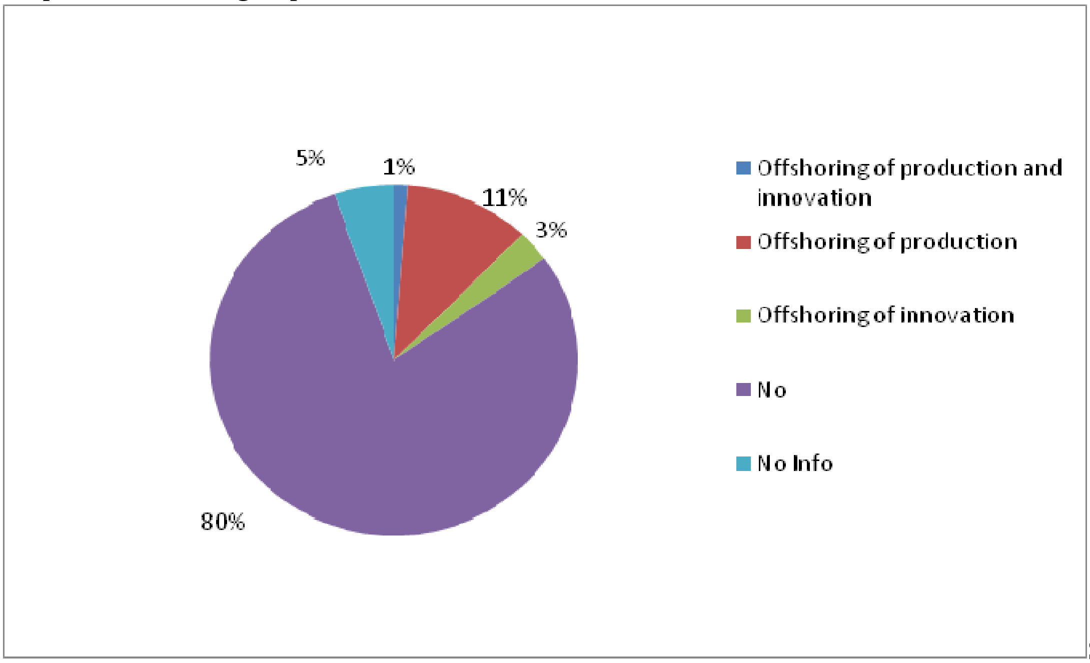
2.5.2 Global Generation of innovation

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"

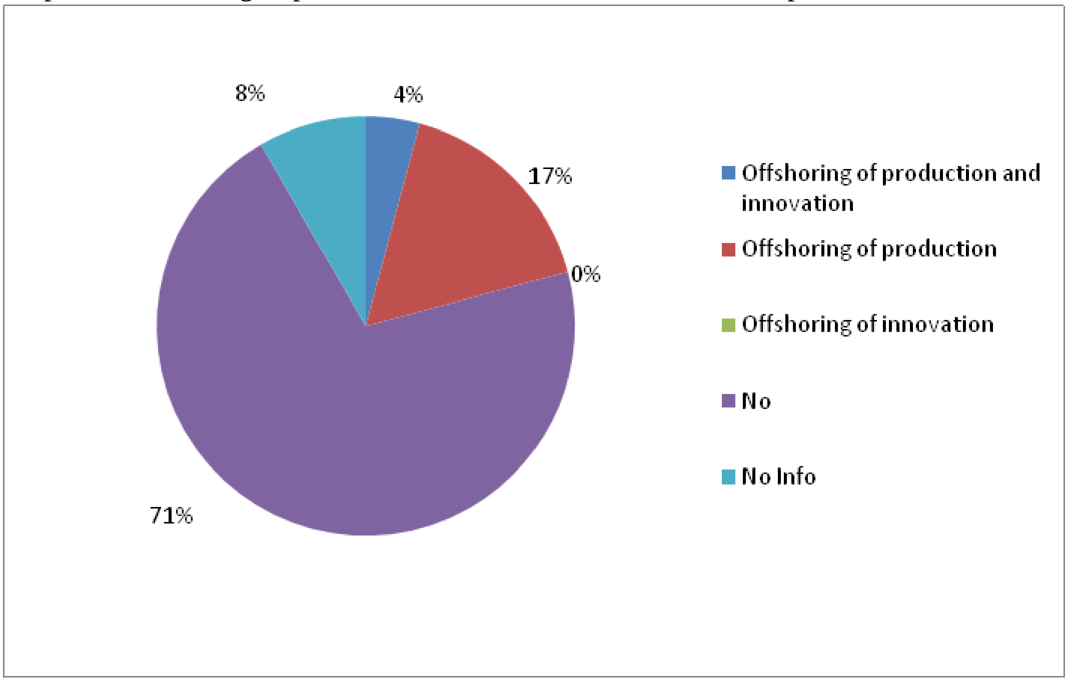
In the case of ICT, innovation networks may not overlap with production networks. Firms may locate innovation centers around the world to tap into specific competences. For example, SOFTNOR decided to locate an R&D center in Easter Europe to tap into a pool of qualified human capital that was available 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 8a.

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 8b.

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	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.

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

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.

Table 42 | Barriers for collaborating in innovation

ICT							
	Share stating moderate or higher barrier	Extreme barrier	Serious barrier	Moderate barrier	Small Barrier	No barrier	Response count
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.

3 ANNEX 3: INTERRIM REPORT COUNTRY SECTOR REPORT ICT ESTONIA

WP 9 Country sector report:

ICT SECTOR IN ESTONIA

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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

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[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

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 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).

3.1 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) (

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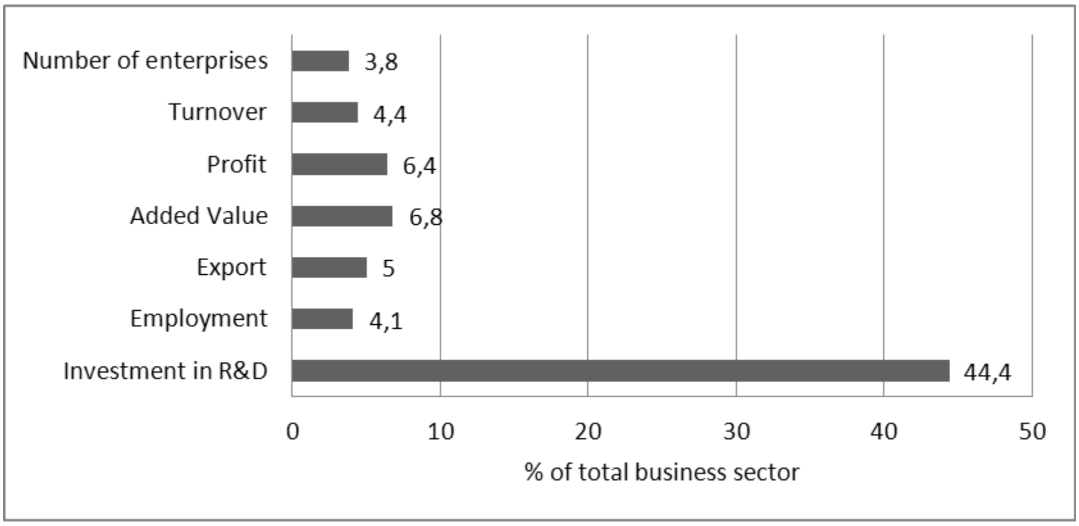
electronics; 268 manufacture of magnetic and optical media; 465 wholesale of information and communication equipment; 582 software publishing; 61 telecommunications; 62 computer programming, consultancy and related activities; 631 data processing, hosting and related activities; web portals; 951 repair 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.

Table 45).

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

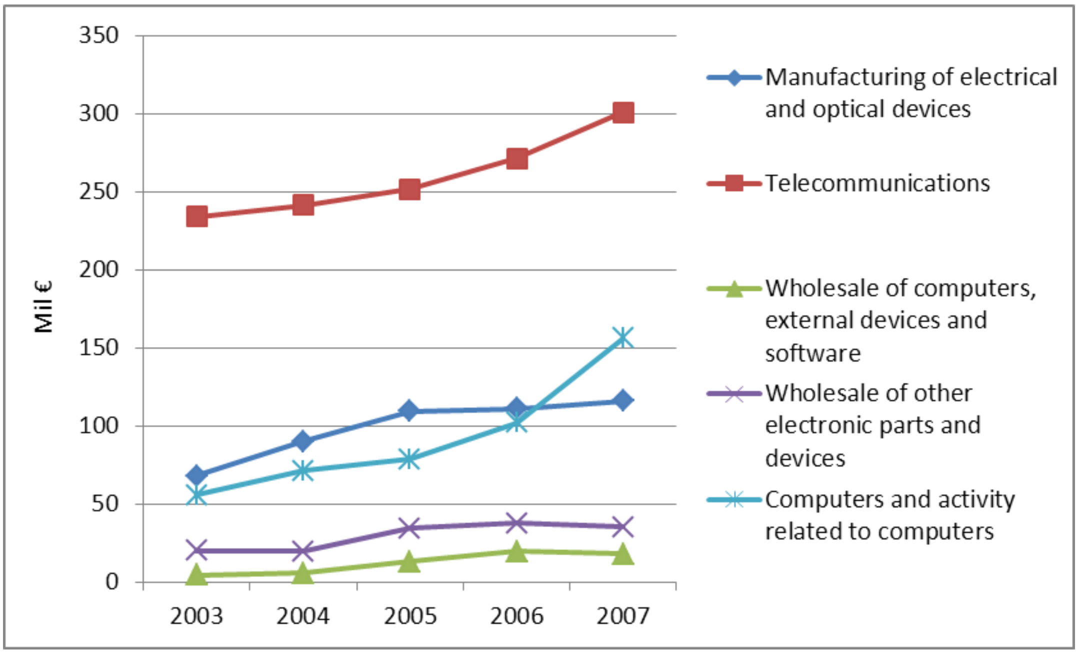


Source: Statistics Estonia, 2010.

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.

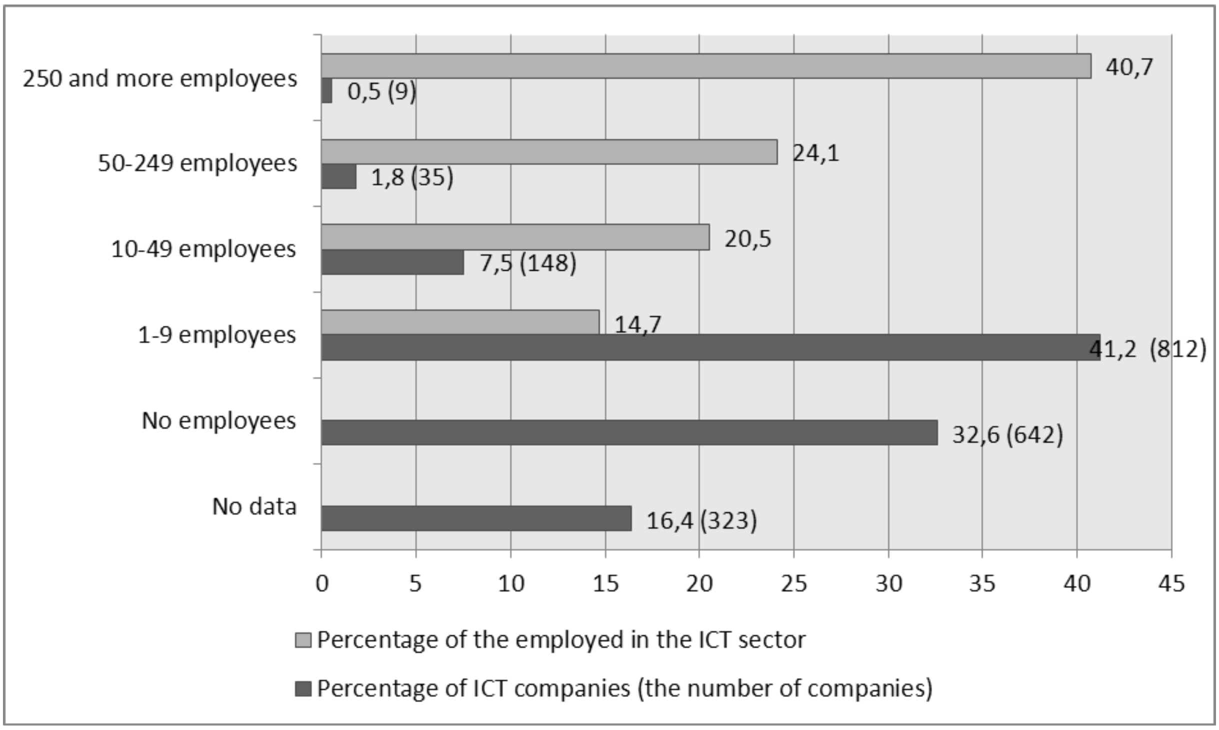
Table 45 | Key figures on Estonian ICT sector enterprises, 2008

	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

Source: Statistics Estonia, 2010.

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).

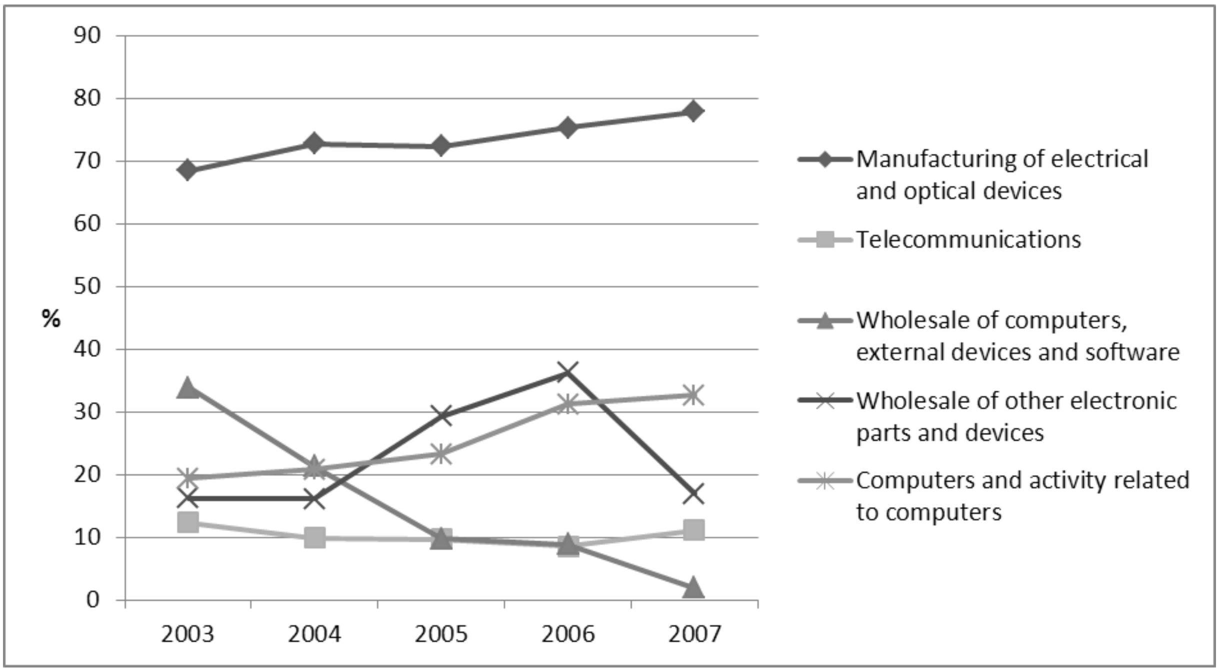
Figure 3. ICT companies



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).

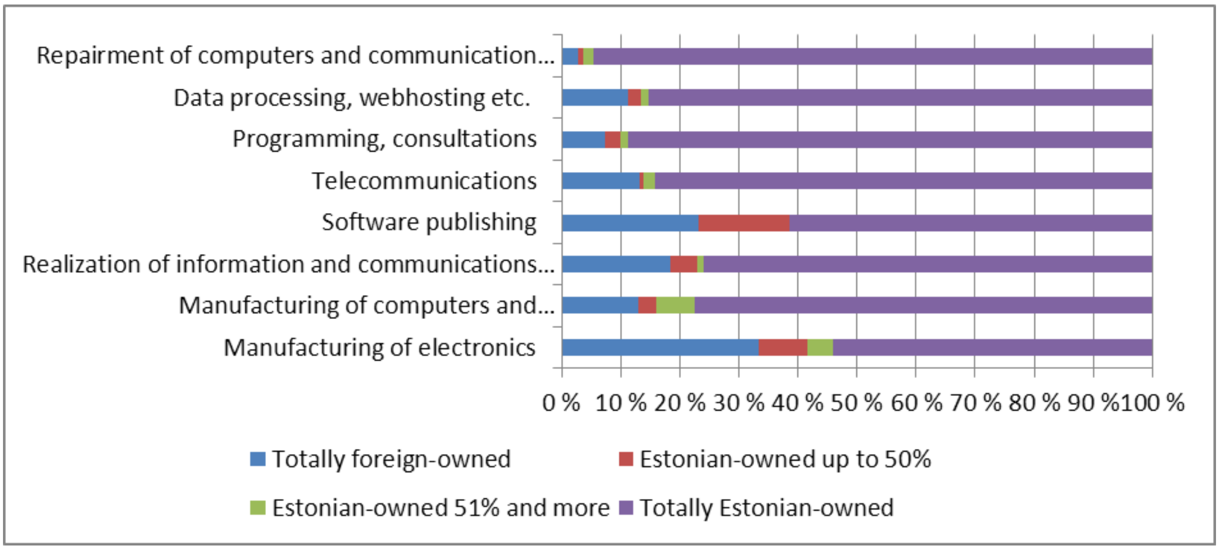
Figure 4. Share of exports in turnover, 2003-2007



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).

3.2 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

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[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.

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 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

	All enterp. (no)	innov. enterpr. (%)	..tech. innov. enterpr. (%)	..product innov. (%)	..process innov. (%)	..product as well process innov. (%)	..non-tech. innov. enterp. (%)	..organis. innov. (%)	..marketing innov. (%)	..organis. as well marketing innov. (%)
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).

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.

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 (Table 49).

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.

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 (Table 50). 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 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	Consultants, commercial 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.

3.3 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	Manu-facturing	....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.

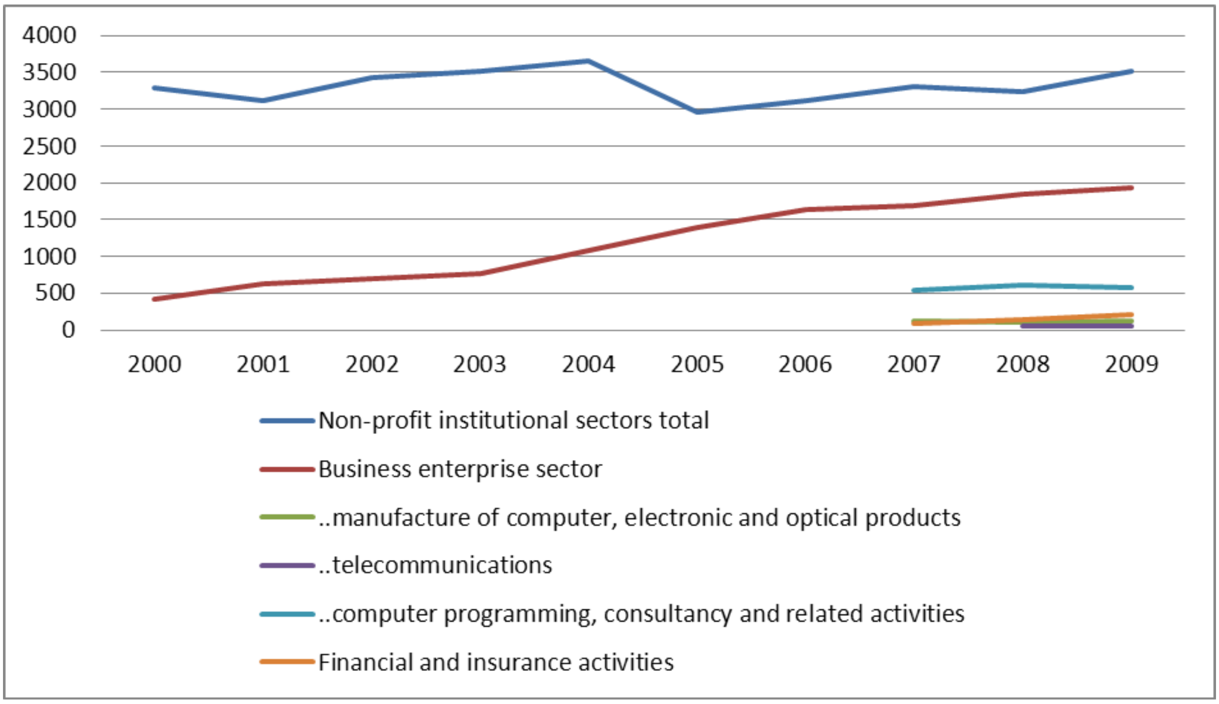
Earlier, it was argued that innovations in the Estonian ICT sector are mostly incremental. This is also confirmed by patenting activity – one of the key indicators used internationally for detecting and analysing the outputs of R&D efforts, although in the ICT sector, quite a significant proportion of 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).

3.4 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

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

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.

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[36]. (Table 54)

[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.

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. 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.

3.5 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.

3.6 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.).

3.7 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.

3.8 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

1. 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.

2. 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.

3. 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.

4. 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

5. 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.

6. 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).

7. 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.

8. 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]

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

[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.

Improvement of international business and technology management skills

10. 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.

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.

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4 ANNEX 4: INTERRIM REPORT COUNTRY SECTOR REPORT ICT CHINA

WP 9 Country sector report: ICT in China

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The purpose of this country sector report is to analyze the dynamics of GIN formation within the Chinese ICT sector, and understand their potential impacts at the national economy level. The following empirical report provides the basis for the China's 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 Chinese ICT firms.

This report is based on empirical data from a) the dedicated Ingineus survey, and b) four strategically selected case studies. The definition of the ICT *sector* was predetermined by the project, and applied.

Two databases are used for China Ingineus survey: one is regionally focusing on Beijing and the other is focusing on Shenzhen (Guangdong province). The first database ("Beijing database" in the following) is owned by Sinotrust, a market research company locating in Beijing, and consists of mainly firm list published by Beijing Administration for Industry and Commerce, as well as Beijing Taxation Bureau. The databank is renewed every three months, and the size we used for ICT industry is 8799. The second database ("Shenzhen database" in the following) is owned by CVISC, a similar research company locating in Shenzhen, and which consists of firm list mainly from several science and technology entrepreneurship service centers in Shenzhen, as well as Shenzhen small and medium enterprises service center.

For Beijing database, the only mode of contact we have used is phone call interview; while for Shenzhen database, three modes of contact - face to face visit, face to face interview on public activities and email - are used. For phone call interview, we had a training course for all telephone interviewers on each question of the questionnaire, and made a pretest for 20 companies to see if any modification was needed about the whole phone call procedure before the formal interview started. The sample drawing method for phone call interview we took is as the following: We use computer to conduct a random sampling every three companies in the list, if a company cannot be contacted, the computer will skip to the next one automatically. If the number of companies does not reach the expected one during the first-round of phone call interview, then we will conduct the second-round phone call interview using the same method as the above; and so forth. For face to face interview, we take two ways to select companies at random, one is to conduct face to face visit, and the other is to invite participants on important public activities, such as Shenzhen Indigenous Innovation Forum, Product Innovation Forum and Innovation Salon, to fill out the questionnaire. For small and medium enterprises, in most cases the interviewee is the owner-manager or top-level manager, while in large firms the interviewee is usually the R&D Head or his/her deputy. Finally we had 242 valid responses.

The case study firms where identified by Ingenius are in the three selected sectors. Each partner carried out 5 interviews with MNC that could be found in those partner countries. The reason for selecting the same company across partner countries is to have the possibility to compare sector dynamics and GIN strategies from diverse regional and national innovation systems. The cases studies are also companies that we knew in advance had international activities (MNC), in order to understand their 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 sector, Sweden, Estonia, China and South Africa followed up on the same companies. In the case of China, we select four as case firms in this report, and Table 55 shows some background characteristics of them.

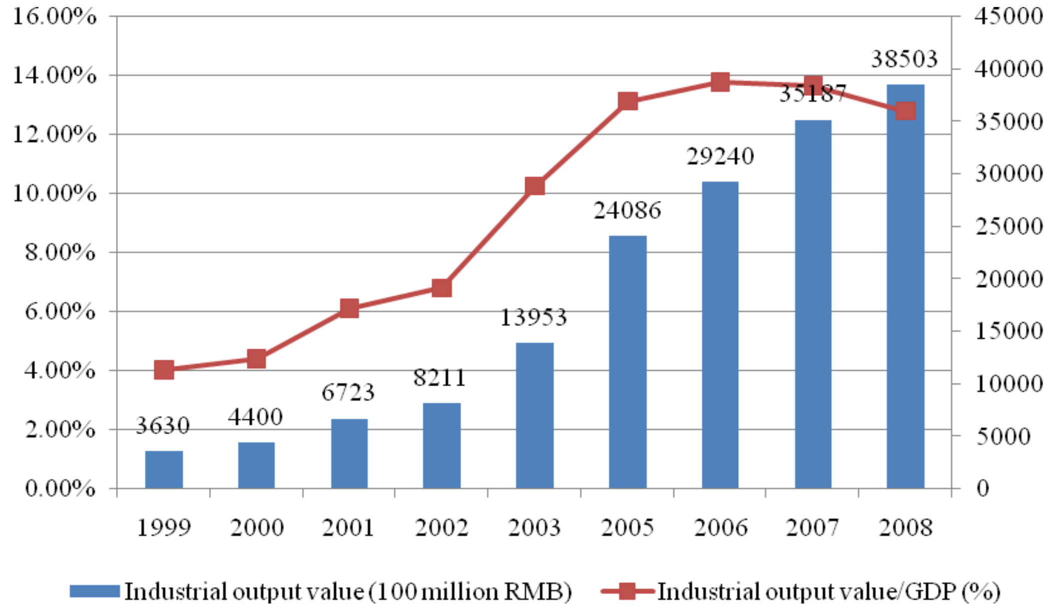
Table 55 | **Key background characteristics of the interviewed firms**

	Location of HQ	Activity in no of countries	Employees in China
Case 1	China	140	60,000
Case 2	Sweden	175	5,800
Case 3	Germany	190	43,000
Case 4	US	Not known	3,400

4.1 Subject 1: The present nature of sector activities in your country

The ICT industry is one of the most fast growing industries in the past two decades in China. The industrial output value has reached 3850 billion RMB in 2008, more than ten times of that in 1999, which made great contribution to China's economic development and has accounted for more than 10 per cent of GDP since 2003 (see Figure 1). The number of employees in the ICT industry of China has increased from 2.0 million in 2003 to 5.2 million in 2008. The ICT industry is the main driver of export of high technology products in China, and 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%). China successfully overtook the positions of Japan and EU in 2003, and took the lead over the US ($149 billion) in 2004 to become the world's biggest ICT exporter ($180 billion). In 2009, there were 61 ICT firms among the top 100 largest exporters of China. With the rapid development of ICT industry, many technology fields such as mobile communication, operating system, wireless internet, next generation network and high definition television have made great achievements with independent intellectual property rights, and a group of excellent firms have emerged and even become leading ones in the world stage, such as ZTE, Huawei, and Lenovo.

Figure 1 ICT industrial output value and its proportion in GDP, 1999-2008

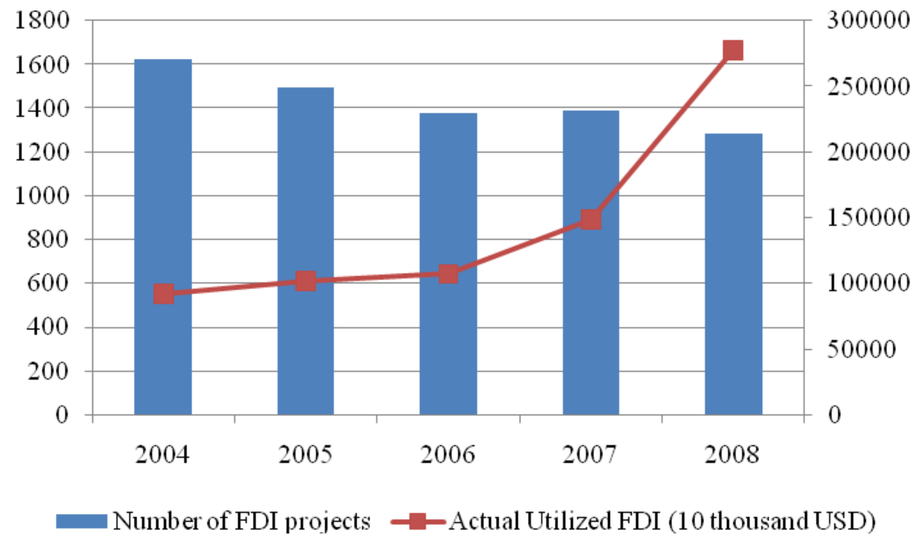


Source: China Statistical Yearbook

Note: Missing data in 2004

The implementation of a more liberal "attracting-in" policy led to a sharp rise in FDI in many sectors, and ICT sector also included. Although there was a small decline in the number of FDI projects during the period of 2004-2008, the actual utilization of FDI has increased rapidly (Figure 2), and in 2008, it has reached nearly $3 billion. However, compared with other sectors, the ICT industry accounted only 3 per cent of total actual utilized FDI of China in the same year (Table 56)

Figure 2 Number of FDI Projects and Actual Utilized FDI of ICT industry of China



Source: China Statistical Yearbook, 2005-2009.

Table 56 | FDI by Sectors of China, 2008 (USD 10,000)

Sector	FDI projects		Actual Utilized FDI	
	Number	Percentage (%)	Value	Percentage (%)
Total	27,514	100	9,239,544	100
Manufacturing	11,568	42	4,989,483	54
Wholesale and Retail Trade	5,854	21,3	443,297	4,8
Leasing and Business Services	3,138	11,4	505,884	5,5
Scientific research, technical service and geologic prospecting	1,839	6,7	150,555	1,6
Information Transmission, Computer Services and Software	1,286	4,7	277,479	3
Agriculture, Forestry, Animal Husbandry and Fishing	917	3,3	119,102	1,3
Hotels and Catering Services	633	2,3	93,851	1
Transport, storage and post	523	1,9	285,131	3,1
Real Estate	452	1,6	1,858,995	20,1
Production and supply of electricity, gas and water	320	1,2	169,602	1,8
Construction	262	1	109,256	1,2
Services to Households and Other Services	205	0,7	56,992	0,6

Culture, sports and entertainment	170	0,6	25,818	0,3
Mining	149	0,5	57,283	0,6
Management of water conservancy, environment and public facilitaties	138	0,5	34,027	0,4
Financial intermediation	25	0,1	57,255	0,6
Education	24	0,1	3,641	0
Health, Social Security and Social Welfare	10	0	1,887	0
Public Management and Social Organizations	1	0		0
International Organizations	0	0	6	0

Data source: China Statistical Yearbook, 2009.

The two-way penetration of inward FDI and outward FDI is one of the main drivers of GIN affiliation of the ICT sector. However, Chinese ICT firms are predominantly small or medium sized, and not affiliated with corporate groups: According to China Ingineus Survey, nearly 70 per cent of firms have 20~249 employees (Table 57), and the proportion of stand-alone company is more than 40% (Table 58).

Table 57 | Organizational size, China Ingineus survey sample (q3.1)

	Response Percent	Response Count
Employee <10	3,3%	8
Employee 10-49	34,7%	84
Employee 50-249	34,3%	83
Employee 250-999	16,1%	39
Employee >1000	11,6%	28
answered question		242
skipped question		0

Table 58 | Organizational characteristics, China Ingineus survey sample (q2)

	Response Percent	Response Count
Standalone company	44.1%	97

Subsidiary of an MNC	26.8%	59
Headquarter of an MNC	29.1%	64
answered question		220
skipped question		22

The ICT industry is more innovation active (i.e. conduct innovation activities such as R&D) than the average of high technology industries in China. On the one hand, the R&D intensity of the former is 6.8 per cent in 2007, while the latter is 6.0 per cent in the same year. On the other hand, firms in the sector are successful in transforming innovation activities into output, especially show high rates of product innovation, for example, the proportion of new product output value in total industrial output value is 25.2 per cent in 2008 (China Statistical Yearbook on Science and Technology, 2009). ICT firms covered by Ingineus survey material also show high product and service innovation rates, and products, services and production process innovations which are new to the industry dominate over innovations new to the firm and the world, while logistics and supporting activities innovation which are new to the firm dominate over innovations new to the industry and the world (Table 59). We can say that the sector has favorable and ample opportunities for innovation at both market (output, pervasiveness) and input (technology, knowledge) sides.

Table 59 | Innovation activities in 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	75,2 %	10.7 %	45.0 %	28.9 %	24.8 %	242
New services	54,5 %	3.7 %	33.1 %	21.1 %	45.5 %	242
New production processes	43,8 %	2.9 %	22.3 %	18.2 %	56.2 %	242
New logistics, distribution etc	15,9 %	1.4 %	7.7 %	10.6 %	84.1 %	242
New supporting activities	42,1 %	1.7 %	13.6 %	22.3 %	57.9 %	242

Besides to be more innovative, the propensity to collaborate is also so high among Chinese ICT firms, and 80 per cent of ICT firms maintain some form of collaboration according to China Ingineus survey. It is also revealed that of the total number of collaborators in ICT, as many as 59 per cent of firms collaborate with customers, 40 per cent with suppliers, and 20 per cent with local universities and research institutes. Taking the telecommunication equipment sector as an example, a famous alliance – TD Industry Alliance – came into being in 2002, which has already adopted 84 members covering all segments of the value chain, including domestic large firms, SMEs, foreign MNEs, universities and research institutes by the end of January, 2011. Such an alliance can be regarded as part of GIN and many members are both rivals and partners in domestic markets or international markets.

Data from the Ingenius survey shows that most firms have their largest markets domestically, and such a domestic market orientation can be considered part and parcel of strong domestic opportunity conditions, and the resulting size composition of the industry (

Table 60). Meanwhile, the second largest market of Chinese ICT firms is export markets, which are oriented towards markets in Asia (Australasia included) or the US (Table 61). The huge domestic market also attracts many FDI into China in the case of ICT industry. In 2008, the industrial output value created by foreign funds accounts for 81 per cent of the total industrial output of ICT industry, but notably, the foreign funds include those from Taiwan, Hong Kong and Macau of China, and the large amount of FDI facilitate the collaboration between domestic firms and MNEs as referred in the above.

Table 60 | Location of largest market, China Ingineus survey sample (q 4.1).

	Response Percent	Response Count
Internal to your enterprise	1.3%	3
A regional market (local region in your country)	19.2%	46
Domestic market (rest of the country)	59.2%	142
An export market	20.4%	49
answered question		240

skipped question	2

Table 61 | 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%	28
South America	15.0%	7
Western Europe	80.0%	10
Central & Eastern Europe	35.0%	11
Africa	15.0%	2
Japan & Australasia	15.0%	19
Rest of Asia	35.0%	24
Rest of the world (developing	5.0%	6
answered question		80
skipped question		162

The size composition of the industry, its market orientation and its collaboration patterns suggests that the Chinese ICT sector as a whole is embedded not only in national user-producer relationships, but also gradually in international network. Below, we will nuance this picture with reference to the case studies, and discuss the global innovation network affiliation of the industry, and not least its future prospects.

Summary 1

GIN affiliation and the nature of ICT sector activities in China

Chinese ICT firms predominantly serve domestic markets. However, with the rapid development of technology capability or technology standard of Chinese firms, more and more firms also serve international market. In general, they are highly innovation active, which illustrates strong opportunity conditions in both domestic markets and international markets. Nevertheless, ICT firms are also much oriented toward innovation collaboration, and the nature of technology makes customers, suppliers and even competitors to be most important partners to collaborate. Taken together, this means that GIN formation is promoted by the narrowed gap between large Chinese firms and MNEs, a large amount of export and inward FDI, and increasing technology uncertainties in this sector.

4.2 Subject 2: Locations and internationalization

The purpose of this subject is twofold. First, we want to understand the country specific "centripetal" forces which contribute to contain or reinforce sector activities at home. Then we want to understand what location factors which are at play if/when companies decide to establish own activities abroad (centrifugal forces). Last, we want to understand divergent (by sector) impact on learning and knowledge accumulation of involved economies (technology transfers, reverse technology transfers).

We now turn to consider explicitly how the above portrayed knowledge and opportunity conditions reflect in the global innovation network affiliation of the Chinese ICT industry. Table 62 shows that 14 per cent of Chinese sample firms have offshored production, while 18 per cent have offshored R&D. This confirms the fact that Chinese ICT firms play a critical role during the transition from GPN to GIN in this sector.

Table 62 | Production and R&D offshoring propensities of China survey firms (Survey q9.1)

	Percent	Count		Percent	Count
Has offshored production	14.3%	34	Has offshored R&D	18.1%	43
Has not offshored production	85.7%	204	Has not offshored R&D	81.9%	195
answered question		238	answered question		238

skipped question	4	skipped question	4

The dedicated survey data allows us to investigate in more detail the location factors which are at play in such offshoring processes. The point of departure for Table 63 is the 34 and 43 observations from Table 63 which have offshored production or R&D. The column marked 1 indicates 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 can see 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. Notably, we find that 31 and 27 out of 43 observations respectively state that market access and knowledge infrastructure are also the most important factors behind the decision to offshore R&D. This is consistent with the case interviews that MNEs are more willing to establish their foreign R&D centers in regions where has huge market size or market potential, in order to capture various opportunities; in addition, these regions should be good knowledge clusters with skilled labors, therefore, they are usually prospective to be knowledge hubs in GIN, such as Beijing in China. And – importantly – we note that only 11 out of 43 observations state that human capital is an important factor behind the decision to offshore R&D. Only 9 out of 43 observations state that cheap production resources and financial incentives are important factors to determine offshoring R&D, although cheap production resources is still the third most important factors (14 out of 34 observations) behind the decision to offshore production. These observations are highly important with respect to the prospective implications of GINs, and for the purpose of developing policy.

Table 63 | Location factors for offshoring of production & innovation, China Ingineus sample (q 9.2, 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	10.7 %	46.2 %	73.1 %	26
Availability of qualified human capital in region	8.3 %	60.0 %	55.0 %	20

Access to knowledge infrastructure and services	15.7 %	44.7 %	71.1 %	38
Access to other infrastructure, cheaper production resources	7.9 %	73.7 %	47.4 %	19
Market access	17.4 %	45.2 %	73.8 %	42
Incentives for the location of activities (tax incentives etc)	7.9 %	57.9 %	47.4 %	19
Efficient financial markets	9.5 %	56.5 %	60.9 %	23
The level of ethical standards and trust	10.3 %	52.0 %	76.0 %	25
The enforcement of intellectual property rights	11.6 %	42.9 %	82.1 %	28
Following clients who are outsourcing	8.7 %	52.4 %	57.1 %	21
Other	0.4 %	0.0 %	100.0 %	1
Answered				242
Skipped				0

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 THEREFORE BE READ FROM LEFT TO RIGHT!

In general, the internationalisation strategies of the case companies reflect the different regime conditions they operate under. Case 1 started its internationalization strategy since 1995. So far, it has already provided products and services that are of high quality with lower cost for over 500 telecom operators in more than 140 countries or regions in the world. Especially, it has established long-term cooperation in foreign markets with plenty of global leading telecom operators, such France Telecom, British Telecom, Vodafone, Telstra and Hutchison Telecom. The company has set up 15 wholly-owned research and development centers with different research directions and emphasis, distributing in USA, Sweden, India, Pakistan and China. The three R&D centres locating in USA are in San Diego, focusing on WiMAX, New Jersey, focusing on terminal technology, and Austin, focusing on IC technology, respectively. The R&D centre set up in Sweden locates in Stockholm, which is focusing on the next generation wireless communication technology. The R&D centre established in India locates in Bangalore, which is focusing on value-added service, while the R&D center in Islamabad of Pakistan is focusing on telecom billing and operation supporting system. The nine R&D centers in China locate in Beijing, Shanghai, Tianjin, Xi’an, Nanjing, Shenzhen, Chengdu, Chongqing, and Sanya, respectively.

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. The orientations of R&D centres established in developed countries are different from those in developing countries. In general, the former mainly aims to develop cutting-edge technologies and conduct the predictive R&D activities for the future. Acquiring qualified human capital is also important, notably during the financial crisis, several major competitors cut their R&D staff in a large scale, and therefore, it acquires a large number of excellent local technical talents. The R&D centers set up in developing countries are mainly regarded as a correspondence for local market development and using local human resources. Especially in the Indian research and development centre, it makes good use of local talents with advantages of software development and English language skills. Another example is that the national billing system in Pakistan was developed by the R&D centre established there. Although rapid internationalization of R&D activities, its production activities still remain in the city where the HQ locates in China, through which it will keep the product with low-cost but high quality. In addition, the political and legal environment in the host country is an important factor for firms to consider when to offshore R&D activities, for example, case 1 has not established R&D centre in Russia due to the risks of political system, although the country has a large amount of qualified talents in the ICT field.

A process of greenfield-based internationalisation is adopted by this company. The localization of employees in overseas market is 60% in average, and in India, the rate of localization has reached 90%. It plans to even introduce management-level talents from local market in the near future. However, it also faces some difficulties in the localization of employees: on the one hand, there are still some barriers for communication between Chinese employees and local employees; on the other hand, in the market it has entered, there are hundreds of minority languages, which is also a great barrier.

Case 2, 3 & 4 all have offshored production and R&D activities, although they show very different internationalization strategies, for example, case 3 internationalize with many joint ventures while case 4 with extensive acquisition-based FDI. Coincidentally, they all regard China as a strategic focus of R&D investment and are gradually putting more and more development based work into China. Taking case 2 as an example, the main driver of internationalisation is “access to competences and resources at an acceptable price”. Its global supply network is polarised among three regions of

America, Europe and China. Meanwhile, China plays an increasingly important role in global R&D activities of this company. Its R&D investment in China has experienced 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. In 2002, it established the Chief Academy of R&D in order to provide a coordinating overview of all its laboratories, collaborations and projects in China. Although the core innovations are mainly developed at "home" currently, based on competences accumulated in-house in this organisation, it has put forward a strategy of "Core China" and will put more development-based activities into China to upgrade this unit in the value chain. For example, in 2004, it exported the first 3G/WCDMA base station products which was totally developed and produced in China.

Case 3 has more localized R&D activities in China than Case 2 and 4. It set up China Research Institute in 1999, which was one of the only three research institutes of this company in the world (the other two are in Germany and US). Its mission is to provide services for the unique innovation of China subsidairy and global businesses. The respondent believes that China has a large customer groups with various market needs and willing to try new things, therefore is an ideal place to develop world-level innovation ideas. It adopt a strategy of "keeping leadership with mainstraim innovation" in high-end market, and "SMART (Simple usage, easy Maintenance, Appropriate price, Reliable, Timely into market)" in emrging market. As Chinese market changes fast, and it usually takes too much time in coordination with HQ to miss market opportunities, its daughter company in China are relatively autonomous and often have strong regional connections and networks, more and more localized research are carried out in China, which is largely driven by the search for opportunities in diverse markets.

Overall, the R&D centers established in developed countries, no matter in home countries or host countries, are technology-based or basic research oriented, and those established in developing countries are market-based or applied research oriented. But the R&D centers in developing countries are increasingly assuming some basic research, due to great importance of developing country markets and skilled talent pool.

Summary 2

Comparing with offshoring of production, offshoring of R&D seems to be a relatively more common phenomenon among Chinese ICT firms. When offshoring of R&D is conducted, the main location factor is market access & knowledge infrastructure and services, which suggests the combination of market-based and technology-based orientation of firms in this sector. Although some differences of location factors for internationalization, we can find a trend of MNCs from developed countries in GIN with less core R&D sites but larger in size of this sector, while China is becoming one of the most important hubs to attract R&D or innovation activities. Meanwhile, MNCs from developing countries in GIN are expanding the R&D sites not only in their own country and other developing countries (e.g. India), but also in developed countries. These two trends seem to be mutual offset for GIN affiliation and so it's difficult to say they would facilitate or constrain GIN affiliation of this sector.

4.3 Subject 3: Sector embeddedness in GINs

The emphasis here is 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 forms under the different sectoral conditions, and how they may interact to create a dynamic evolution of the GIN. We need to map degrees and patterns of internationalisation in the sector activities of the country in question, and interpret these against case and survey insights as well as theory.

The high rates of innovation in the ICT industry as referred in the above do not seem to reflect in patterns of contractual outsourcing of R&D work. Most Ingineus survey sample firms claim that 76 per cent of sample firms produce most technological inputs in-house. Meanwhile, a substantial proportion of these survey firms buy most technological inputs from other branches of their own MNC (

Table 64), which suggests that 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. This reflects that the industry is heavily oriented towards internal knowledge development linked to customer collaboration.

Table 64 | The most important sources of technology, China Survey sample (q6).

	Share	Number
We produce most technological inputs in-house	75.8%	141
We buy most of our inputs from other branches of our own MNC	16.1%	30
We buy most of our inputs from firms which are not MNCs	5.9%	11
We buy most of our inputs from MNCs with which we are not formally affiliated	0.0%	0
We buy most of our inputs from public-sector organizations, e.g. research institutes, universities, etc	2.2%	4
answered question		186
skipped question		56

However, Chinese ICT firms have a high propensity of collaboration, and 80 per cent of the sample firms have various forms of collaborative activities. Another broader definition used by the Ingineus survey - linkages - also shows a high proportion (81%) of international linkages that Chinese ICT firms engage in. This gives a picture of the ICT industry with the characteristics of high in-house R&D investment and broad external linkages or collaborations, which facilitates the GIN affiliation of the sector.

As can be seen from Table 65, only 37 per cent of the sample firms have *not* established formal or informal linkages with customers abroad. Similarly, only about 47 per cent of the survey sample has not established linkages with suppliers abroad. On the other hand, linkages to foreign competitors, consultants and research system actors are rare. 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.

Table 65 | Informal and informal linkages towards foreign actor groups, China Ingineus survey sample (q8)

	Formal	Informal	No linkage	N
Customers	55,3 %	7,7 %	37,0 %	235
Standalone company	45.4 %	8.2 %	43.3 %	97
Subsidiary of an MNC	64.4 %	3.4 %	30.5 %	59
Headquarter of an MNC	59.4 %	7.8 %	28.1 %	64
Suppliers	47,9 %	5,1 %	47,0 %	234
Standalone company	38.1 %	3.1 %	53.6 %	97
Subsidiary of an MNC	59.3 %	5.1 %	35.6 %	59
Headquarter of an MNC	50.0 %	6.3 %	39.1 %	64
Competitors	11,0 %	12,7 %	76,3 %	228
Standalone company	5.2 %	10.3 %	78.4 %	97
Subsidiary of an MNC	16.9 %	15.3 %	66.1 %	59
Headquarter of an MNC	9.4 %	15.6 %	64.1 %	64
Consultants	11,9 %	4,8 %	83,3 %	227
Standalone company	9.3 %	3.1 %	80.4 %	97
Subsidiary of an MNC	16.9 %	1.7 %	79.7 %	59
Headquarter of an MNC	10.9 %	9.4 %	68.8 %	64
Government	9,7 %	5,3 %	85,0 %	226
Standalone company	5.2 %	4.1 %	83.5 %	97
Subsidiary of an MNC	16.9 %	3.4 %	76.3 %	59
Headquarter of an MNC	9.4 %	7.8 %	71.9 %	64
Universities/research labs	10,6 %	4,0 %	85,5 %	227
Standalone company	6.2 %	0.0 %	86.6 %	97
Subsidiary of an MNC	16.9 %	5.1 %	74.6 %	59
Headquarter of an MNC	7.8 %	6.3 %	76.6 %	64
Other	0,0 %	0,0 %	2,1 %	242

Standalone company	0.0 %	0.0 %	1.0 %	97
Subsidiary of an MNC	0.0 %	0.0 %	0.0 %	59
Headquarter of an MNC	0.0 %	0.0 %	6.3 %	64
Answered				242
Skipped				0

In terms of organizational characteristics, HQ of MNCs are more active to establish linkages with customers, competitors, consultants, government abroad than subsidiaries and standalone companies, while the subsidiary of MNCs are more active to establish linkages with suppliers and research organizations abroad than the other two types of firms. Therefore, for Chinese ICT firms, the national HQ has more market-based linkages abroad than the subsidiaries from other countries, while the latter has more technology-based linkages abroad than the former.

The importance of the customer to innovation in the Chinese ICT sector also becomes clearly evident when we turn to consider its embeddedness in global innovation networks. The importance of this actor group is revealed in Table 66, which shows that 59 per cent of the sample firms have collaborated with customers. However, in contrast with the above broader linkages, these collaborative linkages are distinctively oriented towards customers in own region or own country. This suggests home-based collaborations do not overlap with international linkages. We also note that this home-base preference appear to be stronger with respect to competitors and – not surprisingly – government than customers. 89 per cent and 74 per cent of firms that state such collaborative relationships have established these at home respectively. With respect to the former groups, this could be caused by high sensitivity towards trust and social/cultural proximity and by issues related to search costs. As for suppliers, although the collaborative linkages with them are still oriented towards regional and national ones, the suppliers from US also play an important role as foreign collaborative partners.

Table 66 | Collaboration partners used, most important innovation project last three years. China Ingineus survey sample (q7).

	Partner used	Geographical distribution of collaboration when maintained									
		Own region	Own country	N America	S America	W Europe	E/C Europe	Africa	Japan Australaisa	Asia, other	N
Customers	58.7 %	29.6 %	72.5 %	17.6 %	4.9 %	7.7 %	6.3 %	1.4 %	14.1 %	9.9 %	142
Suppliers	39.7 %	27.1 %	69.8 %	20.8 %	2.1 %	3.1 %	3.1 %	1.0 %	9.4 %	8.3 %	96
Competitors	18.2 %	22.7 %	88.6 %	11.4 %	2.3 %	6.8 %	6.8 %	0.0 %	6.8 %	4.5 %	44
Consultancy companies	10.3 %	40.0 %	60.0 %	8.0 %	4.0 %	0.0 %	4.0 %	0.0 %	4.0 %	0.0 %	25
Government	19.0 %	39.1 %	73.9 %	2.2 %	0.0 %	4.3 %	2.2 %	0.0 %	0.0 %	0.0 %	46
Domestic universities/research institutions	20.2 %	36.7 %	71.4 %	2.0 %	0.0 %	4.1 %	0.0 %	0.0 %	0.0 %	0.0 %	49
Foreign universities/research institutions	7.9 %	10.5 %	15.8 %	36.8 %	5.3 %	31.6 %	21.1 %	0.0 %	10.5 %	5.3 %	19
Other	1.7 %	50.0 %	75.0 %	50.0 %	25.0 %	25.0 %	25.0 %	25.0 %	25.0 %	25.0 %	4
Answered											242
Skipped											0

Except for foreign research system, all the actor groups we list in Table 64 are regarded as important partners for innovation by more than 10 per cent sample firms, which indicates that the interviewed firms are embedded in the national or regional innovation systems of their location (in this case China). As the evolution of this sector, both technology and service or application development turn to be sources of core competencies, which result in a substantial deepening embeddedness of firms in GIN, as well as strong linkages between firms and Chinese NIS. This is due to a) huge market size and opportunities in China; b) the customer group is increasingly mature; c) low cost but qualified talent pool. The embeddedness of firms in GIN and local NIS are complementary, for firms from other countries, local NIS may be part of GIN; for indigenous firms, NIS or RIS plays an important role in supporting firms to involve in GIN, i.e. supporting the emergence and development of GIN.

All the four case firms have extensive operation with local partners. Taking Case 1 as an example, firstly, under the guidance of China's indigenous innovation strategy, it meets with national major projects, 863 plan, industrialized projects and electron development fund actively; secondly, it established a Industry-Academia Cooperation Forum in April of 2009 with 17 universities and 4 research institutes, which is so far the biggest industry-academia cooperation organization in domestic telecom industry initiated by a company. In addition, it set up joint labs with more than 50 domestic universities and scientific research institutes; thirdly, it also set up joint labs with IBM, Intel, Qualcomm, Microsoft in China, and joined the TD Alliance, AVS Industry Alliance, and GoTa Alliance to promote industrial development; fourthly, it entered into strategic alliance with the three domestic operators, and headquarters of France Telecom, Vodafone, Telefonica and Hutchison Telecom. They established an innovation center together for joint research and promoting the process of industrialization.

The creative work of Case 2 in China plays a role in a 'globally-linked' approach 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).[38] The fact that its operations in China were brought into global innovation network occurred in 1999, with

[38] 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.

the initiation of cooperation between its joint venture in Nanjing and a subsidiary in US to develop a CDMA R&D project and carry out in China. This means that its Chinese unit started to collaborate with parent company and other overseas R&D facilities, and signifies the entry of Chinese units into globally-linked innovation programmes. In 2002, the joint venture in Nanjing became the supply hinge and logistic centre of the company's Pacific market. In a similar manner, in 2003, another joint venture in Beijing took over product analysis responsibilities and R&D duties for the Asia-Pacific market region. A more general and less formalized manifestation of involvement in globally-linked innovation may be the emergence of precompetitive basic/applied research in China, whose results (somewhat in the manner of a public good within the firm) are likely to be available in any part of the group those are seen to be relevant, rather than having any priori one-to-one link to any innovation project in China. Sources of such research include: R&D Centre in Shanghai, collaboration research with Chinese universities, such as Tsinghua University, Chinese University of Science and Technology, and Beijing University of Post and Telecommunications.

There are some principals to integrate the global resources. According to case 3, the factors considered include presence in lead markets, close to production, close to customers, cooperation with public research, strong patent portfolio, network of excellent people, network regional capabilities and so on. Therefore, its R&D in Europe is focusing on medical, automotive, automation, in USA is focusing on I&C, biotechnology, nanotechnology, in India is focusing on software, while in China is focusing on production technologies. It has carried out extensive cooperation with Chinese enterprises, universities and other local organizations.

It signed an agreement with Huawei in Beijing to jointly invest 100 million US dollars setting up TD-Tech Co. Ltd. on February 13 2004, focusing on TD-SCDMA technology and products development, manufacturing, sales and service, in order to promote the further development of TD-SCDMA. In June 2005, it decided to investment 1 billion US dollars in further jointly developing TD-SCDMA standard with Datang, which account for 2/3 added investment in Asia in the same year. It also cooperate with 16 Chinese famous universities, established a Automatic Control and Communication Engineering Laboratory with Tongji University, a Wireless Information Service Test Center with Shanghai Jiaotong University, a Mobile Advanced Animation R&D Center with Tsinghua University, and a Software and System Engineering R&D Center Zhejiang University.

Case 4 has a close cooperation with local companies, but most of which are part of its supply chain, especially companies locating in Guangdong Province. Though it has its own R&D center in Shanghai, it pays more attention to cooperation with local universities for a lot of R&D programs, for example, it has established a lab in Tsinghua University. To this comapny, China is not only a market, but also a place where ideas could come from. Therefore, this company proposes a strategy of “for China, in China”.

Summary 3

The GIN embeddedness of the Chinese ICT sector

The Chinese ICT sector source a relatively low proportion of total R&D from outside actors, but represents a high in-house R&D investment and broad external linkages or collaborations. Meanwhile, the international linkages in this sector 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. Further, due to huge market size, increasingly mature customer group and low cost but qualified talent pool in China, we can find a substantial deepening embeddedness of firms in GIN, as well as strong linkages between firms and Chinese NIS, which are complementary to each other.

4.4 Subject 4: Coordinating and communicating in GINs

The purpose with this subject is to assess the challenges of communication and coordination with complex GIN networks, under different sectoral conditions; how this constrain or nurture GIN formation and thus the relative importance of learning in such versus learning through home regional or national innovation system linkages.

For the ICT industry, some sub-sectors don't involve production and suppliers in the traditional sense (such as software, consulting service), which in turn reduces the challenges related to value chain design, production planning and logistics, especially on a global scale. Furthermore, it is commonly argued that modularity, codification and industry standards on technology also reduce the challenges related to GIN communication and coordination. However, in the Chinese ICT cases such assumptions do not hold, and the dispersed activities in geographical scope and broad network linkages still lead to problems of co-ordination, communication and integration between and of its constituent element. Table 67 reveals that only overcoming organisational barriers is perceived as a small barrier or not a barrier at all by more than 50 per cent of the sample firms. Barriers related to finding relevant new knowledge on a global scale (i.e. search) and managing globally dispersed projects are perceived as a moderate or more serious barrier by over 15 per cent of the sample, but even more challenging is harmonising tools, structures and processes. More than 4 % of the sample firms find this to be an extreme barrier.

Table 67 | Factors which represent a challenge of barrier to international innovation collaboration, China Ingineus survey sample (q11).

	Share stating moderate or higher barrier	Extreme barrier	Serious barrier	Moderate barrier	Small Barrier	No barrier	Respons e count
Finding relevant new knowledge	20.3 %	3.4 %	2.6 %	14.2 %	14.7 %	28.0 %	232
Overcoming organisational barriers	15.9 %	3.0 %	4.3 %	8.6 %	13.4 %	39.2 %	232
Changing the current location and related costs	15.9 %	3.1 %	4.0 %	8.8 %	10.2 %	18.1 %	226
Managing globally dispersed projects	19.2 %	3.1 %	1.3 %	14.7 %	13.4 %	25.4 %	224
Harmonising tools, processes, etc	20.0 %	4.3 %	2.2 %	13.5 %	13.9 %	27.0 %	230
Answered							242
Skipped							0

In general, 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 too fast for codification and standardisation to keep pace, and when rapidly changing technological landscapes necessitate broad, explorative innovation search processes. There exist two levels of coordination and communication: one is firm – GIN interaction, and the other is intra-firm coordination. The latter also include two levels of coordination and communication: HQ – subsidiary relationship and inter-subsidiaries’ relationship.

In general, the technology characteristics of ICT sectors lead to more decentralized R&D activities, and R&D subsidiaries has more autonomy. However, the coordinating and communicating patterns depend much on the role R&D subsidiary plays. Case 2 divides decentralized R&D laboratories into three types: support laboratory (SL), locally integrated laboratory (LIL), and internationally interdependent laboratory (IIL). It adopts a multi-mechanism against different types of laboratories. Support Laboratory (SL) essentially plays the role of facilitating technology transfer in company. The more traditional variant of support laboratory (SL1) facilitates inward technology transfer, by assisting a subsidiary in which it is located in assimilating and, if necessary, adapting the technology to host-country needs or conditions. A more recently emergent variant (SL2) involves itself in a form of outward technology transfer, by assisting and advising other units of the MNE in the use of established knowledge of the group. In terms of SL1, in particular, ad hoc support laboratory type activity may have been present in Chinese unit’s preliminary and development stages before the establishment of formally constituted labs. However, higher-profile SL type work can then also be found in some of the units in the R&D system that later emerged. Its R&D Centre in Shanghai has wide-ranging responsibilities in the areas of communication software. With the more advanced commitments and capabilities, the centre also retains significant SL responsibilities, one of its functions is to help Chinese unit in inward transfer and application of technologies from the parent company (SL1), and also provide related technical support for Chinese (SL1) and foreign (SL2) customers in the areas such as receiving net, mobile systems and consumables, 3G and broadband. Tight monitoring and centralized control from HQ is needed for SL.

Whilst SLs merely facilitate the transfer and improve the application of existing technologies (already embodied in goods and services), the two remaining types of laboratory play the roles in creating new technologies and sources of competitiveness. The locally integrated laboratory (LIL) works in a closely integrated manner with other functions of a subsidiary there (logically a PM) to develop a distinctive product which can be supplied to local, regional or even global markets. Thus a LIL and its subsidiary not only extend the competitiveness of a MNE, but place the initial manifestation of this in a location that can supply the relevant creative (including R&D) inputs. Its R&D centre in Shanghai, Mobile World China Subsection, Wireless Technology Ltd. in Chengdu, Data Application Technology R&D Centre in Guangzhou, TD-SCDMA R&D Centre in Nanjing as well as R&D projects of several JVs in China all involve in LIL type functions. Taking the R&D projects of JVs as examples, we find the significant LIL outputs in both Panda Communication Ltd R&D Centre in Nanjing (ENC) and Mobile Communication Ltd Centre in Beijing (BMC). ENC committed itself to the R&D of second generation GSM mobile communication systems and CDMA systems. Now it is responsible for R&D of GSM AC-A systems and GSM CAN systems of Ericsson's global markets, and for GSM exchange system, CDMA systems and receiving system (ADSL, ADC, PSTM) for the Chinese market. BMC showed a strong input to global operations, with responsibility for accessory products of communication systems successfully exploited in the MMC exchange implement for Vodaphone (Australia) and helped in the simplification of its range of mobile phones. Also the company and China Telecommunications Scientific Technology Academy R&D Centre include LIL work for the Chinese market (products of WCDMA) and for the global market (research of 3G for future mobile communication systems and the WCDMA FDD wireless receiving net). LILs derive distinctive perspectives from two knowledge communities: that of the MNE group and that of the host country research institutions. They have high interdependence with internal and external environment of the company, so information technologies such as video conference are frequently used.

The third type of R&D facility pursues the longer-term enrichment of technology potentials by tapping into distinctive scientific (precompetitive) research agendas and knowledge stocks of particular countries' NSIs. Thus the internationally interdependent laboratory (IIL) carries out basic or applied research, separately from the current commercial activities of the company, but interdependently with similar units internationally. An IIL network therefore seeks to articulate a range of separate precompetitive projects in several countries (each building on distinctive attributes of its host NSI), but to also encourage communication between them so that potentially significant synergies in their results can be detected and, hopefully, built into subsequent innovation programmes. Thus IILs can be components (along with LILs) in globally-linked approaches to innovation, and we have already noted that the emergence of this type of work in China may imply its growing positioning in the company's creative programs and perspectives. Since IIL type work depends on top quality local capacities in scientific research, it is not surprising to find that it is the defining content of the company's cooperative projects with Chinese universities. In

1999, it sponsored an acoustics laboratory in Beijing University of Science and Technology to carry out research in disciplines relevant to its evolving commercial priorities. It also cooperated with some comprehensive universities, such as Tsinghua University and Chinese University of Science and Technology, as well as some Professional Universities, such as Zhengzhou Telecommunication Engineering School and Beijing University of Post and Telecommunications, in research projects and organizing conferences, in order to identify potentially important directions for future basic or applied investigation. IIL utilize a wide range of information from probably different scientific disciplines, and more autonomy from HQ is needed and people-based coordination and communication patters such as international transfer of managers and cross border visits works well.

Case 3 experienced a transition from centralized R&D pattern into a decentralized one. The original model where the headquarter was responsible for the research work while the subsidiaries were responsible for the production and sales led to an unfavorable result that the products didn't fit for the Chinese market and not practical. Further, the efficiency of the head-quarter's research work was rather low, and their work was more conservative, and therefore couldn't meet the need of the fast changing Chinese market. So it carried out an internal restructuring. In addtion, it only set up three overseas R&D centers in Germany, US and China, so they three seem to be much independent. In China, the research work is conducted mainly by Chinese employees, while the HQ will provide relevant support. The HQ will assign R&D managers to be responsible for the team construction, the pattern of which could combine China's efficiency and experiences with the prudence and logic of Germany well, ensuring the efficiency and quality of R&D. As the overseas R&D centers set up by case 1 mainly take the responsibility of tracking cutting-edge knowledge, it adopts a more centralized pattern, however, in order to facilitate knowledge flow, the company establishes a rather well electronic platform. All case firms seems to move toward a more complicated and multifaceted integration on coordination and communication mechanisms.

Summary 4

Coordination and communication in GINs

The technology characteristics of modularity, codification and standardisation of ICT sector do not seem to overcome the challenges of its coordination and communication in GINs. ICT firms still experience problems with respect to the usage of harmonising tools, structure or processes, identifying relevant knowledge on a global scale, and managing globally dispersed projects. Firms try to establish appropriate coordination and communication mechanisms to facilitate knowledge flow at intra-firm level and firm-GIN level. However, the coordinating and communicating patterns depend much on the role the decentralized R&D subsidiary plays.

4.5 Subject 5: Prospective, impact from crisis

The purpose of this section is to assess whether or not the financial crisis impact sector activities and GIN evolution. A number of possible scenarios can be imagined, for instance less long-term intramural R&D and more sourcing of contract R&D on a more short-term basis; less emphasis on searching for knowledge and coordination/communication within GINs and stronger emphasis on production in low-cost sites (GPN); financial problems among GIN/GPN partners creating "harsher" (more opportunistic) transaction environments, etc. In short, the crisis can, under different sectoral conditions, trigger increased as well as decreased emphasis on innovation; and cause GINs to expand as well as retract.

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. From Table 68, we can see that only 38 per cent of ICT firms think that the financial crisis has few or no impact on them, especially, it seems that the financial crisis will have a significant impact on the GIN affiliation of the sector, or the ICT firms' innovation activities more broadly, for example, more than half firms plan to increase innovation effort, and 10 per cent of firms plan to relocate innovative activities from abroad.

Table 68 | How have you reacted or planning to react to the current global economic crisis? Chinese Ingineus survey sample (q14)

	Percent	Count
Few or no changes	38.3%	92

Increasing effort at innovation on our part	53.8%	129
A serious reduction of innovative activities	4.6%	11
Relocation abroad of innovative activities	3.3%	8
Relocation of innovative activities to you from abroad	10.4%	25
Answered		240
Skipped		2

Summary 5

Financial crisis impact on GIN formation in Chinese ICTs

The large proportion of ICT sector firms which serve both domestic markets and export markets seem not to be sheltered from the financial crisis, which reflects the strong impact of global environment on Chinese ICT sector, and furthermore the deep embeddedness of Chinese firms in GIN. However, the financial crisis will increase firms' innovation effort rather than reduce them. A main point of view in China is that the financial crisis is a rather good time for firms to innovate or industries to upgrade. In addition, the financial crisis will also have an impact on GIN formation in ICT sector, and for example, some firms plan to relocate their innovative activities from abroad, and which means there may be a substitutable effect between intramural innovation and foreign outsourcing.

4.6 Subject 6: Looking forward, implications for policy

The purpose of this section is first to assess the extent to which innovation in the different sector can be assumed to become more or less embedded in GINs; and thus provide part of the basis for developing implications for policy. Under this section it is important to capture issues such as expectations of increasing or decreasing dependence on knowledge/technology from North in the South; the possibility of shifting focuses of innovation from the North towards the South; of actors in the South repositioning themselves in the value chain; and of possible retractions of GIN as a result problems related to operating in and coordinating between different actor groups and contexts. The policy discussion should focus on identifying areas in which regional, national and EU level policies can contribute to "anchor" different GIN nodes in territorial innovation systems and in this way enable necessary GIN linkages to go hand in hand with technology transfer into and knowledge development within territorial economies.

Table 69 indicates simultaneously the importance of different location factors and different areas in which public policy may intervene. As would be expected, more than 85 per cent of the sample state that more public economic support for innovation activities would be desired. Almost as many firms state that more stringent IPR regulations or enforcement and higher skills in the labour are of moderate or high importance. Notably, other than open and flexible migration policy, all items we listed such as better access to international research networks, support for the internationalization of innovation and technology transfer, FDI and trade rules, international risk capital are considered to be moderate or higher importance by more than half the sample. There issues are also reflected in the firm interviews to varying degrees, which have policy implications for the innovation at both the industry-level and firm-level.

Table 69 | Considering your future innovation activities, please assess the need for improving the following factors (degree of need). China Ingineus survey sample (q13)

	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	63.8 %	16.6 %	27.7 %	19.6 %	16.6 %	19.6 %	235
More public incentives and economic support	86.7 %	43.3 %	35.0 %	8.3 %	6.3 %	7.1 %	240
Better access to international research networks	67.4 %	20.3 %	27.5 %	19.5 %	16.9 %	15.7 %	236
Higher skills in the labor force	82.7 %	35.0 %	35.4 %	12.2 %	6.8 %	10.5 %	237
More stringent IPR regulations/enforcement	83.8 %	38.0 %	29.1 %	16.7 %	7.7 %	8.5 %	234

Better and clearer rules regarding FDI and trade	59.8 %	20.5 %	22.2 %	17.1 %	19.7 %	20.5 %	234
More open and flexible migration policy for employing experts from abroad	39.2 %	8.6 %	9.9 %	20.7 %	19.8 %	40.9 %	232
Greater availability of risk capital for innovation activities with an international dimension	52.1 %	15.4 %	15.8 %	20.9 %	23.1 %	24.8 %	234
Answered							242
Skipped							0

The main challenges at the industry level, and thus on policy, is summarized as the following. 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, which does not only need legal oversight, but also is a problem of moral consciousness and difficult to remove in short-term in developing countries.

Secondly, to change the pattern of labour cultivation, the availability of qualifications in the labour market is still a problem of ICT sector. In the past decades, with the expansion of enrolment of Chinese universities, they have sent more personnel to the ICT industry in order to match its rapid development. However, there is still a shortage of qualified personnel, for the education system has a gap with the industrial practice. Many firms point out that they have to give extensive training to fresh graduates. For example, case 2 established a campus club with Shanghai Jiaotong University in June of 2010 in order to jointly cultivate specialized ICT talents. The company will create various opportunities to facilitate the direct communication between students and experts from ICT industry, provide more intern positions, and organize innovation contest in the ICT field. Therefore, 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 labours 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. The OECD ICT report shows that none of China's MNCs have been listed in the world top 250 firm classification (OECD, 2006).[39] China's largest PC maker Lenovo quadrupled its revenue to $13 billion after taking over IBM's PC business in 2006, but is still one-ninth the size of IBM ($91 billion) and one-fifth the size of Dell ($55 billion). 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. Huawei has the largest export of $7.0 billion among domestic firms, but which was only 1/3 of the largest ICT exporter, Dafeng (Shanghai) computer (wholly owned by Taiwan Quanta).[40] On the other hand, the industry relied heavily on foreign imports of key components and advanced equipment for production. Many high value-added parts imported went essentially to those sectors that China took the lead in, in terms of export and production. For example, China ran trade deficits of $50 billion in integrated circuits, $7 billion in semiconductors for producing mobiles and computers, as well as a small portion of tubes for TV production (OECD, 2006). From the above, we can see that there are too few large domestic ICT firms in China, and so 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. As for domestic large firms such as case 1, they have entered the markets in most developing countries, which means that the developing country markets are reaching an saturated state, and they have to take a more difficult task to exploit or extend new markets including high-end market in European countries and North America where have a much higher profit. With respect to globalization, 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. For foreign MNEs, although there is no doubt that China is a strategic maket with great innovation or profit protential, the dynamics of the market brings many uncertainties on both product and policy-making. Some Chinese state-owned clients of Case 3 pay much attention to low price when purchasing due to the invervention of government, so they prefer to buy low price equipments regardless of how the product quality and life,

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

[40] Data gathered from Ministry of Commerce, last accessed 9 October 2010.

while good quality and long life of products usaully match with a high price. In order to adpat to such a situation, the company has to simplify the functions of the product in order to satisfy the need with a low price. But such a process needs cost as for a strict Germany company. Case 4 points out some policies in China are lack of transparency, for example, in the public procurement, what's the meaning of homemade products, it's difficult to find a detailed and clear definition. In addition, many foreign MNEs are worried about the fast learning or imitation capability of Chinese firms, and some have developed a positive attitude, for example, case 2 points out that the best way is continuous innovation to develop faster than Chinese firms.

Summary 6

Prospects & policy implications for Chinese ICTs

The most important areas in which public policy may intervene for the ICT industry are more public economic support for innovation activities, more stringent IPR regulations or enforcement, availability of higher skills in the labour. In addition, better access to international research networks, support for the internationalization of innovation and technology transfer, FDI and trade rules, and international risk capital are also considered to be important moderately by firms. Both firm-level and industry-level challenges should be dealt with by Chinese domestic firms to improve their own technological upgrading, learning and network controlling capability in GIN.

4.7 Conclusion

The "attracting-in" and "walking-out" policies in the past thirty years in China have promoted the embeddedness of Chinese ICT sector into GPN and GIN. Not only many foreign MNEs entered into China and became large exporter of ICT products, but also 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 affiliation of Chinese ICT sector.

The Chinese ICT sector sources a relatively low proportion of total R&D from outside actors, but represents a high in-house R&D investment and broad external linkages or collaborations. Meanwhile, the international linkages in this sector 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. We can find a trend of MNCs from developed countries in GIN with less core R&D sites but larger in size of this sector, while China is becoming one of the most important hubs to attract R&D or innovation activities. Meanwhile, the MNCs from developing countries in GIN are expanding the R&D sites not only in their own country and other developing countries (e.g. India), but also in developed countries. These two trends seem to be mutual offset for GIN affiliation and so it’s difficult to say they would facilitate or constrain GIN affiliation of this sector.

When offshoring of R&D is conducted by Chinese ICT firms, the main location factor is market access & knowledge infrastructure and services, which suggests the combination of market-based and technology-based orientation of firms in this sector. As a represent of developing countries, China plays an increasingly important role in the GIN and are changing from “development” into “both research and development” (case 2, 3 & 4), and in certain fields such as 4G, domestic firms are transitioning from technology following to parallel development with important leaders in this sector.

However, the technology characteristics of modularity, codification and standardisation of ICT sector do not seem to overcome the challenges of its coordination and communication in GINs. Firms try to establish appropriate coordination and communication mechanisms to facilitate knowledge flow at intra-firm level and firm-GIN level. However, the coordinating and communicating patterns depend much on the role the decentralized R&D subsidiary plays.

5 ANNEX 5: WP9 COUNTRY SECTOR REPORT: ICT IN INDIA

5.1 Subject 1: The Present Nature of Sector Activities in India

5.1.1 Background of the Sector

India has been successfully participating in the global division of labour in different services and emerged as a leading player in the export of IT software and services. This has been made possible in the *inter alia* by taking advantage of the large pool of skilled manpower on the one hand and opportunities opened up by new technologies that increasingly splintered off services from its providers. What is more, in the service sector induced turnaround in India's GDP growth and remarkable performance of the external sector observed during the last decade the role of software and IT enabled services, has been substantial.

The performance in software and IT Enabled Service (ITES) exports during the last two decades has been remarkable by any standard wherein it has been doubling in almost every alternative year. The recorded annual compound growth rate has been over 50 percent in the 1990s and 38 per cent since 1997-98 and such a record has been unprecedented. As of now, the software and service exports accounts for over 16 per cent of India's exports and even higher than the traditionally leading item in India's export basket viz. textile and textile products. Needless to say, the remarkable export performance has attracted the attention of researchers and is well documented in the literature (Schware 1987, 1992, Heeks 1996, Kumar 2001, Arora et.al 2001, Joseph and Harilal 2001, Parthasarathi and Joseph 2002, Joseph 2002, Nath, P and A Hazra 2002, Kumar and Joseph 2005 to list a few). The uniqueness of software export performance becomes more striking when compared with that electronic hardware exports. While software accounted for only about 22 per cent of total electronics exports in 1985-86, it increased to 92 per cent in 2005-6 (see Fig 1). What is more, it is also been noted that the export performance of software and service sector and its presence in over 170 countries and customer base that include most of the fortune 500 companies along 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. Further the organizational, managerial and other innovations introduced by the IT firms are increasingly being emulated by firms in other industries contributing to their enhanced performance (Arora and Athreya 2002).

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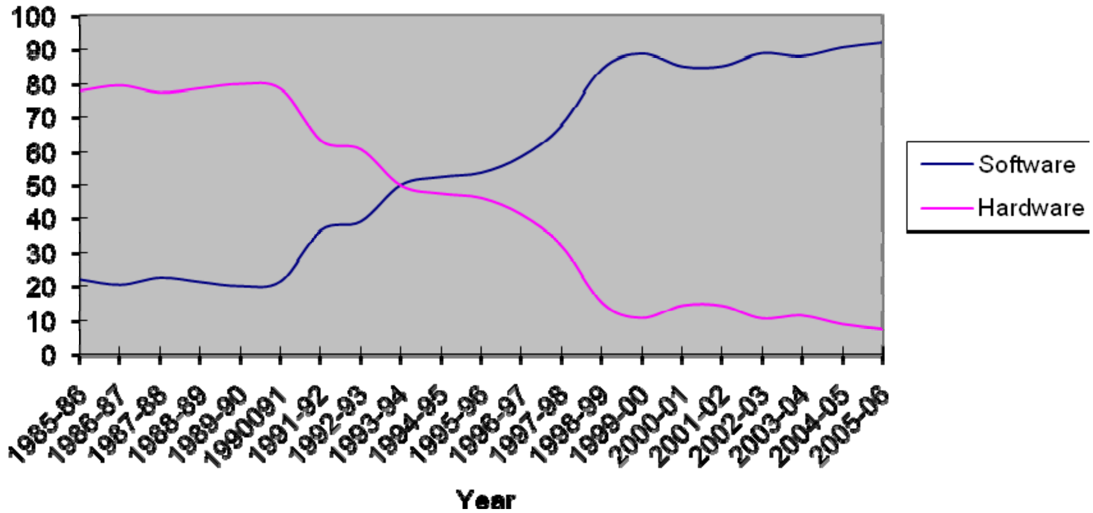
Fig 1: Share of Software and Hardware in IT Exports



5.1.2 Contribution to GDP, Export and Employment

The IT and ITES industry in India in value terms, according to the latest estimates by Electronics and Software export Promotion Council of India, in the year 2008-09 is US$ 61.98 billion. This indicates an almost thirteen fold increase from $4.8 billion in 1997. As a result, the share of IT sector in India's GDP recorded nearly five-fold increase from about 1.2 per cent in 1997-98 to 5.8 per cent in 2008-09. Out of the total production of computer software /services US$ 49.54 billion (79.92 percent) is exported. This accounted for about 16 per cent of the india's total exports (both services and merchandise). The fact that only 20.08 percent is consumed by the domestic market indicates the export oriented nature of the Industry. By way of comparison, Chandrasekhar et al (2006) finds that IT revenues in 2004-05 were about 20 per cent higher than construction sector and almost three times higher than in mining and in electricity, gas and water supply. More over gross revenue, from IT services exceeded 12 per cent of the GDP generated in India's service sector that accounts for about 54 per cent of the GDP.

According to Nasscom (the leading National Association of software companies in India) surveys, the software industry employed 284,000 people in 1999-00 as compared to 160,000 professionals in 1996 and reached a level of 2.23 million 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.

During the last ten years the industry has been generating more than a 0.1 million employment every year and the total number of jobs created during the last decade exceeded one million. The observed performance of the software and service sector in employment generation appears highly impressive when considered against the fact that employment generation by the organized manufacturing sector has been on the decline during the last decade (Nagaraj 2004) and according to NSSO statistics during 1999-00 to 2004-05 growth in employment in the rural and urban areas has been only of the order of 1.97 per cent and 3.22 per cent respectively (Chandrsekhar et al 2006).

5.1.3 From Software to IT Enabled Services (ITES)

IT sector in India that began as an exporter of software services, of late, have emerged as a major player in business process outsourcing (BPO) through Internet or the so-called IT Enabled Services (ITES). In 1999-00 the total ITES exports was only of the order of $565 million but as per the estimates by Nasscom (2006), the ITES exports increased from $3.1 billion in 2003-04 to US $ 4.6 billion in 2004-05 recording a growth rate of 48 per cent and are estimated to reach $ 12.8 billion by the end of 2008-09. As a result, the share of ITES in total software and service exports almost doubled from about 14 per cent 2000 to 20 per cent in 2008-09. Hence, but for the rise of ITES exports, the growth of IT exports would be even lower than what was observed earlier.

The recent growth in ITES exports from India has been facilitated by a number of factors. From the supply side India, 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. English is widely used as a medium of instruction, which in turn provides an ample supply of manpower for ITES services at a much lower cost[41] as compared to other countries. In general the operating cost per employee in India is only about 20 per cent of that in the US and the comparable cost in Philippines is about two per cent higher than in India. From the demand side in the competitive world of today, substantial cost advantage is accrued by the firms resorting to offshoring and outsourcing of services. Mckinsey (2003) shows that there are very large

[41] 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.

differences in the wages paid for equivalent skills between the US and developing countries like India and Philippines. For example the equivalent of a software developers who costs $ 60 per hour in the US cost only $ 6 an hour in India. In addition, 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[42].

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 including the arts and science graduates. It is also found that ITES sector is more employment intensive with employment per million dollars of exports as high as 70, which is more than twice that of the software sector (Joseph 2004). No wonder with 20 per cent of the total exports ITES sector generates as much employment as the software sector. Thus viewed ITES/BPO appears to have the potential of generating substantial employment for the growing number of educated youth in the country. While software industry in India is shown to have led to an enclave type development, the ITES is found geographically diffused across different regions in the country and generating more linkages with rest of the economy. Hence for those regions, which were not successful in attracting software investment, ITES offer an alternative. Accordingly, different state governments have initiated policy measures to attract ITES activity into their states with considerable success.

5.1.4 Home Grown Success: But ncreasing role of MNCs

Although Tata Consultancy Services had been exporting software since 1974, the entry for example, of Citicorp Overseas Software Ltd. (COSL) in Bombay in 1985 and of Texas Instruments (TI) in Bangalore in 1986 for software development highlighted India's potential to outside MNEs more vividly. Subsequently, a number of other western corporations began to follow the footsteps of COSL and TI, such as HP in 1989 and followed by Novell, Oracle, among others. Seeing the potential, a number of Indian companies engaged in the manufacture of computer hardware started to spin-off their software divisions

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[42] 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.

(Kumar 2001 and Kumar and Joseph 2005, for more details). 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).

Today almost all the leading IT software companies have established development base in India. Their overall share in India's exports of software has been increasing in the recent past. While they accounted for over 20 percent of the total exports in 2004-05 by 2008-09 it has increased to about 30 per cent. Nonetheless, MNEs do not figure among the top seven software companies in India, ranked either on the basis of overall sales or exports. Among the top twenty software companies too, no more than four are MNE affiliates or joint ventures. MNEs, however, are important clients of Indian software companies. There are hardly any Fortune *500* MNEs that do not resort to outsourcing of software from India.

Over the years, the role of FDI increased in India's software sector and it has been claimed that in states like Karnataka[43] and Maharashtra, the three foreign companies have been entering the software and service sector every fortnight. Detailed authentic data on FDI in the Software and service sector, however, is not readily available. Nasscom used to publish a directory of firms operating in the software and service sector that contained details of software and service firms like ownership, sales, employment, export, location etc. some inference could be drawn from this data base for the early years of this millennium.

As is evident from Table 70 during 1991-2001, while total number of foreign collaboration approvals in the country increased from 976 to 2270, (2.3 times increase) those in the service sector increased from 118 in 1991 to 1040 in 2001 – nearly 9 fold increase! As a result, the

[43] See for details http://www.bangaloreit.com/html/itsckar/itindustriesothercities.htm

Table 70 | Trend in Foreign Collaborations in India's Service Sector

Year	Total Foreign Collaborations	Collaborations in Services	Share (%)	% with Equity
1991	976	118	12,09	41,56
1992	1520	195	12,83	80,51
1993	1476	196	13,28	77,55
1994	1854	314	16,94	NA
1995	2337	415	17,76	84,82
1996	2303	518	22,49	88,41
1997	2325	644	27,7	89,44
1998	1786	519	29,06	84,97
1999	2224	782	35,16	91,82
2000	2144	885	41,28	90,73
2001	2270	1041	45,86	96,25

Source: Compiled from DSIR, *Foreign Collaborations: A Compilation* (different years) Ministry of Science and Technology, New Delhi.

share of foreign affiliates in the service sector increased from 12 per cent in 1991 to nearly 46 per cent in 2001. It is also noted that most of these were involving equity participation. Among the services, bulk of the foreign affiliates was in the field of software services. In 2001, for example, out of the total number of 885 approvals in the service sector 566 (64%) was in the software and service sector. The corresponding share for the year 2000 was found to be 58 per cent. Thus, if the above empirical evidence is any indication 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. However, there has been much slip between the cup and the lips – as we shall see below only a fraction of these approvals actually get fructified.

Based on the compilation made from the NASSCOM directories we have arrived at the regional distribution of foreign firms in the software and service sector. It is possible to have certain extent of underestimation in the contribution of foreign firms as the Nasscom Directory lists mostly the Nasscom members and some of the foreign firms who are not members of Nasscom are not covered. It is evident from Table 71 that as we move from 1997-98 to 2002-2003 the total number of foreign

Table 71 | Region-wise Distribution of the number of Software and service firms (%)

Location	Foreign (%)		Local (%)		Total (%)	
	1997-98	2002-03	1997-98	2002-03	1997-98	2002-03
Delhi	38,6	23,56	21,93	21,34	24,09	22,12
W. Bengal	3,51	2,63	6,27	6,24	5,91	5,48
Gujarat	1,75	1,75	3,66	1,2	3,41	0,95
Maharastra	12,28	15,91	27,94	23,98	25,91	22,12
Andhra Pradesh	3,51	10,53	8,36	8,63	7,73	9,07
Karnataka	31,58	30,7	16,71	19,18	18,64	21,74
Tamil Nadu	8,77	13,16	10,44	12,95	10,23	13,04
Kerala	0	0	1,57	1,92	1,36	1,51
Others	0	1,75	3,13	4,56	2,73	3,97
Total	100	100	100	100	100	100

Source: Based on data compiled from the Nasscom Directories.

firms have almost doubled from 57 to 112. The result has been that the share of foreign firms in the total number of firms increased from about 13 per cent 1997 to 20 percent in 2002. This however accounts for only a fraction of the approval given by the government. To be more specific, during 1998-2000, according to DSIR data, 545 foreign affiliates have obtained approval in the field of software development. Yet the total number of foreign firms in 2002-03 was found to be only one-fifth of the approvals in the three years mentioned above. This point towards the fact that, India is yet to fully exploit the potential. Given the large gap between approvals and actual, there is the need for detailed inquiry into the factors that stands in the way of FDI fructification.

It is also noted that as of now Karnataka accounts for the largest share of foreign firms where as Maharashtra has the highest share of local firms. In Karnataka, it was found that out of the top ten firms five are foreign firms[44]. Going by the number of foreign firms, in 1997 Delhi, Maharashtra, Karnataka and Tamil Nadu together accounted for over 90 percent of the total number of foreign firms. As we move towards 2002, though the share of these four states declined by almost 10 per cent, Andhra Pradesh emerged with more than 10 per cent and therefore, the share of five top states is as high as 93 per cent. Thus it appears that not withstanding the initiatives by various state governments, the foreign investment is still concentrated in a few states.

Foreign firms are found to be more export oriented as compared to the locals firms. The export intensity (measured as a proportion of output being exported) is found to be as high as 92 per cent for the foreign firms where as the corresponding share for the local firms is about 70 per cent and of late there has been an increase in the domestic market orientation of domestic firms (see Table 72). The table also shows that the foreign firms

Table 72 | Export intensity of foreign and local firms in the Software Sector (%)

Location	Foreign		Local	
	2001-02	2002-03	2001-02	2002-03
Delhi	0,97	0,95	0,69	0,72

[44] See for details http://www.bangaloreit.com/html/itsckar/itindustriesothercities.htm

W.Bengal	0,99	0,98	0,73	0,85
Gujarat	0	0	0,78	0,74
Maharashtra	0,85	0,85	0,74	0,76
Andhra Pradesh	0,98	0,98	0,87	0,87
Karnataka	0,94	0,94	0,76	0,76
Tamil Nadu	0,8	0,89	0,75	0,77
Kerala	0	0	0,8	0,84
Others	0,92	0,8	0,69	0,7
Total	0,92	0,93	0,74	0,7

Source: Based on data compiled from the Nasscom Directories.

in Maharashtra are more domestic market oriented as compared to their counterparts in other states. This perhaps points towards greater demand forthcoming from the state that is more industrially developed.

Notwithstanding the higher export orientation of the foreign firms; the role of foreign firms in export appeared to be similar to that we have observed with respect to the number of firms. Table 73 presents data on the region-wise export by foreign and local

Table 73 | Region-wise distribution of exports by foreign and local firms (%)

Location	Foreign		Local		Total	
	1997-98	2002-03	1997-98	2002-03	1997-98	2002-03
Delhi	23,39	19,12	11,27	14,68	12,61	15,59
W. Bengal	0,71	0,49	1,38	0,82	1,31	0,74
Gujarat	0,01	0,01	0,17	0,11	0,15	0,03
Maharastra	18,96	27,51	44,4	33,7	41,59	32,43
Andhra Pradesh	1,4	2,68	4,97	9,64	4,57	8,22
Karnataka	33,11	26,99	25,01	31,58	25,91	30,64

Tamil Nadu	19,89	21,68	12,43	9,17	13,25	11,72
Kerala	0	0	0,16	0,23	0,14	0,19
Others	2,53	1,59	0,21	0,14	0,47	0,44
Total	100	100	100	100	100	100

Source: Based on data compiled from the Nasscom Directories.

firms. The table further confirms the high regional concentration of exports. Even with in each state, one or two metropolitan centers accounts for bulk of exports. Thus, Bangalore and to a lesser extent Mysore in Karnataka, Mumbai and Pune in Maharashtra, Noida and Gurgaon in the Delhi area, Hyderabad in Andhra Pradesh and Chennai in Tamil Nadu are the centers of software and service activities in the country. The operation of the foreign firms is also confined to these centers. The total exports by the foreign firms during 1997-02 recorded an annual compound growth rate of 51 per cent which is found to be higher than that recorded by the local firms (30.5%) and by the industry as a whole (33.5%). Thus in terms of the growth rate it appears that the foreign firms have been more dynamic as compared to their local counter parts. As a result, the share of foreign firms in the total export increased from 11 per cent in 1997 to 20 per cent in 2002.

5.1.5 On Survey Method for WP9

The report for WP9 is largely based on the INGINEUS survey and the case study of three firms in India. This is also supported by the use of Directory of Indian ICT firms, NASSCOM, and the electronic Database called PROWESS published by the Centre for Monitoring Indian Economy(CMIE).

The survey was designed to be implemented to cover all the IT firms in India. This was intended to be a census survey of all firms, but with an expectation of 30 percent response rate. The firms were chosen from the NASSCOM Directory of ICT firms. The NASSCOM Directory is released every year and covers all areas of software production and related industries such as IT Enabled Services. The 2009-10 Directory provides information on 1287 firms in different areas of IT industry.

A pilot survey was conducted with five firms in India, the responses and our feedback was send to the INGINEUS WP2 leaders for modification of the questions on this basis. Initially a web based survey was implemented, but the yield was very low. Hence direct interviews were planned.

For the face to face interviews, it was not viable to cover the entire country as it would very expensive and time consuming. Instead we chose cities/ IT clusters that together represented nearly 93 percent of all firms according to the NASSCOM directory. A survey team was developed to conduct face to face interviews. The survey was undertaken in eight cities during the period March 1st to April 30th, 2010 ending up with a sample of 325 completed surveys representing a favourable response rate of 24 per cent. (see Table 74).

Table 74 | INGINEUS Survey design

Cities chosen for survey	Number of Firms as per NASSCOM survey 2009-10	number of firms surveyed Manually	percentage of firms surveyed manually
Bangalore	281	50	17,79
Delhi/Noida/Gurgaon	256	75	29,3
Mumbai	185	68	36,76
Pune	72	20	27,78
Chennai	147	39	26,53
Trivandrum	184	20	10,87
Hyderabad	107	25	23,36
Kochi	55	10	18,18
Manual Total	1287	307	23,85
Online Total		18	
All Total		325	

For the case study we had identified three firms that had previously been agreed upon through matching done by the INGINEUS case study consol. The identified firms were large firms, all three MNCs, two with head quarters in India and one with head quarters in the US. But all three firms had operations in mainland Europe. The case study interviews were conducted with high ranking representatives of the firms in India as per the TOR of various work packages.

5.1.6 The Present Nature of Sector Activities in India: Evidence from INGINEUS Survey

The INGINEUS survey shows that in terms of organizational structure, about half the firms are stand alone firms while the other half of the firms was either subsidiary or headquarters of MNCs. About a third of the firms were subsidiaries to MNCs while about 16 percent were headquarters of MNCs (see Table 75). This represents a highly globally integrated ICT sector from India. Particularly important is the rise of MNCs head quartered in India, hitherto to unknown to Indian manufacturing is atypical of the traditional manufacturing sector in India.

Table 75 | Organizational Characteristics of firms surveyed

	Number	Perecnt
A stand-alone company?	167	51,7
A subsidiary of an MNC?	106	32,8
The headquarters of an MNC?	50	15,5
Total	323	100
No response	1	

When it comes to the size structure of firms measured in terms of employment, the survey found that more than 40 percent of the firms had 250 or more full time employees, of which 14 percent of the firms had greater than 1000 full time employees. (Table 76). The largest size class was 50 to 250 employees, accounting for more than 39 percent of the firms. From the size distribution it can be stated that Indian ICT firms are to a large extent mid sized firms, with considerable presence of very large sized firms.

On the other hand, the share of firms with less than 250 FTE was only 54 percent for MNC subsidiaries and for MNC head quarters, it was only 48 percent. And, more than 51 percent of the MNC firms were large sized firms with 250 or more employees, and 46 percent of the MNC subsidiaries were also large sized. The corresponding size class for stand alone firm was only 32 percent.

Table 76 | Distribution of firms based on Size and organisation

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
Fewer than 10 FT Employees	4,23	1,03	0	2,42
10 to 50 FTE	23,94	16,49	6	18,34
50 to 250 FTE	40,14	36,08	42	39,1

250 to 1000 FTE	21,13	27,84	40	26,64
Greater than 1000 FTE	10,56	18,56	12	13,49
	100	100	100	100

Moreover, as already noted, the firms are highly oriented towards the export market. Estimates done at the national level on export intensity (export as a proportion of output) indicated export intensity as high as 80 percent of the total production. This again is vastly different from the traditional manufacturing sector of India. While in India, the manufacturing sector exports were not appreciable, 58 percent of the firms in the INGINEUS survey claimed that export was the biggest market. Local demand was only marginal, while 37 percent of the firms reported domestic market as their largest market.

However it is to be noted that the demand at the local or domestic region were felt largely among the stand alone firms. More than 50 percent of the stand alone firms were catering either to the local demand or the domestic demand. On the other hand both subsidiaries of MNCs and MNC headquarters had their largest market as exports. To be more specific, more than 70 percent of both MNC subsidiaries and head quarter firms had claimed that their largest market was export market. (See Table 77). While only 44 percent of the standalone could claim as export market oriented firms. This market orientation difference in the organizational characteristics is expected to have its implications on the opportunity conditions as well as the innovative behaviour of firms.

Table 77 | Location of Largest Market by Firm Type

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total	Number
Internal to your firm	4,24	1,89	2	3,12	10
The local region in your country	6,67	2,83	6	5,3	17
Domestic Market (The rest of your country)	44,24	24,53	18	33,64	108
An Export Market	44,85	70,75	74	57,94	186
Total	100	100	100	100	321

The largest market destinations for Indian firms were North America. 79 percent of the exporting firms exported to North America, followed by South America (55%). Asian Economies were also important export destination. Only 40 percent of the firms exported to Europe, whether to West Europe or to East and Central Europe.(See Table 78). The opportunities for marketing for Indian ICT firms were thus essentially export driven, that too to a large extend to meet American demand.

Table 78 | Important Destinations of Exports

	Number	Percentage
North America	147	79
South America	103	55
West Europe	74	40
Central and East Europe	73	39
Africa	38	20
Japan and Australasia	68	37
Rest of Asia	92	49
Rest of the World	56	30
Total	186	100

Moreover, even when we compare the exporters alone, there are considerable differences on the direction of exports among firm types. And, these differences are not much focused on the traditional North American, South American or the European market. There are considerable differences in these traditional markets as well. Rather the starkest differences arise in the unconventional and sometimes developing country markets. For instance, the difference in export destination to Africa is very stark when we compare stand alone firms with that of MNCs. While only 9 percent of the stand alone firms had Africa as an important export market MNC subsidiaries had 21 percent and MNC headquarters had more than 40 percent firms having export business with Africa. (See Table 79). There is very less market access and penetration to Japan and Australasia for stand alone firms as well. Thus while stand alone firms do under perform in the traditional markets, the new markets are where they get competed out by their MNC counterparts.

Table 79 | Important Destinations of Exports by Firm Type

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
North America	67,57	85,33	89,19	79,03
South America	40,54	65,33	64,86	55,38
West Europe	36,49	38,67	48,65	39,78
Central and East Europe	37,84	41,33	37,84	39,25
Africa	9,46	21,33	40,54	20,43
Japan and Australasia	17,57	44	59,46	36,56
Rest of Asia	39,19	58,67	51,35	49,46
Rest of the World	27,03	34,67	27,03	30,11

Summary of Subject 1

The Present Nature of Sector Activities in India

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. Given the export orientation, the nature of activities undertaken by the industry was driven by the exogenous factors and oflate there has been a diversification towards IT enabled services. The survey has highlighted the heterogeneity of firms in different organizational categories. The local standalone firms are relatively smaller in size, found to be focusing more on the domestic market as compared to the MNC subsidiaries and headquarters of MNCs. These differences are expected to have it bearing not only on the opportunity conditions and innovative behavior but also on the potential for GIN formation. 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. It appears that there is significant difference in the opportunity conditions faced by stand alone firms vis-a-avis the MNC subsidiaries and MNC headquarters. The latter two types of firms given their larger size and greater orientation towards the more demanding external markets like that of the US are favorably disposed to GIN formation.

5.2 Subject 2: The nature of Innovation in the Sector

Traditionally the comparative advantage of Indian firms has been in the export of services such as customized software development. (Arora et al 2001). It was also shown that Indian firms have been operating mostly at the lower end of value chain by carrying out low-level design, coding and maintenance. (Kattuman and Iyer 2001). As a result, revenue per employee in 1999 ($ 16,000) is found to be only about one-tenth of Israel and one-fourth of Ireland (Arora et al 2001). Moreover, the net export earning has been only of the order of 50 per cent of the gross FoB value of total exports of software and services (Joseph and Harilal 2001). However, of late there are number of indications to show that the trend is changing. With the MNCs increasingly looking for complementary capabilities, 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). Now the firms are increasingly entering into high end consulting, engineering and R&D services with the development of domain expertise and export of packaged software.

Since the conventional measures of innovation like R&D intensity (measured as Research expenditure as proportion of sales) has certain limits in capturing innovation in a service sector like ICT, a study (Joseph and Abraham 2005) developed an Index of Claimed Technological Competence (ICTC) using firm level information on their areas of specialization. The theoretical base of the index has been drawn from the literature on technological opportunity. The estimated index has shown an upward mobility of firms. To illustrate, in 1998 over 56 per cent of firms were in the low index category (less than 30%) where as in a short span of three years the share of such firms declined to around 44 per cent. Similarly in the higher index category (greater than 60%) the share of firms increased from 5.3 per cent in 1998 to 8.3 per cent. in 2001. The estimated index of leading IT firms like Infosys, Wipro and TCS were found to be more than 75 per cent. The rise in the level of index was not confined to the high index category. In the middle index category (30-60%) as well the proportion of firms increased by 10 per cent point.

The Indian firms also have been able to acquire the necessary quality certifications. As of now there is hardly any firm with required quality certification and it was found that 82 firms in India have got SEI CMM level 5 certification in 2006 (see

Table 80) and this accounted for about two-third of such firms in the world.

Table 80 | Status of quality Certification obtained by Indian IT firms

Description	No. of Firms
ISO 9001	330
ISO 9002	23
ISO 9001/9002	345
ISO 9001:2000	72
SEI CMM Level 5	82
SEI CMM Level 2,3,4	41
CMMi Level 5	32
CMMi Level 2,3,4	14
PCMM Level 5	13
PCMM Level 2,3,4	11

Six Sigma	44
Others	41
Total	401

Note: Total refers to the total number of firms for which information available
Source: Based on Nasscom 2006.

5.2.1 Results of the Survey

A large number of firms claimed that they have been innovative. More than 72 percent of the firms claimed that they had at least one of the innovation activities (listed in Table 81) and they were novel at least to the firm. However, even in this broad definition of innovation, there are substantial differences across organizational type of the firms. Stand Alone firms recorded no innovation by any criteria or measure of novelty for nearly 37 percent of the firms, while MNC subsidiaries recorded no innovation only for 21 percent of the firms. On the other hand, 90 percent of the MNC headquarters firms recorded some form of innovation.

Table 81 | Incidence of innovation by type of firms

Innovation	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
No innovation at all	36,53	20,75	10	27,24
Any Innovation	63,47	79,25	90	72,76
Total	100	100	100	100

A similar differentiation for innovation seems to exist across size class as well. When firms are either very small or they are very large their level of innovative activity seems to be quite high, as compared to mid-sized firms. Maximum share of firms that claimed to have done innovation when the firm size was less than 10 employees. More than 85 percent of the small sized firms claimed this. However, in the next size class of 10- 50 employees, the share of innovators declined to 59 percent. Thereafter it consistently increased across size classes to reach nearly 82-85 percent of the firms claim innovation.(see Table 82).

Table 82 | Firm size and Any Innovation Activity[45]

Innovation	< 10 FT Employees	10 -50 FTE	50 - 250 FTE	250 -1000 FTE	> 1000 FTE	Total
No innovation at all	14,29	41,51	20,35	14,29	17,95	22,15
Any Innovation	85,71	58,49	79,65	85,71	82,05	77,85
Total	100	100	100	100	100	100

Nevertheless, a close examination of the innovations in term of their novelty and type of innovations reveals that despite 73 percent of the firms claiming innovation activity, these activities are only moderately novel and hence, can claim only limited ‘radical’ness in their innovation. Nearly 38 percent of the firms did not produce any new product and nearly 33 percent did not generate a new service. Approximately half the firms did not do any improved methods in production, logistics or management of the firm. Also, innovation that generated entirely new product or service were only seen in about one seventh of the firms, while other forms of innovative activities such as innovation at production process, logistics or supporting activities were only in one twentieth of the firms. Most innovative activities were new to the industry and new to the firm. More than 34 percent of the firms claimed to have brought to market a new product to the industry, and nearly 32 percent brought to market a service new to the industry(see Table 83). Most innovative activities were thus new to the industry, and new to the firm, but not globally novel. The relatively higher level of innovations that are new to the industry but not to the world indicates the adaptive innovation that is taking place in the sector.

[45] The totals for this table and the above table don’t match as all firms did not report their number of employees.

Table 83 | Different types of Innovation Activities in past three years

	New to the world	New to the industry	New to the firm	None	Total respondents
New products	14,2	34,26	16,05	37,73	324
New services	12,65	31,79	24,38	32,82	324
New or significantly improved methods of manufacturing or producing	6,17	27,47	20,06	47,24	324
New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services	6,48	26,23	20,68	47,55	324
New or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems etc.)	5,25	26,54	22,53	46,32	324

About 62 percent of the firms claimed that they had a new product in the last three years. While it was 67 percent of the firms in case of services indicating increasing incidence of innovations in services as compared to products. In general the incidence of other forms of innovations are found to be lower – a little over 50 per cent. But there are considerable differences across the organizational type of the firms in various types of innovation activities. For instance, while 50 percent of the stand alone firms claimed new products, it was as high as 88 percent in case of MNC headquarters and 69 percent in case of MNC subsidiaries (see Table 84). Such differences in the innovation activity based on organizational types are visible across all types of innovation activities. 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. While stand alone firms are the least innovative among the lot.

Table 84 | Distribution of Innovation activities by their nature across different type of Firms

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
New products	50,3	68,87	88	62,04
New services	56,29	75,47	86	66,98
New or significantly improved methods of manufacturing or producing	42,51	56,6	78	52,47
New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services	44,31	51,89	80	52,16
New or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems etc.)	43,11	55,66	84	53,4

However, the innovation ability of MNCs or MNC subsidiary were largely limited to innovations new to the industry and not radical to be called as new to the world. Be it product, or service, or any form of innovation, the largest share for the MNC headquarters was in “New to the industry”. This was the case with subsidiaries of MNCs as well. But in the case of stand alone firms, most of their innovation activity was only new to the firm for distribution and management but for products, services and processes, their innovation activity was new to the industry as well. (See Table 85)

Table 85 | Share of firms which had done Innovation Activities in past three years classified by Firm Type and Novelty of Innovation

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
New Product				
New to the world	11,98	14,15	22	14,2
New to the industry	23,35	39,62	60	34,26
New to the firm	18,56	15,09	10	16,05
New Service				
New to the world	10,18	16,04	14	12,65

New to the industry	23,35	34,91	54	31,79
New to the firm	25,15	24,53	22	24,38
New Process				
New to the world	4,19	6,6	12	6,17
New to the industry	19,76	31,13	46	27,47
New to the firm	19,76	18,87	24	20,06
New Distribution				
New to the world	7,78	4,72	6	6,48
New to the industry	17,37	31,13	46	26,23
New to the firm	20,36	16,04	32	20,68
New Management				
New to the world	6,59	4,72	2	5,25
New to the industry	12,57	37,74	50	26,54
New to the firm	25,75	13,21	32	22,53

From the above evidence it can be stated that the Indian ICT firms are only moderately innovative with most innovations not new to the world. Among the Indian firms, however, it is the MNCs with Indian headquarters that are more innovative, than MNC subsidiaries in India. The least innovative among the different types of firms were the stand alone firms, whose innovative activity was limited largely to the firm rather than the industry.

Now turning to the question of sources of technology for innovation first we take up an analysis of the traditionally recognized source, viz, R&D of the firm. More than 60 percent of the firms had in-house R&D activity. However, such R&D activity was comparatively weak for stand alone firms, with only 46 percent of the firms having R&D activity, while MNC subsidiary and MNC headquarter firms had substantially higher levels of R&D activity with both having more than 75 percent of the firms.(See Table 86

Table 86 | Existence of R&D Activity in Firm

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
R&D No	53,89	25,47	22	39,63
R&D yes	46,11	74,53	78	60,37
Total	100	100	100	100

Innovation, as expected, is closely related to R&D activity. Irrespective of their organizational type, if firms had invested in R&D activity, then some form of innovation seems to follow. As can be seen from Table 87, all types of firms that are engaged in R&D activity is seen to have been successful in coming up with some form of innovation. However, the interesting and pertinent difference comes in case of firms with no R&D activity at all. As can be seen, even without any R&D activity 42 percent of the firms had some innovation. However, these innovations seem to follow a pattern based on organizational type of firms. More than 54 percent of the MNC headquarter firms, though not reporting any R&D, had some innovation. This was also true of Subsidiary firms and 48 per cent of such firms without any R&D activity had some innovations innovation was more than 48 percent. When it comes to stand alone firms it was only 38 percent. Thus it can be argued that the difference in innovation activity across different organizational types of firms seen earlier are not so much related to their ability to involve in R&D activities, rather they may more be related to their other sources of technology than R&D. (Table 87)

Table 87 | R&D activity and any Innovation by Firm Type

	No R&D Activity			R&D Activity is Present		
Firm Type	No innovation	Any Innovation	Total	No innovation	Any Innovation	Total
Stand Alone	62,22	37,78	100	6,49	93,51	100
Subsidiary of MNCs	51,85	48,15	100	10,13	89,87	100
MNC Head quarter	45,45	54,55	100	0	100	100
Total	58,91	41,09	100	6,67	93,33	100

As can be seen from Table 88, most firms depend mostly on their own technological inputs from in-house. More than 57 percent of the firms depend on in-house technological inputs as their most important technology source. This is followed by Technology purchase from other MNCs with which these firms are not formally connected. More than 19 percent of the firms depend on this type of technology sourcing. Their own branches of MNCs form the source of technology for 12 percent of the firms and another 10 percent purchase from other non-MNC firms. The technology sourcing from public funded institutions such as universities and research institutes is very minimal.

The stand alone firms are greatest dependents on own technology inputs. More than 73 percent of the stand alone firms depend on their own technology as inputs. In case of MNC subsidiaries this dependence is reduced to 46 percent and when it comes to MNC headquarters the share further declines to 23 percent, reflecting on the fact that MNC head quarters and MNC subsidiaries are relatively less dependent on in-house technological inputs for innovation, while stand alone firms have little choice other than in-house technology inputs. On the other hand, for 16 percent of the MNC subsidiaries and 21 percent of the MNC head quarters their own branches were the most important technology source, which differentiated them from stand alone firms. Further, the largest difference between MNCs and stand alone firms seems to stem from technology purchases from other MNCs.(Table 88) .

Table 88 | Most important source of technology for your enterprise

	Stand Alone	Subsidiary of MNCs	Head Quarter of MNCs	Total
We produce most technological inputs in-house	73,13	46,08	22,92	56,45
We buy most of our inputs from other branches of our own MNC	7,5	15,69	20,83	12,26
We buy most of our technological inputs from non-MNC firms	6,88	14,71	8,33	9,68
We buy most of our inputs from MNCs with which we are not formally connected	11,25	20,59	41,67	19,03
We buy most of our inputs from public-sector organisations, e.g. research institutes, universities etc	1,25	2,94	6,25	2,58
Total	100	100	100	100

In conclusion, the innovative ability of firms seems to be related to not only their ability to do R&D activity but also sourcing technology from other sources as well indicating the relevance of networking in innovation. In this network relationship, public funded organizations such as universities or research labs are not the preferred ones. But they seem to appear through other firms, particularly MNCs. However, not all firms are able to tap into these sources of technology. While stand alone firms are limited in their technology sources to themselves, MNC subsidiaries are able to look beyond themselves and source from other branches, MNC head quarters and also through informal interactions with other MNCs. This gradation in technology sources seems to reflect on their innovation ability as well. The more outward oriented the firms' search for technology inputs, the greater appears to be their innovation activity.

The substantiation of the nature of innovation done from the case studies is as follows.

Case one, a MNC headquartered in India, with an export orientation of more than 90 percent of its products. The traditional demand for its services and products come from the US export market. However, the market is being increasingly to Europe and especially in the recent years with a domestic focus. The firm focused mainly on customized services in its early stages, but now gradually moving to products as well. The core innovation competence comes from internally and also from subsidiaries in other developing countries of the world. Though the firm has subsidiaries in the developed world as well, their innovation activity is limited compared to the firms in the developing world. They attribute this to two reasons, one the newly emerging markets that were hitherto untapped, to a large extent, provides the ground for new products and services, and also the availability of large number of skilled engineers provide a conducive in-house environment. However, the innovations are not 'radical' in nature, but are mostly 'adaptive'.

5.2.2 Summary 2

There are indications to suggest that Indian ICT industries becoming increasingly innovative especially when compared to its traditional focus on less innovative and low end activities of software value chain.

Nonetheless, the survey observed significant difference across firms of different organizational categories. While the MNC subsidiaries and headquarters of MNCs are found to be more innovative, the standalone firms lagged behind. Here gain the MNC headquarters appeared more innovative as co compared to the MNC subsidiaries. It is observed that most of the innovations are new to the firm with very limited presence of innovations that are either new to the world or new to the industry. This is especially the case with respect to stand alone companies. The survey further revealed that in terms of innovative activities mid sized firms lagged behind as compared to their counterparts in the larger and smaller size categories. While the incidence of R&D activities is found helpful for firms to be innovative, bulk of the firms are not found to be engaged in any R&D activities at all. This is found to be especially holding good with respect to standalone companies. In such a context majority of firms depended on in-house technological inputs as the most important source of innovation. When it comes to MNCs, they are found having linkage with other firms and other MNCs. To the extent that the firms that are more innovative are also found to be more outward oriented tends to suggest their potential GIN formation. Thus viewed the standalone companies, given their smaller size, less outward orientation and low level of innovative activities are less likely to be active participants in GINs.

5.3 Subject 4: Locations and Internationalizations

The INGINEUS Survey shows that more than half of the firms had not offshored production or innovation activities, while 45 percent of the firms had offshored their activities. Yet, the offshoring activity status was associated with organizational type of the firm. While only 31 percent of the stand alone firms did offshoring of their production or innovation activities, for MNC subsidiaries the share was 57 percent and for MNC headquarters more than 70 percent (see Table 89). Hence it could be inferred that stand alone firms have much lower levels of offshoring activity compared to MNC subsidiaries and MNCs head quartered in India have shown much higher tendency outsourcing.

Table 89 | Off Shoring of production and innovation

	Has not off shored activities	Has off shored production or innovation activities	Total
Stand Alone	69,46	30,54	100
Subsidiary of MNCs	43,4	56,6	100
Head Quarter of MNCs	30	70	100

Percent	54,94	45,06	100
Total	178	146	324

The motivation for offshoring among Indian firms show that knowledge and skill related factors are important motivations for offshoring (see Table 90). Human capital and physical capital for knowledge such as specialized knowledge, skills, and infrastructure for R&D, cheaper production resources, large markets access and other factors like financial markets are also important. However, motivations for offshoring of production are much stronger than offshoring of innovation.

Table 90 | Motivations for offshoring

		Off shoring of Production		Off shoring of Innovation		Any off shoring	
		No.	Percent	No.	Percent	No.	Percent
09.02.2001	Availability of specialised knowledge in the host region	116	79,45	98	67,12	130	89,04
09.02.2002	Availability of qualified human capital at a lower cost than in your own country	109	74,66	90	61,64	125	85,62
09.02.2003	Access to knowledge infrastructure and services in the host region (R&D infrastructure, technical support services etc.)	102	69,86	102	69,86	128	87,67
09.02.2004	Access to other infrastructure, cheaper production resources and services (land, inputs or unskilled labour, ICT, electricity, roads, airports, ports etc.)	95	65,07	83	56,85	125	85,62
09.02.2005	Opportunity to sell existing products and achieve greater access into new markets	95	65,07	85	58,22	116	79,45
09.02.2006	Incentives for the location of activities in the host region (e.g. favourable regulations, special tax regimes, testing facilities and trials etc.)	86	58,9	69	47,26	98	67,12
09.02.2007	Efficient financial markets (including Venture Capital)	99	67,81	82	56,16	112	76,71
09.02.2008	The level of ethical standards and trust	96	65,75	86	58,9	115	78,77
09.02.2009	The enforcement of intellectual property rights	93	63,7	90	61,64	114	78,08
09.02.2010	Follow sourcing of off shoring	97	66,44	83	56,85	122	83,56
09.02.2011	Others	2	1,37	2	1,37	4	2,74

Firms perceived that the collaborations with their clients/customers as important and helpful for their most important innovation in the last three year (see Table 91). Suppliers, competitors and consultancy companies too were moderately important collaborators for innovation. Public funded bodies such as governments, local universities provided collaboration for nearly 50 percent of the firms in their innovative efforts. However, foreign universities were the least important among all the collaborators.

Table 91 | Collaborations that were used for their most important innovation in last three years

		Total Collaborations used	Your Region	Your country	North America	South America	Western Europe	Central & Eastern Europe	Africa	Japan & Australasia	Rest of Asia
7.1	Clients	70,86	36,42	37,35	38,27	25,31	13,58	12,65	8,95	14,2	18,52
7.2	Suppliers	65,03	28,7	29,1	23,15	18,83	9,57	4,94	4,01	7,41	7,41
7.3	Competitors	61,35	23,46	35,49	23,46	16,05	6,48	4,94	3,4	8,64	7,41
7.4	Consultancy companies	57,36	20,68	32,1	21,3	13,89	4,94	3,7	1,23	6,17	6,48
7.5	Government	54,6	19,75	33,64	8,33	5,25	3,09	3,09	1,54	4,32	1,85
7.6	Local Universities research institutions/ labs	46,63	19,75	28,7	0,31	0,31	0	0	0	0,31	0,31
7.7	Foreign research institutions/ labs	30,37	0.31	1.23	12.35	9.57	5.86	4.94	0.93	3.09	2.78
7.8	Other	2,15	0,62	1,54	0,31	0	0	0	0	0	0

It is interesting to note that even though the market for the firms are largely outside the country with a large focus on the North and South American markets, when it comes to innovative activities, the local region, the domestic country are as important or , in some cases more important than the collaborations from North America or South America. Clients in N. America are as important as the domestic and local region but none others are important as the local and domestic collaborators. This tends to suggest that while Indian firms are largely export oriented with limited innovative ability as stated earlier, 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.

To support the argument made earlier, we divide all actors into domestic and foreign actors, and then map the collaborations for innovations based on organizational characteristics of the firm. We find that the stand alone firms are by and large dependent more on the domestic collaborators while MNCs and subsidiaries of MNCs depend more on foreign actors for collaborations for their innovation activity. Here again the MNC subsidiaries and MNC head quarters display more or less same picture. The pattern in innovation, sources of technology and the collaborative strategies suggests a dichotomous nature of ICT sector in India as well. On the one hand, there are a large number of stand alone firms, that are oriented towards domestic market and less innovative, there are also MNC subsidiaries and MNCs headquarters who are comparatively more innovative and are more open in terms of their source of technologies as is evident from their increasing collaboration with other agents, both internally and externally.

Table 92 | Collaborations used for most important innovation in last three years by location of the Actors and firm type

		Stand Alone	MNC Subsidiary	MNC head quarters
Client	Domestic	43,14	15,29	22,73
	Foreign	56,86	84,71	77,27
Supplier	Domestic	65,63	31,08	28,57
	Foreign	34,38	68,92	71,43
Competitors	Domestic	67,86	31,58	22,5
	Foreign	32,14	68,42	77,5
Consultancy	Domestic	65,82	31,82	26,19
	Foreign	34,18	68,18	73,81
Government	Domestic	78,95	52,38	58,97
	Foreign	21,05	47,62	41,03
Local Universities	Domestic	96,97	97,96	97,3

	Foreign	3,03	2,04	2,7
Foreign Universities	Domestic	3,03	2,56	3,7
	Foreign	96,97	97,44	96,3

5.3.1 Summary of Subject 4 :

Offshoring of either production or innovation is not a major agenda of Indian ICT firms. Such an observed pattern needs to be viewed against the fact that, India is already known as a location with abundant supply of manpower at relatively low cost, a key factor in determining the offshoring decision of firms. Nonetheless, we find that there is significant difference across firms in terms of their offshoring activities. While offshoring is much less prevalent incase of standalone companies the subsidiaries and head quarters are increasingly engaged in offshoring. In general, firms are found to be collaborating with its clients and customers. Here again while the domestic firms collaborate with actors at the domestic level MNCs tend to collaborate with actors in foreign countries.

5.4 Subject 5 Sector Embeddedness in GINS

5.4.1 Participation in GINs: Existing evidence

The only available data until the INGENIUS survey on increasing participation Indian firms in Global R&D activities related to a survey of cases involving FDI in R&D conducted by Technology Information, Forecasting and Assessment Council (TIFAC) of the Department of Science and Technology for the period 1998-2004. Though 160 firms were surveyed, information on investment and employment could be gathered only from 100 cases. Information on the areas of activity and other information like country of origin could be gathered from 135 cases. It was found that during the period 1962-90 only six cases of FDI in R&D was reported. But during 1990-2000 the number increased to 49 and within four years (since 2000), 46 more cases got established.

It is observed that software is an area that attracted maximum FDI in R&D that accounted for nearly 23 per cent of the cases. If we include IT hardware and communication, the share increases to over 39 per cent (Table 93). This evidence tends to suggest that India's IT sector that is known during the early years for it comparative advantage in operating in the low end of the value chain of software is moving up the value chain. In addition, it could be inferred that the relatively vibrant sectoral innovation system in India's IT and software sector evolved over the years should have been instrumental inducing foreign firms in the IT and software sector to establish their R&D units in India.

In terms of the nature of activities undertaken by the units, it is found that 53 per cent of the cases involved shifting of in-house R&D activities from the home country to offshore locations. Needless to say, it is with a view to take advantage of the availability of needed manpower at a relatively low cost as compared to the home country. These units are found entirely catering to the needs to the home country requirements. There are no cases reported wherein R&D services are exported to multiple clients through open market system. However in case of engineering, chemicals and agriculture there are many cases that cater to the domestic market as well. In terms of equity/ownership, 51 percent of the companies never had any partnership with the local firms as they work only for the parent company.

Table 93 | Area of specialization of FDI in R&D

Area of R&D	No of Companies	%
Software	31	22.96
Computer Hardware, Chip Design etc	7	5.19
semiconductors analog	3	2.22
Internet OS development	4	2.96
Wireless development	6	4.44
optical net work	3	2.22
Auto Design	9	6.67
Drug Design, Agro Chemicals, Leather Chemicals, Dyes	16	11.85
Others (aerospace, engineering, bioinformatics etc Medical, Engineering, Power, Aerospace)	56	41.48

Total	135	100.00

About 43 per cent are found having partnership with local firms. The local firms are found to be well established large firms like Infosys, Wipro, HCL with very little presence of small firms as local partners. About six per cent of the companies started with a local partner but did not have a local partner as on 2004 when the survey was undertaken.

The incidence of FDI in R&D is reported to have increased manyfold since 2004. However, there is hardly any systematic analysis of the implications of such increased incidence of FDI in R&D on the national and sectoral innovation system in general and the innovation capability building on the other. To some extent the answer depends also upon the nature of knowledge-spill over and other externalities that would have profound influence on productivity and output growth. Studies (e.g. Basant Rakesh 1996) on the effect of foreign technology purchases, domestic R&D and spillovers on productivity of Indian firms during the earlier period do not reveal an encouraging trend. However, results of such analysis are likely to be different under the new regime and therefore calls for more detailed inquiries.

In terms of the country-wise distribution of FDI in R&D it is found that while the US accounted for 53 per cent of the number of units their share in actual investment (71.6%) and employment (69%) is much higher (see Table 94). Going by all the four indicators, USA is followed by Germany. It is worth noting that China has a notable position in terms of both employment (2.2%) and actual investment (5.3%) .

In terms of the location of such R&D ventures in India it is found that 45 per cent of them were in Bangalore, followed by Delhi (10%) and Mumbai (8%). While the state of Maharashtra (Mumbai and Pune) accounted for 17% of the number of units, three southern states Karnataka (mostly Bangalore) Andhra Pradesh (Hyderabad 7%) and Tamil Nadu (Chennai 4%) together accounted for 56 per cent of the total number of ventures. Here it needs to be noted that in terms of regional concentration FDI in R&D depicts more or less the same picture as that of general FDI indicating that, the presence of a vibrant regional innovation system is an important factor that governs the location decision.

Table 94 | Country-wise wise Distribution of FDI in R&D (up 2004) (%)

Country	Number	Planned investment	Investment in R&D	R&D employment
USA	53	60.59	71.59	69.20
UK	7	0.54	2.14	4.15
SWITZERLAND	2	0.14	0.67	0.74
Sweden	2	0.46	0.10	0.35
South Africa	1	3.71	0.06	0.22
Norway	1	0.01	0.00	0.00
Netherlands	3	3.49	1.62	2.31
Mauritius	2	1.13	1.01	1.15
Korea	3	2.40	6.86	2.83
Japan	7	3.66	0.83	0.87
Germany	7	18.34	6.78	8.92
France	5	4.75	1.84	4.22
Denmark	1	0.00	0.00	0.02
China	2	0.65	5.31	2.22
Canada	3	0.16	1.00	2.58
Australia	1	0.00	0.20	0.22
Total (%)	100	100.00	100.00	100.00
Total (actual Rs Million		209167.9	50989.2	22979

Evidence from INGINEUS survey

As noted already in the report, Indian ICT firms are largely export oriented firms, but with limited innovation activity, both in terms of quantum of innovation activity and the degree of novelty of their outcome. However, firms that are MNC head quarters or MNC subsidiaries did show greater dynamism in terms of innovative ability. Further, this difference in innovative activity seem to stem from the sourcing of technology by MNC and MNC subsidiaries, wherein their major source of technology was through informal linkages with other MNC firms. There was very limited offshoring of their production or innovation activity by stand alone firms, while the MNC head quarters and MNC subsidiaries had substantial offshoring activity. Collaborations for innovation in case of domestic oriented stand alone firms were mostly with their clients within the country. On the other hand, collaborations were foreign for the MNCs and MNC subsidiaries.

Linkages with foreign actor groups represent the network of the firms and the quality of network with various actors. Having no linkages represent an innovation system that is closed to the global innovation network. Having linkages, but very formalized linkages shows structured networks that are straight jacketed, often thinning out probabilities of innovations, unlike the rich, knowledge intensive and informal networking environment that generates innovation activities. In the Indian case it can be seen that most firms (82%) have some form of linkages with their foreign clients. Nearly 70 percent of the firms had linkages with the foreign suppliers (Table 95). Indian ICT firms do have moderate levels of linkages with other foreign actors such as competitors, consultancies and government and foreign universities. However, all these linkages are largely formal in nature. Thus there is this dichotomous situation where either firms have formal structured linkages or they do not have linkages at all. This represents a weakly embedded network relation among actors in the GINs and their outcomes, we have seen earlier are not encouraging in terms of innovative activity.

Table 95 | Formal and informal linkages towards foreign actor groups

		Yes, formal	Yes, informal	No
8,1	Clients	75	7,72	17,28
8,2	Suppliers	61,63	8,95	29,42
8,3	Competitors	45,37	10,49	44,14
8,4	Consultancy companies	51,85	7,72	40,43
8,5	Government	48,46	3,7	47,84
8,6	Foreign Universities/research institutions/labs	35,8	4,32	59,88
8,7	Other	0,31	0,31	99,38

Indian ICT firms seem to be self reliant on all functions of the firm, excepting for product development. Be it management, marketing or strategizing in all aspects, more than 75 percent of the firms claimed that they conducted these functions internally. Subsidiaries of these firms, be they located in the developed world or the developing world, were delegated almost all functions by nearly 15 to 18 percent of the firms. However, outsourcing of the firms activities to another partner, be it in India, developed world or the rest of the developing world were very weak. Thus Indian ICT firms are only very weakly linked to the global innovation network in terms of delegating the functions of the firms to other non-related partners.

Yet this is not a homogenous picture of all firms in the Indian ICT industry. The stand alone firms seem to confirm to a large extent to the pattern described above. The MNC subsidiaries and MNC head quarters on the hand seem to share these functions across the subsidiaries as well as themselves. Approximately only 50 percent of the MNC head quarter firms did tell that they conducted most functions themselves (Table 96). Rather 50 percent of them stated that their subsidiaries in both the developing world and developed world were delegated with almost functions. Even among these firms, however there is no explicit tendency to outsource their functions to partner firms. Moreover, the preferred direction of flow of direction of functional delegation to subsidiaries was towards developing world rather than the developed world in most functions. However, there was one exception, that when it came to technology and process development the developed country subsidiaries were preferred to developing world subsidiaries. In case of MNC subsidiary firms too this spreading out of their functions to other subsidiaries in both developing and developing world is true.

Table 96 | Performance of Various Functions of the Firm and Internationalization

	Firm type	By your unit in your location	subsidiaries of firm in developed country	subsidiaries of firm in developing country	Outsourced to partner in your country	Outsourced to a partner outside your country in a developed location	Outsourced to a partner outside your country in a developing location
Strategic Management	SA	84,4	6	5,4	0	0	0,6
	MNCSUB	58,5	16	16	0,9	0,9	0,9
	MNCHQ	56	30	38	2	0	0
	TOTAL	71,5	13	13,9	0,6	0,3	0,6
Product development	SA	0	12,6	4,2	0	1,2	0,6
	MNCSUB	0	20,8	21,7	2,8	2,8	1,9
	MNCHQ	0	20	42	4	2	0
	TOTAL	0	16,4	15,8	1,6	1,9	0,9
Marketing, sales and account management	SA	73,1	6	5,4	1,8	2,4	0,6
	MNCSUB	57,6	24,5	22,6	1,9	1,9	0
	MNCHQ	58	32	40	2	0	0
	TOTAL	65,6	16,1	16,4	1,9	1,9	0,3
Operations	SA	75,5	10,8	3	0	0,6	0
	MNCSUB	68,9	19,8	19,8	2,8	1,9	0,9
	MNCHQ	58	32	34	2	2	0
	TOTAL	70,6	17	13,3	1,2	1,2	0,3
Procurement, logistics, distribution	SA	77,3	9,6	5,4	0	1,8	0,6
	MNCSUB	63,2	23,6	22,6	1,9	1,9	0
	MNCHQ	60	32	34	0	2	0
	TOTAL	70	17,7	15,5	0,6	1,9	0,3
Corporate governance	SA	77,8	15	3,6	0,6	0	0
	MNCSUB	69,8	18,9	25,5	2,8	0,9	0
	MNCHQ	52	28	36	2	2	2
	TOTAL	71,2	18,3	15,8	1,6	0,6	0,3

Human resource management	SA	85	7,2	4,2	0	0	0,6
	MNCSUB	74,5	19,8	21,7	1,9	0	0,9
	MNCHQ	54	22	28	0	2	0
	TOTAL	76,8	13,6	13,6	0,6	0,3	0,6
Technology and process development	SA	82	10,2	3,6	0	0	0
	MNCSUB	69,8	22,6	17	0,9	0,9	0
	MNCHQ	54	36	24	2	2	0
	TOTAL	73,7	18,3	11,2	0,6	0,6	0
Firm infrastructure	SA	85,6	7,2	4,8	0	0	0
	MNCSUB	69,8	23,6	18,9	1,9	0	0
	MNCHQ	50	22	44	0	0	0
	TOTAL	74,9	14,9	15,5	0,6	0	0
Customers and after sales service	SA	82,6	8,4	4,8	0	0,6	0
	MNCSUB	68,9	19,8	19,8	1,9	0	0
	MNCHQ	52	24	40	0	2	0
	TOTAL	73,4	14,6	15,2	0,6	0,6	0

Note:

For case 1, the firm has operations and subsidiaries in 25 countries, 19 of them in the developed world and the rest in the developing world. A global giant in outsourced work they do not do any products, but make new services as well as processes in delivery and management. This case seem to reflect the nature and sources of innovation of typical MNCs headquartered in India. The firm's main sources of information for innovation come from their clients, who are mostly demanding customers from the developed world. They have in-house R&D centres in two global locations attached to their subsidiaries which generate solutions. They do not have any informal or formal linkages with universities or public research labs. While they have subsidiaries across the world which acts as sources of information for innovation they do not do any outsourcing of their processes. Thus, while this firm represents a global MNC from India, innovation networks beyond the firm's boundaries are weak. Its production network and delivery network have global presence but they are internal to the firm. In fact it is trying to strengthen its internal networks with its subsidiaries stronger.

Summary 5

The GIN Embeddedness of the Indian ICT sector

Indian ICT firms seem to be more inward oriented when it comes to innovation. Regardless of the activities considered, more than 75 percent of the firms claimed that they conducted their functions internally. However, outsourcing of the firms activities to another partner, be it in India, developed world or the rest of the developing world were very weak. Thus Indian ICT firms are only very weakly linked to the global innovation network in terms of delegating the functions of the firms to other non-related partners. While, the above picture is applicable in all aspects with respect to the stand alone firms, the MNC subsidiaries and MNC head quarters seem to share these functions across the subsidiaries as well as themselves. Approximately only 50 percent of the MNC head quarter firms are found undertaking most functions by themselves. In case of the rest of the firms, the functions have been delegated with preference for subsidiaries in developing world rather than the developed world. When it came to technology and process development the developed country subsidiaries were preferred to developing world subsidiaries. Thus viewed the local stand alone firms appears to be not getting embedded with the GINs while it takes place in case of MNCs.

5.5 Subject 6: Coordinating and communicating in GINs

In the Indian case coordinating and communicating internationally has been limited. Larger share of Indian firms had a perception of international collaborations being challenged than in the Norwegian case. Atleast 50 percent of the firms felt that each of these factors were barriers to innovation collaborations. The most important barrier to collaboration was changing the current locations and the cost of changing this configuration. Nearly 14 percent of the firms felt this was an extreme barrier for collaboration at an international level. However, differences in perception on challenges to collaboration based on organizational characteristics were substantial. Among stand alone firms, a comparatively low share of firms voiced out any of the given factors as barriers to collaboration.

On the other hand, MNCs with Indian headquarters had a higher share of firms agreeing that these factors were relevant as challenges to innovation collaborations. In all the factors approximately 70 percent of the Indian MNC head quarter firms agreed that there were serious barriers to internationalization(Table 97). In the light of the fact that stand alone firms had low levels of actual international collaborations, it may be interpreted that these firms did not realize the extent of these challenges. While the internationalized firms had a greater sense of these threats. As high as 32 percent of the MNC headquarters in India felt that changing the current location of operations and the ensuing costs was an extreme barrier to international collaborations.

An interesting aspect is that while MNC headquartered in India sought these as challenges, MNC subsidiaries did not see these as threats vastly different from that of stand alone firms, except for organizational barriers for collaborations. Their perceptions seem to be marginally more unfavourable than stand alone firms. We had seen earlier that MNCs do not internationalize through outsourcing or partner firms, but by mainly establishing subsidiaries. The fact that MNC head quarters find greater challenges in innovation collaborations may be associated with the relative inexperience in functioning as global MNCs. 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. Moreover, most MNC subsidiaries have greater experience being part of an MNC than most MNC headquarters in India Hence, while the MNC subsidiary will carry a weak perception of collaborations for innovations. But MNC head quarters from India are relatively new, with only little experience in international collaborations for innovation.

Table 97 | Factors that represent a challenge or a barrier to international innovation collaboration

	Firm Type	Extreme/ Serious/ Moderate Barrier	Extreme barrier	Serious barrier	Moderate barrier	Small barrier	Not a barrier at all	Total
Finding relevant new knowledge across the globe	SA	51,61	7,74	9,03	34,84	26,45	21,94	100
	MNC sub	50	5,66	17,92	26,42	33,96	16,04	100
	MNC HQ	76	6	36	34	12	12	100
	Total	54,98	6,75	16,4	31,83	26,69	18,33	100
Overcoming organisational barriers and having necessary incentives for collaboration	SA	47,44	3,21	12,82	31,41	26,92	25,64	100
	MNC sub	65,1	7,55	25,47	32,08	17,92	16,98	100
	MNC HQ	66	10	34	22	24	10	100
	Total	56,41	5,77	20,51	30,13	23,4	20,19	100
Changing the current	SA	51,61	6,45	13,55	31,61	23,23	25,16	100

location of operations and the cost of changing this configuration	MNC sub	55,65	15,09	15,09	25,47	29,25	15,09	100
	MNC HQ	86	32	18	36	4	10	100
	Total	58,52	13,5	14,79	30,23	22,19	19,29	100
Managing globally dispersed projects and cultural differences between different countries	SA	48,7	7,79	10,39	30,52	24,68	26,62	100
	MNC sub	54,28	5,71	16,19	32,38	29,52	16,19	100
	MNC HQ	66	6	34	26	26	8	100
	Total	53,4	6,8	16,18	30,42	26,54	20,06	100
Harmonising tools and structures across the network to enable collaboration	SA	45,81	5,16	8,39	32,26	24,52	29,68	100
	MNC sub	53,4	3,88	17,48	32,04	28,16	18,45	100
	MNC HQ	76	10	26	40	14	10	100
	Total	53,25	5,52	14,29	33,44	24,03	22,73	100

Summary 6

Coordinating and communicating in GINs

Given that the extent of participation especially by the stand alone firms is low in the GIN, the issues of coordination are found limited. However, such issues have been reported by the MNC headquarters. The headquarters of MNCs were especially concerned with the issues relating to changing the current location of operations and the cost of changing the configuration.

5.6 Subject 7: Impact from Crisis

Evidence tends to suggest that Indian economy has not been affected much seriously by the global financial crisis. This has been attributed mainly to the fact that India's financial sector is much less open today as compared to that of developed countries. However, in case of IT sector the situation is likely to be different as it is much more outward oriented than the rest of the economy. However, the survey results indicate that financial crisis seems to have not much of a serious effect on the innovative activity of the firms especially a standalone firms and MNC subsidiaries (Table 98). About 37 percent of the

Table 98 | Firms Response to financial crisis

	stand alone	MNC subsidiaries	MNC headquarters	Total

Few or no changes	44,94	33,33	18,37	36,86
Increasing efforts at innovation on your part	48,73	48,57	36,73	46,79
A serious reduction of your innovative activities	2,53	2,86	8,16	3,53
Relocation abroad of your innovative activities	2,53	11,43	30,61	9,94
Relocation of innovative activities to you from abroad	1,27	3,81	6,12	2,88
	100	100	100	100

firms stated the crisis did not affect the innovation activity, while 45 percent of the firms stated they would increase their efforts at innovation activity. Here it is to be noted that out of the MNC headquarters only 37 percent reported such an option. This could be on account of the fact that, their major markets, like the US, being in financial crisis, their cash flow might have been affected. In general the perceptions of standalone companies (not exposed to export market) and MNCs subsidiaries tend to be more or less the same and that of MNC headquarters different. While 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.

5.7 Subject 8: Looking Forward –Implications for Policy

Public policy played a key role in the emergence, growth and structural transformation of India's IT sector. The policy initiatives made from time to time by both the central and state govt 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. Nonetheless, there are a wide range of constraints that are being confronted by the firms not only with respect to manpower availability but also in the sphere of innovation infrastructure. To address the manpower bottleneck a series of interventions by the state and the individual firms along with industrial associations have been made.

From the survey, a clear majority of firms (55% rated very high to moderately high) stated that Public incentives and economic support may be important intervention that could enhance innovation activity in future. Similarly public intervention for generating skilled labour force in the economy was also perceived important for innovation. In a context wherein firms in India's IT sector are increasingly entering into software product development IPR related issues are also considered an important area for policy attention. Similarly more than 50 percent of the firms felt availability of skilled manpower as an area of priority policy action (Table 99). It is also worth noting that almost 45 percent of the firms called for policy interventions towards strengthening universities and public research laboratories. In general, the perceptions of the firms towards factors that would help improving innovative activities comprises of almost all the elements of a vibrant innovation system

Table 99 | Improving the following factors for FUTURE innovation activities

	very high	moderately high	moderately low	very low	no need	no response
Support from centres	16,67	30,56	19,14	15,12	13,27	5,25
Public incentives	13,89	41,36	17,59	8,02	14,2	4,94
Universities and Ris	24,38	22,22	25,93	12,35	10,19	4,94
labour force	20,06	29,63	22,84	11,42	11,11	4,94
Judiciary and IPR	12,04	33,02	22,84	14,2	12,35	5,56
FDI and Trade policy	16,05	29,01	23,46	11,73	14,51	5,25
Migration Policy of foreign scientist/technicians	15,12	29,01	20,68	12,35	18,21	4,63
Risk capital Availability	14,2	29,32	19,14	12,96	17,59	6,79

Concluding Observations

The analysis undertaken in this report tend to highlight the heterogeneity within India's IT sector. We observed significant difference across firms of different organizational categories like standalone firms, subsidiaries of MNCs and headquarters of MNCs. While the first and last categories of firms are of Indian origin that of the second category belonged to large multinational companies from abroad. With respect to size the standalone firms were found to be smaller as compared to their counterparts. But when it comes to market orientation the MNCs subsidiaries and MNC headquarters, that are larger in size, are found to be oriented mostly to the export market. The innovative behavior of firms tend to reflect their size as wells as market orientation. While there is some evidence to suggest increasing orientation towards innovation among all categories of firms we found significant differences between them. The MNC headquarters and MNC subsidiaries were found more innovative with relatively large number of innovation that are new to the industry and new to the world. The higher innovativeness of these two categories of firms has been facilitated, among others, by their greater orientation towards research and development. Thus viewed the opportunity conditions for MNC subsidiaries and MNCs headquarters are more conducive for GIN formation. The empirical evidence was supportive of the limited participation of standalone companies as compared to their counterparts. The survey also indicated that Indian IT firms are very weakly linked with global innovation network in terms of delegation of different functions. Given that the extent of participation is especially low the issues of coordination are also found to be limited. But when it comes to MNC subsidiaries and headquarters of MNC there do occur various coordination issues in innovation.

In general, the innovative activity of large majority of Indian farmers are at a low level. This needs to be seen in terms of the nature of the domestic market with which they deal with that are likely to be less demanding as compared to the market confronted by the larger counterparts. The limited innovation capabilities set limit for their ability to participate in global innovation network. Their limited R&D orientation also cannot be delinked from the less demanding nature of the market that they are catering too. Thus viewed, greater penetration of IT into other sectors of the economy and its consequent outcome in terms of greater domestic demand might act as an inducement mechanism for the emergence of an innovative IT sector and which in turn might induce the firms to join the global innovation network. If the evidence from existing studies is any indication, these smaller firms are also expected to compete with their larger counterparts in the labour market. This inturn adversely affects their access skilled manpower, a key factor that determines the ability of firms to engage in innovation related activities.

While we find considerable similarities between MNC headquarters and MNC subsidiaries in many respects they behave very differently. For example, when it comes to the challenges for international innovation collaboration, the experience of MNC head quarters is found significantly at variants with other two categories. Similarly, in terms of interaction with knowledge infrastructure within the country the interactions of MNC headquarters is found more intense as compared to other two firms.

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

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Introduction

This report analyses what kinds of GIN constructs have developed and are currently under development in the Danish agro-food innovation system, with the point of departure in the Danish food and beverage industry. Innovation in the Danish agro-food industry increasingly takes place in networks that involve companies, consultancies and often public research institutions embedded in the national innovation system.

The agro-food innovation system has so far been categorised as supply-driven, with an emphasis on process innovation relying on a variety of technologies from other sectoral innovation systems (Pavitt 1984). This is generally confirmed in the Danish agro-food innovation system. However, there are new, important tendencies emerging in some specific technology areas of the industry. This is explained by the co-evolution of this industry and the Danish innovation system, which today hosts five of the largest food-related biotech companies in the world. As a result, this industry represents two different types of internationalisation of innovation – or embeddedness in global innovations networks – namely one of knowledge augmenting and one of knowledge exploiting (as developed by Kuemmerle 1999).

Hence, one group of companies in this industry (in this paper represented by case companies I and II) has developed very specialised actors within biotechnology. In this group, innovation is performed globally and there is a high degree of collaboration between a wide range of actors generating global breakthrough innovations in their specialised niche markets. In the other group of companies in the industry, the companies focus on their end-markets, e.g. incremental innovations such as applying products to new markets that are either international (local tastes) or functional (the gourmet value chain, organics, and healthy foods). In this part of the industry (represented by case companies III and IV), innovation includes, for example, 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. Consequently, the Danish agro-food innovation system uses the two models for internationalisation of innovation, exploration and exploitation.

The framework conditions of the Danish agro-food industry are characterised by a limited home market situated in a small open economy (Katzenstein 1985). In order to cover the costs of innovation and other investments, Danish companies need to engage in international markets by exploiting their knowledge beyond the national borders. This is mainly done within Europe (Christensen et al. 2008). Moreover, the research environment in Denmark, although highly competent, includes a limited number of researchers as compared with larger economies. This adds to companies' need to engage in close national and European networks (and clusters) and/or explore international supplementary knowledge. Our survey results show that the private companies in innovation networks are often vertically embedded in the existing production networks; for example, suppliers and customers upstream and/or downstream in the value chain. Consequently, as companies increase innovation activities, they also need to expand their operations and markets by increasing their engagement with customers or suppliers, which leads to new network configurations in the industry, some of which go beyond borders.

While the agro-food industry is categorised in the literature as being traditional, relatively low-tech, and oriented towards the local market, looking into the Danish agro-food industry, we found evidence that this industry is currently going through a process of international restructuring – a globalisation process. Some examples are changes in the transport sector, companies exploring new tastes beyond their home markets, and innovations related to conservation. A large proportion of the recent breakthrough innovations made in the Danish food industry relates to providing ingredient and enzyme solutions for globalised customers.

Methodology

This report is based on empirical data collected in Denmark in 2010. The data set consists of three main sources of information: 1) the INGINEUS survey carried out in the industry in early 2010, 2) four in-depth case studies and 3) country statistics and literature studies.

The database used for identifying companies for the survey was Orbis, a company database offered by Bureau Van Dijk, The Netherlands, which holds 241,000 Danish companies. The database covers a large proportion of Danish companies.[46] The companies included in the agro-food industry were all companies in NACE rev. 2 codes 10 (manufacture of food products) and 11 (manufacture of beverages). Companies with a minimum of 5 employees were selected in the initial download. This resulted in a total of 474

[46] According to the official Danish Statistics from 2007, there are 305,319 companies in Denmark (Statistics Denmark, 2010).

companies in the uncleaned database. Subsequently, a number of companies were taken off the list, as they were not related to industrial manufacturing: e.g. local meat shops (66 instances) and local bakeries (113 instances). Companies that had closed down since the database was last updated were also removed (37 companies). Finally, companies without email were excluded (39 companies). The eventual cleaned database consisted of 219 companies, of which 9 had apparently non-functional email addresses. The companies were approached by the following procedure. For companies with between 5 and 30 employees, we used the general company email account. For companies with between 31 and 250 employees, we sent the link to the company manager. Finally, for companies with 251+ employees, we contacted the Research/innovation manager. Of the 210 companies that received the questionnaire, 48 companies responded to the survey. This is an overall response rate of 23%. Table 100 gives an overview of the companies in the survey.

Table 100 | Companies in the INGINEUS Survey (Denmark) by type. INGINEUS Survey 2010.

Type of companies in the INGINEUS survey	Percent
A stand-alone company	81.0%
A subsidiary of a MNC	16.6%
The headquarters of a MNC	2.4%

In addition to the survey, four case companies were chosen. These were chosen on the criterion that they are among the largest and most innovative and internationalised corporations in the industry. Hence, they work as critical case studies and will be considered representative of the ‘cutting edge’ of the emerging trends in the industry in terms of global innovation network. Two of the case companies are in the part of the industry that relates to biotechnology, while the other two are strong international players in more traditional products. Table 101 shows the main characteristics of the four case companies.

Table 101 | INGINEUS Denmark case companies, main characteristics

Company	Type of products	Market internationalisation	R&D internationalisation

Case 1	Ingredients, Biotech-related	Global	Global
Case 2	Ingredients, Biotech-related	Global	Global
Case 3	Beverages	Global	Denmark
Case 4	Dairy	Europe	Denmark

Finally, a search of secondary data was undertaken, including official reports, companies' annual reports, industrial associations, Ministry of Food, and Ministry of Science and Technology. In addition to this, statistical data were collected from Statistics Denmark. All Danish companies are obliged to report annually to Statistics Denmark, thus the reliability of data is very high. Finally, we attended several industry workshops and conferences related to the Agro-Food Science Park.

6.1 Subject 1: The present nature of the agro-food industry in Denmark

The Danish innovation system has its roots in an agrarian economy and is, to some extent, still relying on agriculture and food production.[47] Along with the development of an increasingly knowledge-intensive economy, a strong agro-food innovation system has developed which is one of the most innovative agro-food industries in the world today. As most agro-food products are relatively freshly produced, with limited shelf lives, and food tastes vary considerably over geographical area, products are predominantly sold within Denmark and Europe. The industry is dominated by small and medium sized enterprises

[47] In terms of products, the industry includes actors involved in the development and production of: processing and preserving meat and production of meat products; processing and preserving fish, crustaceans and mollusks; processing and preserving 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 feed.

(SMEs), and very few large-scale multinational companies (MNCs); however, it accounts for approximately 20% of Danish exports, of which 64% are sold within Europe. Additionally, there are four universities and a large number of research institutions which relate to the industry.

The Danish government has a strong focus on this sector, aiming at developing the national food industry into an Agro-Food Valley by the year 2022 (Ministry of Food and Agriculture, 2009). The visions for this Agro Food Valley are: to remain as lead location for innovation; to increase the industry's competitiveness; to sustain an environmental and sustainability focus; to strengthen organic production; to make developments within the gourmet value chain; and lastly, to make developments within tourism. One of the recent political initiatives is the establishment of an Agro Food Park outside Århus, which is a science park for agro and food processing companies and research institutions located near one of the largest Danish universities. This park has the capability of hosting 50 companies with more than 3000 employees, and aims to facilitate collaboration along and across the value chains. Some of the large Danish food companies are present in the region, two of which are Danisco, with 260 scientists in R&D (of 600 globally), and Arla, currently with 300 employees in innovation; but the majority of companies are SMEs that are attracted to the spillover effects they get from this agglomeration.

There is a high level of specialisation within the areas of dairy, ingredients, beer and meat. The Danish agro-food industry has developed into an innovation system with domestically embedded knowledge generation and a high concentration of different types of network constructs. Most of these networks are among Danish actors in the industry, and few have an international scope (Landbrugsrådet 2006). Therefore the competitiveness of the industry is thought of as being strongly related to high innovation and research intensity (Landbrugsrådet 2006). This is also facilitated by the government support in the establishment of 'clusters' in food- and agriculture-related industries, which are seen to enhance collaboration across companies, industries, and public and private actors, such as the Agro-Food Valley (Agrotech 2009). Although agro-food is often seen as a low-tech sector, the Danish agro-food industry is well embedded in the Danish system of lifelong learning and therefore has a high focus on innovation and learning.

Other related industries have emerged from the Danish agro-food innovation system, such as the pharmaceutical industry[48] (Hansen 2010). Other examples of 'spinoffs' from the agro-food industry are furniture, machinery and biotech. Still, the agro-food industry remains the most important one for the Danish economy among the

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[48] The development of the Danish pharmaceutical industry relates to the high concentration of pigs in Denmark, which were initially used for insulin production.

manufacturing industries. Figure 1 shows the development in turnover of the different Danish industrial sectors between 2000 and 2009. The figure clearly illustrates that the food and beverages and machinery industries belong to the core industries in the Danish economy.

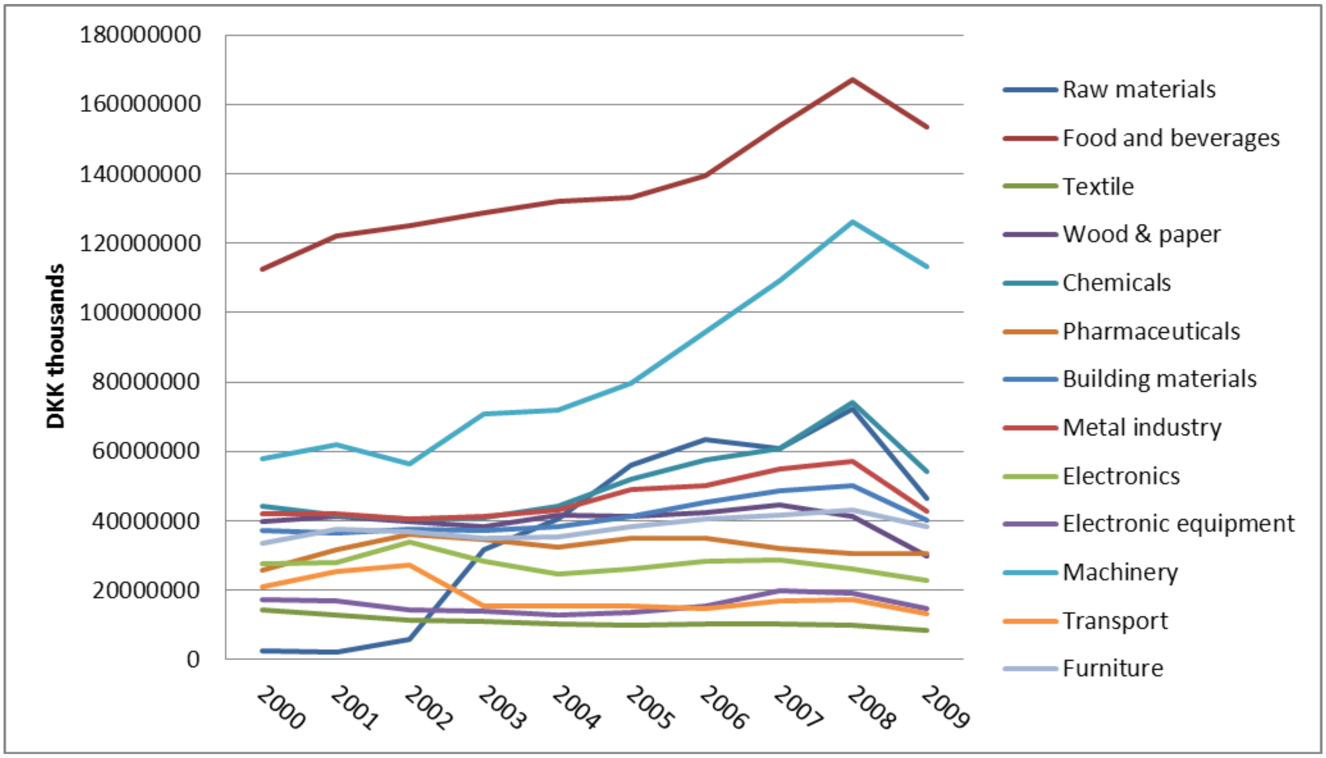


Figure 1. Turnover of Danish Businesses by Industrial Sector

Source: Statistics Denmark 2010

The industry is innovative. At the national level there were 3512 people employed in research and development (R&D) in agro-food in 2008. Approximately 60% of these were in the private sector, which spent a total of DKK 2.1 billion on R&D in 2008, an increase of 28% (from 1.6 billion) from 2007 (Ministry of Science and Technology 2010).[49] Overall, the agro-food industry accounts for 5% of the total

[49] This is the second-largest amount within the Danish industrial sectors (after 5.9 billion spent in the pharmaceutical industry).

private R&D spending in Danish industries. According to the Ministry of Science and Technology (2010), 246 of the Danish agro-food companies carried out R&D in 2008. 90% of their R&D spending was funded by the companies themselves, 6% by other national sources and 4% was financed by foreign actors, mainly within the European Union (ibid.). The distribution of researchers is widely spread among large companies and SMEs (Figure 2). The largest share of researchers (31%) is employed in the 145 small companies (>50 employees in total), while the 5 companies with more than 1000 employees accounted for 30% of the R&D personnel.

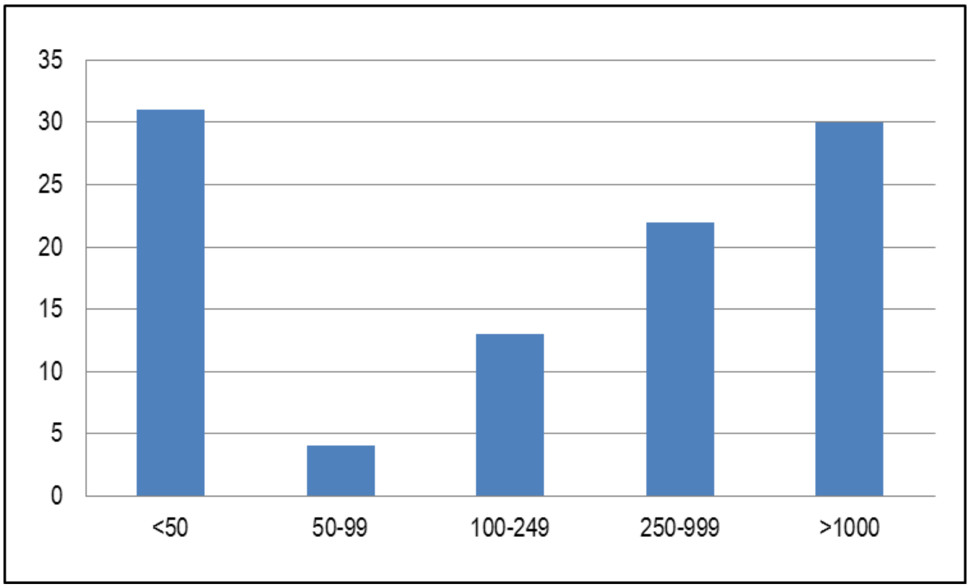


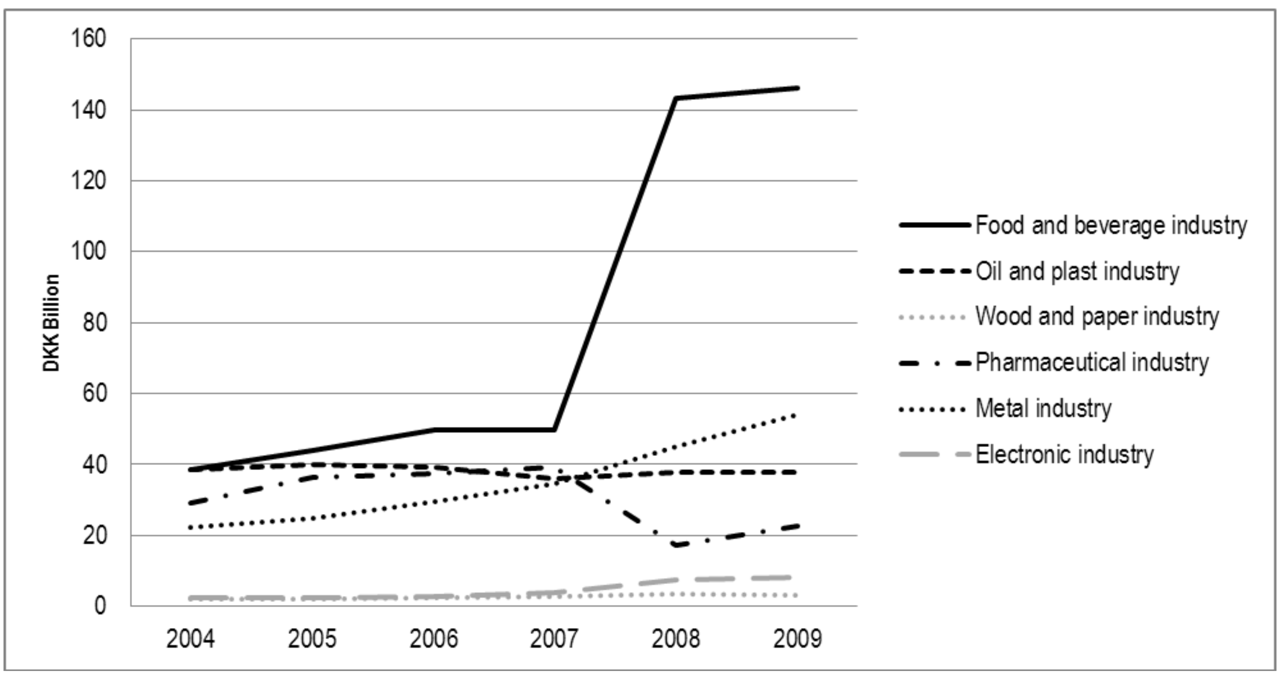
Figure 2. Number of full-time employed researchers in Danish agro-food industry by company size

Source: Statistics Denmark 2010

The Danish agro-food industry is in the international top, internationally, in terms of innovation, patents and scientific publication, and the research institutions and large companies are highly internationalised. In terms of research and publications, 75% of the peer-reviewed publications coming out of the Danish food industry and research centres are co-authored with authors from abroad (ibid.). The five most important foreign partners in joint publications are Great Britain (11%), Sweden (10%), the US (9%), Germany (8%) and the Netherlands (7%). By number of publications, Denmark ranks as number 19; however, when adjusted for the size of the country, Denmark ranked highest in the world in 2010 (Danmarks Biblioteksskole 2010).

A large proportion of the recent global breakthrough innovations made in the Danish food industry relates to ingredients, preservation and enzyme solutions. Five of the largest global players within ingredients, enzymes and preservation are based in Denmark but engaged globally. These companies are also among the most patenting companies in Denmark. Novozymes and Danisco are at the top, achieving 62 and 39 patents in the period 2004–2008 respectively[50] (Ministry of Science and Technology 2010; Patent- og Varemærkestyrelsen 2010). From an international perspective, the Danish agro-food industry filed the third largest number of agro-food patent applications among the OECD countries in the same period (after Switzerland and the Netherlands; Patent- og Varemærkestyrelsen 2010).

In terms of internationalisation of activities (beyond the market), this industry is very active in foreign direct investments compared to Danish manufacturing industries in general (see Figure 3). Off-shoring of activities through foreign direct investments (FDI) is high and, over the last five years, the Danish food and beverage industry has invested heavily abroad. Most of these investments are placed in Europe. As a result, the food and beverages industry has obtained the highest level of outward FDI among the Danish industries.



[50] Novo Nordisk ranks third with 32 food-related patents in 2004–2008 (Patent & Varemærkestyrelsen 2010).

Figure 3. Outward FDI flows by industrial sector (primary products and services are not included). Source: Statistics Denmark 2010

Outward stock of investments is considerably higher than the inward stock in the industry, i.e. foreign companies investing in Denmark, although this has also increased somewhat (see Figure 4).

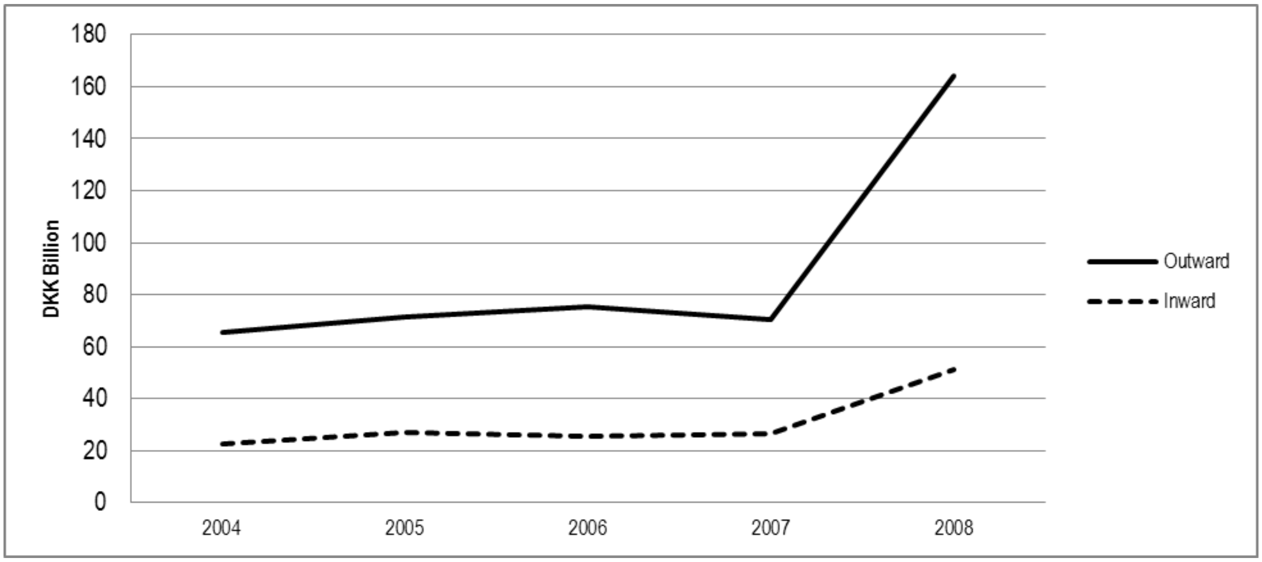


Figure 4. FDI stock (inward and outward) in the Danish Agro-food industry, DKK Billion

Source: Statistics Denmark 2010

According to the European Cluster Observatory, Denmark is the third largest food cluster in the European Union (ECO 2010), measured by the number of people employed in the industry. Moreover, the Danish agro-food industry is perceived as innovative among the food clusters in the European Union, and is also very export oriented (see Table 102).

Table 102 | The top three agro-food clusters in Europe

Cluster	Employment	Innovation	Export

Lombardia (Milan), IT	107,806	Medium	Strong
Cataluña (Barcelona), ES	103,066	Medium	Strong
Denmark, DK	76,203	High	Very strong

Source: European Cluster Observatory 2010

Among the publicly funded research funding, agro-food-related research institutions receive 7% (which is more than the IT and energy sectors). Three universities are the most active actors in R&D within agro-food.[51] All three universities collaborate with companies to a large extent. Therefore, the share of applied research is higher in the agro-food sector (61%) than within other research areas (42%).

However, as was also shown in the figures above, internationalisation of internalised R&D in this industry is in its orphan stage. According to Statistics Denmark (2008), the agro-food companies altogether only reported off-shoring and outsourcing of 86 knowledge-intensive jobs and 949 unskilled jobs in 2008. The restructuring into global innovation networks is a long process. But the agro-food companies do consider the increased internationalisation of R&D. As we will show later, those companies specialising within biotech are the most internationalised in innovation through exploration; whereas companies with more machinery are mostly internationalised in market exploitation.

The Danish food industry is highly collaborative vertically as well as horizontally (Hansen 2009). As we will show later, the industry has a high degree of vertical collaboration upstream and downstream in its value chain, i.e. with suppliers and customers. Having core suppliers is common in this industry, and is often described as 'from farm to fork' integration of production ('Fra jord til bord'). The explanation can be found at the company level: the distribution of the size of companies in the INGINEUS survey mirrors the distribution in the agro-food industry in Denmark. 74.4% of the response companies were SMEs (i.e. fewer than 250 employees); hence they are small companies depending on outward collaborations with others. Although the industry consists of a large number of SMEs, these are highly internationalised in terms of market.

[51] University of Copenhagen, University of Aarhus and Technical University of Denmark.

Table 103 | Distribution of companies in the INGINEUS Survey

Number of full-time equivalent employees in the company	Response Percent
Fewer than 10	9.3%
Between 10 and 49	39.5%
Between 50 and 249	25.6%
Between 250 and 999	20.9%
More than 1000 employees	4.7%

Table 4.

Source: INGINEUS survey 2010

The Danish agro-food companies are generally export oriented. 56.1% of the companies reported a significant share of their sales activity abroad and 38% of the companies had their largest market outside Denmark (see Table 104). Nine companies reported that they export more than 80% of their products, 11 companies export between 50% and 79% and the remaining 28 companies (equivalent to 58%) reported less than 50%. The most important destinations of exports, among those answering ‘an export market’ as their largest market, are shown in Table 105.

Table 104

Location of the largest market	Per cent
Internal to the enterprise	7.1%
A regional market	14.3%
Domestic market (Denmark)	40.5%
An export market	38.1%

Source INGINEUS Survey

Table 105

Geographical destination – the largest market	Share
North & South America	13%
Europe	69%
Africa	0
Asia (incl. Japan) and Australia	18%

Source INGINEUS Survey

Table 105 illustrates the extent to which the Danish agro-food industry is supra-regionally embedded in the European context. 69% of the companies exporting have their largest market within Europe, with only 31% in destinations in the rest of the world. This does not necessarily imply that these companies do not sell beyond Europe, but their main geographical destination of export is within Europe. These data, however, show the internationalisation of these companies' markets; hence, they do not indicate their engagement in outsourcing of production and innovation collaboration.

Summary

The Danish agro-food industry has developed into an integrated innovation system based on domestically embedded knowledge and networks between many actors, of whom the majority are SMEs. The industry is innovative and companies have a relatively high level of engagement in collaboration around and investments in R&D. In terms of market, the companies are internationalised, but predominantly within Europe.

Internationally, the industry has two main types of companies: one which is very specialised, with a high level of internationalisation, and one which innovates in Denmark and sells abroad. The sectorial innovation system has an international outlook and links to research beyond the national innovation system. The level of co-authorship and patenting shows the internationalisation of innovation, at least at the overall level. 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 internationalisation of the market. Furthermore, the formation of clusters in food- and agriculture-related industries enhances collaboration across companies, industries, and public and private actors. The companies are embedded in their particular value chain and in the overall Danish agro-food innovation system.

The present nature of the agro-food industry in Denmark is that this is a solid platform, well embedded in the national innovation system, with strong linkages within the value chains and between industries.

6.2 Subject 2: The nature of innovation and technology in the sector

The largest Danish agro-food companies are among the world leaders. Due to the Danish innovation system's framework conditions of being a small, open economy, companies' operations are generally embedded in networks, predominantly at the national level (e.g. windmills, agro-food, clean tech and transport) or as clusters with regional (sub-national) specialisation, such as Medico-Valley in the Copenhagen area and the Agro Food Science Park in Århus. Danish lead firms are characterised by their strong networks within the Danish innovation system, upwards as well as downwards in their value chains, and a supportive innovation system. However, since the home market is also small, being a successful player in industries driven by innovation implies potentially a high level of internationalisation. Those Danish companies that have developed into lead firms are now strong international and specialised niche players.

The main research focus areas for the large companies are within ingredients, enzymes, yeast and other biotech-related or IT-related products (one of the large meat producers is engaged in development of robotics). However, as

Table 106, below, illustrates, new-to-the-world innovation is rather limited in this sector, and predominantly happens within product innovation.

Table 106 | Type and quality of innovation experienced in the Danish agro-food industry

Experienced innovation in the past three years (2006–2008)

Innovation type	New to the world	New to the industry	New to the firm	None
New products	13.2%	26.3%	47.4%	26.3%
New services	9.7%	9.7%	29.0%	61.3%
New production processes	2.6%	18.4%	60.5%	21.1%

New logistics, distribution	0	3.1%	31.3%	65.6%
New supporting activities	0	0	54.5%	45.5%

. Source: INGINEUS Survey

In regard to the quality and type of companies' most recent innovation, 74% of the respondents had experienced product innovation; however, only 13.2% of them had introduced 'new to the world' product innovations within the past three years, whereas 26.3% had introduced products 'new to the industry' and 47.4% 'new to the company' innovations in the same period. This result supports the assumption that the majority of the Danish agro-food companies engage in incremental innovation. Most companies reported that they had introduced new production processes. However, only 2.6% of these companies introduced 'new to the world' production processes, while 18.4% had introduced 'new to the industry' and 60.5% 'new to the firm' innovation. Very few companies had introduced new services and new logistics within the last three years. For both types, innovation has been developed within the 'new to the firm' category.

The companies engage in different collaboration constructs when exploring technology (see Table 107). Two thirds rely on collaborations with other private companies as their most important source of technology. This illustrates the highly networked nature of the sector. One explanation for this could be that these companies are often suppliers and customers to each other along the different value chains, and that they have a high degree of integration of research along their farm-to-fork chains. That leads to one-stop-shops for customers. A current example of research along a farm-to-fork chain is the collaboration across five companies in the development of ice cream. This network includes suppliers of ingredients for texture and flavour, a dairy producer, a producer of machinery for ice cream production and a large ice cream manufacturer.

Table 107

The most important source of technology for the company	Percent
We produce most technological inputs in-house	22.0%
We buy most of our inputs from other branches of our own MNC	12.2%
We buy most of our technological inputs from non-MNC firms	31.7%

We buy most of our inputs from MNCs with which we are not formally connected	34.1%
We buy most of our inputs from public sector organisations, e.g. research institutes or universities	0

. Source: INGINEUS Survey

Regarding the level and types of R&D, there is a need to distinguish between the different types of companies in the industry. Companies I and II are engaged in **research**[52] into breakthrough innovation within biotech-related segments of the agro-food industry, whereas companies III and IV are more 'traditional' in their production and predominantly engaged in **development**[53] of their products. This distinction is of course something of a caricature, as companies I and II also develop and companies III and IV also do some research; however, in the latter case, the research is marketing-oriented as their new products are initiated by the markets in which they operate. Company IV is co-operatively owned; therefore, it is owned by the farmers who supply the produce. Hence, the main activities of Company IV are related to processing and marketing its products. This company structure is common in the Danish agro-food sector and has an important impact in constraining and facilitating the companies' global and innovative engagements.

Knowledge ranges from, at one extreme, being very technical within subjects such as chemistry, enzymology, DNA mapping and immune systems. This is related to radical innovation into new products. Companies I and II both have two different strings of in-house innovation, of which one relates to long-term investments into radical innovation requiring 'hard-core experts' (Company II). This type of knowledge is, in Companies III and IV, sourced from external partners. At the other extreme, knowledge

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[52] **Research:** Within the development of new products and core research, the companies are interested in accessing relevant knowledge actors and environments. This was expressed in the interviews as 'not all good knowledge and innovation come from Denmark' kinds of arguments. Some companies expressed that they are looking for supplementary skills, specialists etc. because they have reorganised their R&D into 'global operations' in which projects are taken care of by the most specialised in the particular field, often spanning across R&D locations/sites.

[53] **Development:** Within the agro-food market there is a high degree of diversity, e.g. in tastes, textures, raw produce, quality etc. Therefore, companies internationalising their markets need to engage in some development of their products to local markets, local raw materials and local conditions. This relates to a market access strategy. All the case companies were engaged in development of their products for local markets.

and innovation implies short-term improvements and mid-term product development. Hence, it requires application technologies and knowledge about the markets. All four companies are engaged in the latter and engage with their customers. For this, they need employees/researchers with in-depth knowledge on the differentiated segments of the agro-food industry. Often, these people are recruited from within the agro-food industry.

While looking at the integration of the four companies in global innovation networks, there is a rationale in splitting up how the Danish agro-food companies have developed in regard to the following three dimensions: global, innovation and network. In order to create a typology of global innovation networks, companies may engage more or less globally (i.e. in Europe or worldwide); internationalise more or less innovative activities (exploiting or exploring); and connect more or less within an innovation network (i.e. with suppliers and customers along their value chain or with highly specialised research centers and companies). See

Table 108 for an illustration of these three dimensions. These will be dealt with in the individual case companies below.

Table 108.

	Global	Innovation	Network
High	Worldwide	Exploration	Beyond the value chain
Low	Denmark/Europe	Exploitation	Within the value chain

Source: Chaminade 2010

6.2.1 Summary

The majority of Danish agro-food companies are not engaged in new-to-the-world innovation. The survey companies are generally engaged with incremental innovation. 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.

This industry is open when it comes to accessing and sourcing new technology. As we will see in the next section, the more upstream in the value chain specialised large companies are, the more active in global innovation networks they will be. Conversely, those companies with market-oriented innovation strategies are more locally connected with specialised research institutions.

6.3 Subject 4: Locations and internationalisation

This section looks into the companies' location and internationalisation strategies of R&D and innovation at the company level in order to develop the typology further.

Company I:

Knowledge is the main product of this company: delivering solutions to customers based on recipes developed by the company – including their products as ingredients. R&D is of high priority: 4.3% of turnover is allocated R&D, which is carried out predominantly in five large R&D platforms plus some supplementary smaller research units. 870 people work internally within R&D, of which more than 60% have a university degree. This company has a strong need for specialised knowledge at all levels. The company has a high level of specialisation and often recruits from the food sector. These recruitments come from specialised segments of the food industry. For research, 10% of R&D spending is placed outside the company, and this is often in collaboration with universities. The other type of innovation (development) in the company takes place in close collaboration with customers. Food tastes are different around the world and, even for the same products, the company needs local varieties; e.g. ingredients vary for different types of raw materials or for similar products (for instance, some enzymes may be applicable with minor alterations for production of pancakes, chapattis and tortillas).

The company engages in the off-shoring of R&D for two main reasons: 1) it is cheaper and 2) to serve the markets better. Regarding 2), there is some evidence that the global production network of this company, as an existing configuration, developed into the global innovation network of which the company is a part today. Except from one research site, the R&D centres are placed near existing production facilities. The company links to academic institutions at home and abroad through different programmes; for example, annual awards for world-class researchers and through the website 'innosearch', which is an interface for connecting innovation-related problems with problem solvers globally. At home, the company plays a very active role in the agro-food cluster and has a seat on the board of the Agro-Food Park in Århus.

Company II:

This company is also a global leader in its field. It is very research-intensive, with an R&D spending of 14.3% of the revenue. All the R&D sites are placed in locations with significant sales and where the company can identify an interesting and well-performing research environment. Today, research centres are located in the US, Japan, Brazil, Denmark, China, Japan, Switzerland, India, England and Australia.

The company has the understanding that ‘not all good innovation can take place in Denmark’. Hence, its competitiveness is seen by the innovation managers to be a question of global presence: ‘you look more serious if you have local R&D’ (interview). However, so far the company is strongly embedded in the national innovation system: ‘We are not moving R&D away from Denmark; approximately half of R&D is located in Denmark, and more people are hired every year’ (interview). However, the share of researchers being located in Denmark is diminishing. ‘One interesting question here is whether we can find all the qualified people we need in the Copenhagen area, which is problematic’; likewise, ‘it is easier to attract US personnel to North Carolina than to Denmark. It is difficult to attract foreigners to Denmark. High taxes are frightening for most foreigners, and they rarely stay for more than three years’ (as, up to 2011, foreign researchers got tax holidays in Denmark, but this was limited to the first three years[54]).

For the development of products for new markets, local presence is crucial: ‘sitting in Denmark, thinking about what would work for preserving juice from fruits in India may not be the most brilliant thing to do,’ and ‘their [South Africa’s] bread is different and has a different look, which is important to acknowledge while developing our products’ (interview). Still, the company has strong embeddedness in the local environment in Denmark: there is a long tradition for biotechnology in Denmark, and many important players along with their major competitors.

Company III:

This company has been producing the same type of products for centuries and is mainly engaged in developing different tasting varieties. The core of the company’s strategy is to keep its growth of production and market. R&D focuses on products, production processes, packaging and sustainability. One of the core issues is how to keep the products fresh. All R&D activities are centred in the headquarters of the company and have recently been reorganised: ‘Our corporate R&D focus is no longer linked to the supply chain, but to the marketing process and the end customer’ (interview). Products are not changing radically, but a number of alterations and incremental changes take place both in the production process – focusing on making the products last longer, extending the shelf life – and in marketing (targeting other customer groups, e.g. women).

Company III has strong historical ties with two of the largest universities in Denmark, DTU and KU (Life). The company finances seven full-time professors within very specialised research areas. In addition

[54] The three-year period has recently been extended to five years of tax reduction for foreign researchers.

to this there are 40 PhDs and post-docs on their pay-list working at the company: ‘most of them continue their careers elsewhere – and by that constitute a foundation for further research collaboration’ (interview). There is some internationalised research into developing the inputs (barley) in different natural environments in collaboration with local institutions.

Company IV:

This company is a dairy company, which is also engaged in R&D into milk-related ingredients and nutrition. The R&D activities are predominantly market-oriented. Due to short shelf life and market diversity, this company is not engaged globally. However, it has experienced an internationalisation within Europe. The company is embedded in the Danish research environment as many of the research projects involve public funding and university partners. Most knowledge is produced in Denmark. This is explained by the company as: ‘Denmark has a strong tradition for agro-food’ and ‘Danish research in the agro-food sector is very specialised, as knowledge competences at Danish universities are very good, deep and specialised in some specific areas’ (interview). Company IV is also engaged in some basic genome research (of milk!) for which it collaborates with the whole value chain of dairy research in Denmark, from the farmers to the end consumers.

Company IV sources large parts of its specialised R&D: 10–15% of R&D expenditure is used externally, either through co-operation or hands-off sourcing. Co-operation is often carried out in medium- to long-term projects with universities, e.g. by industrial PhDs, or short-term collaborations on specific projects, or with suppliers. At the international level, collaboration happens in relation to very specific R&D activities (IPR always stays in the company): ‘We buy this research or knowledge in universities, where we know there are special instruments or special knowledge competences’ (interview). Internationalisation of R&D is only used as a strategy of moving closer to markets. Consequently, there is considerable down-stream collaboration internationally with customers on potential product development. The company reports a higher level of collaboration today than 10 years ago.

6.3.1 Summary

The four companies represent two different types of internationalisation of R&D. Company I and Company II are both engaged in off-shoring of innovation as a part of a knowledge-augmenting strategy. Companies III and IV are internationalising their markets, not their innovation activities. In the

Table 109, below, the four case companies are listed. As in Table 108, a capital letter indicates a ‘high’ in the three dimensions mentioned above, while a lower-case letter indicates a ‘low’:

Table 109 | Degree of global innovation network in the four case companies

Level of GIN	Global (G/g)	Innovation (I/i)	Network (N/n)
Company I GIN	5 large R&D platforms Europe, US, China	Future oriented, new to the world innovation. 4.3% of turnover into R&D	Development: customers 10% of R&D spending outside the company (universities)
Company II GIN	R&D projects managed globally 10 R&D locations spanning 5 continents	14.3% of turnover into R&D Biotech	Collaborations with companies in China, universities in Bangalore (IIT & IIS) DK universities
Company III giN	Sample collections internationally R&D at headquarters in Denmark	Marketing-driven research Focus on end-customer	Collaboration with University A high number of co-sponsored professors, PhDs and post-docs
Company IV gi/IN	6 R&D centres in Europe	R&D is predominantly market-oriented Some research into milk-genome	Public research funding University partners 10–15% of R&D budget is spent externally

All four companies are strongly embedded in the Danish sectoral innovation system for agro-food. All four have strong relationships with university partners in Denmark as well as with 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, specialised areas (surface-grown enzymes, bio-fuel). Consequently, their innovation activities become geographically spread and localised into specialised units. Their Danish headquarters operate within all the different areas and co-ordinate the process. Two of the companies are engaged in the Agro-Food Science Park: Companies 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 for ice cream, mentioned earlier.

The more high-tech (or biotech), the more global: Companies I and II have strong collaboration and established R&D facilities globally. The companies' networks help companies globalise – 'Our Danish university partners and suppliers help in finding potential international partners for collaboration'

(Company IV). Meanwhile, none of the companies has reduced its innovation activities in Denmark with globalisation, as is also indicated by the two most globally engaged companies in the following citations:

> *'This is not a process in which some locations are overtaking others in the global game. It is a question of being present globally. If a company wants to become a serious supplier or partner, it needs to be present. And you look more serious if you have local R&D.' (Company I)*

> *'The company needs a mix of brains and competencies from around the world, and it can be difficult to attract qualified people to Denmark.' (Company I)*

> *'We believe that the knowledge capital we can get in Denmark generates efficiency and new ways of organising our work practices. As long as this comes out of the Danish system, we feel embedded here.' (Company II)*

> *'We learn a lot from our networks in Denmark. There are many good partners in our clusters in Denmark and at a high international level.' (Company II)*

However, their embeddedness is limited by the extent to which they find relevant partners in the national innovation system:

> *'The more we engaged with diverse markets, the more we needed local solutions for local problems.' (Company II)*

> *'We do not have an urge to collaborate with Danish universities if they are not world-class.' (Company II)*

6.4 Subject 5: Sector embeddedness in GINs

The innovation policy in Denmark is based on establishing industry clusters within strategic areas, of which agro-food constitutes one. Regional Innovation centres, such as the Agro-Food Park, have funding for supporting entrepreneurs and establishing national innovation network facilities. In addition to this, there is a system of technical service institutions offering 'Approved Technological Service' (GTS, Godkendte Teknologiske Serviceinstitutter) for the companies. SMEs receive a financial subsidy for their first-time use of one of the GTS institutes (Christensen 2008:424). By 2008, the Ministry of Science, Technology and Innovation had established 27 innovation networks overall, consisting of companies, regional centres for technology, universities, and GTS. These networks focus on specific areas such as pharmaceuticals, biotech, agriculture, robotics, IT, renewable energy and health (Forsknings- og Innovationsstyrelsen, 2008). In addition to the formal networks, there are networks formed through strong informal institutions. Denmark is a network society, a 'village economy' (Maskell, 2004), and the innovation policies are also built to support, strengthen and develop existing network structures.

The institutional framework obviously impacts the collaborative patterns of R&D activities, as reported by the companies in the survey (see Table 110). 28.6% of the companies collaborate with consultancy companies (such as the GTS) mainly in Denmark. Hence, they are strongly embedded in the institutional framework. However, the most frequent partners in collaboration on R&D and innovation activities are customers and suppliers, again predominantly in Denmark and the rest of Europe. In other words, these companies have a relatively high degree of collaboration in innovation and this collaboration takes place within their established value chains/production networks (see Figure 5).

Table 110 | Collaboration in innovation with external partners (type of collaboration actor and location).

With whom did the company collaborate on innovation over last three years + geographical location of collaborations	% comps using this type of partner	Region	Denmark	N America	S America	W Europe	C & E Europe	Africa	Japan & Australia	Rest of Asia	N
Customers	42.9	2.0	36.7	2.04	2.04	16.3	4.1	2	2	2	21
Suppliers	53.1	6.1	32.7	2.04	2.04	18.4	2.0	2	0	2	26
Competitors	10.2	2.0	4.1	0	0	4.1	0	0	0	0	5
Consultancy companies	28.6	2.0	24.5	0	0	6.1	2.0	0	0	0	14
Government	8.2	0	8.2	0	0	0	0	0	0	0	4
Foreign universities/research labs	4.1	2.0	2.0	0	0	0	0	0	0	0	2
Other	2.0	0	2.0	0	0	0	0	0	0	0	1

INGINEUS Survey 2010.

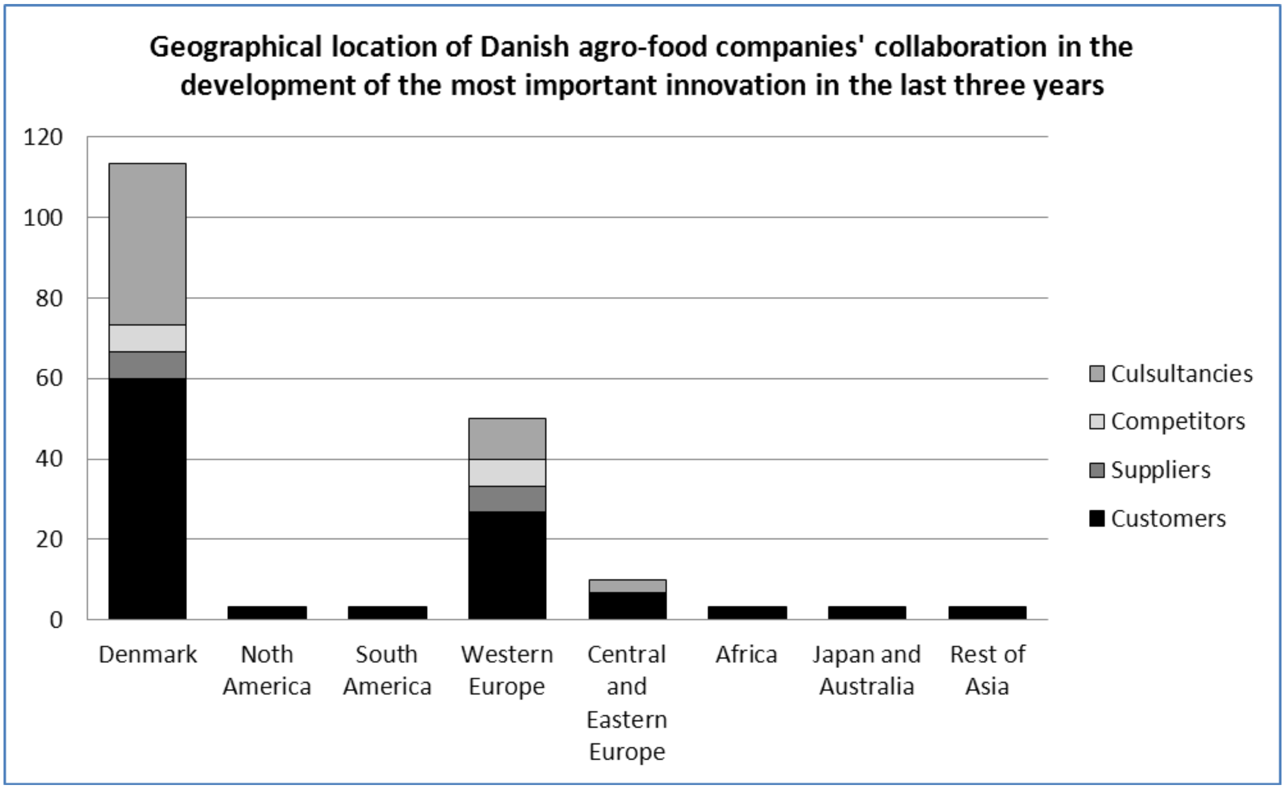

Figure 5. Agro-food collaboration and location of innovation over the last three years

The level of outsourcing and off-shoring is considerable lower and is happening much more within their value chain. Regarding its relationships with customers, Company I expressed the following:

> *'often, customers ask us for a solution to their problems. For example, if they want to reduce the use of polluting chemicals or reduce the use of energy in producing their food-product, we develop a solution that includes ingredients such as enzymes from our company. Sometimes, research is carried out in a joint venture with the customer, and then the customer will get the exclusive right to use it for a period of time. However, if the quantities are very small, this is not an option' (interview).*

Relatively few companies have off-shored production and innovation activities. Only 10 companies have off-shored. This was in order to access specialised knowledge in the host country. The main reason for those engaged in off-shoring was related to innovation, i.e. the availability of specialised knowledge, human resources and knowledge infrastructure (see Figure 6). 60% of the companies off-shoring stated 'availability of specialised knowledge, human resources and knowledge infrastructure' as their main location factor, while the rest of the companies reported access to markets (20%) and local incentives (20%) as the main reason.

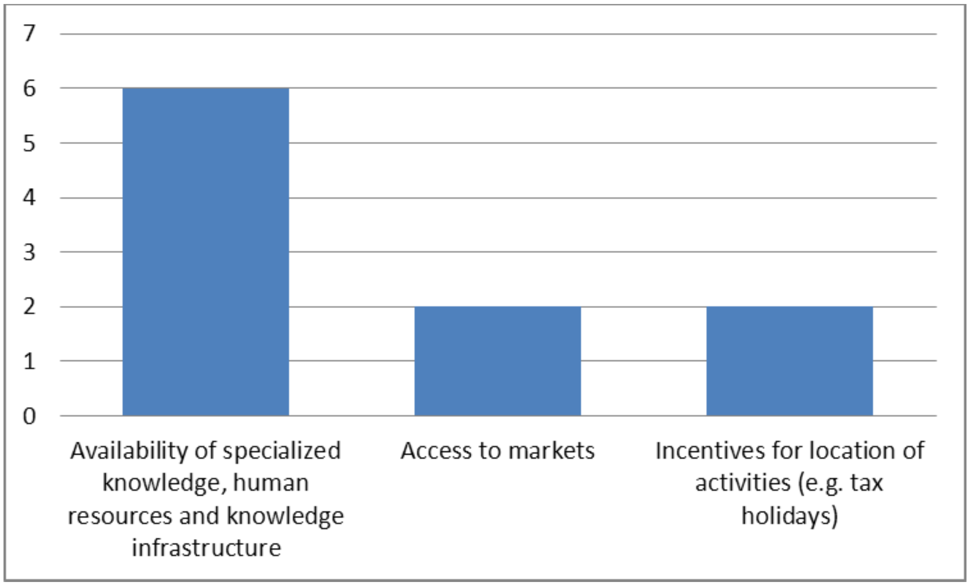

Figure 6. Location factors for off-shoring of production and innovation. INGINEUS Survey 2010.

Availability of knowledge, human resources and host-location knowledge infrastructure are relevant factors for off-shoring, which relates to applying products to local markets. In the agro-food innovation system, one very special feature is that markets have different tastes. Moreover, the companies also kept most R&D in-house. One main reason given by the companies is that this is the only way they can protect their intellectual property rights, particularly in the new locations.

According to the typology of GINs above (Table 109) and the definition by Chaminade (2009), true GINs need to include locations beyond the Triad, have new-to-the-world innovation and involve different actors. This research uncovered the involvement of the case companies in various network constructs. Some parts of the industry are particularly related to development carried out in their already established global production networks. The more specialised and technical knowledge is either generated at their R&D sites or sourced internationally from specialist actors. Either way, this is not necessarily connected to previous locations of subsidiaries. Company IV engages with international actors, through its Danish network, for example to access facilities for testing its products on the human immune system. For this, Company IV uses foreign universities as contract research organisations for codified activities. Company III has changed its R&D focus from basic research to a more market-oriented approach, as expressed by a manager: 'our corporate R&D focus is no longer linked to the supply chain, but to the end-customer.' In this change, most knowledge activities moved back in-house and into the headquarters. Companies I and II are much more embedded in, and reliant on, their GINs.

Company II gave the example of collaboration in research in its development of emulators:

'This is about how to bind oil and water in products, and at some point we get down to a level where we do pure chemistry. Therefore, we need very specialised people who can work at the molecular level. For that, we need highly educated experts who can separate molecules from nature and create new raw materials… We need people in biotechnology and therefore we collaborate to a high degree with people from universities' (interview).

The same company explained its collaboration in development with customers:

'This company develops recipes for the customers. The recipe is actually the most difficult part to develop. This is done in collaboration with the particular customer. After that process, it is just like following a cooking recipe – but with our particular ingredients' (interview).

Company I explained that Bangalore in India is a very good location, as there are many qualified people: 'IIT and IIS are very prestigious in this area and have world-class research. It is easier to tap into these knowledge resources if you have a local presence' (interview). There are two sets of strategies behind the engagement of Company I in foreign universities: head-hunting and networking – these are often combined as new employees bring about new local networks. As was the case in Company II, Company I also engages in outsourcing for certain codified, very technical tasks, for example, complex molecular modeling.

From the survey (see Table 111 and Table 112), it can also be seen that this sector in general is less embedded in GINs than is the case in the large companies constituting the case companies. The vast majority of companies in the Danish agro-food industry are not collaborating much, and those that do, collaborate with suppliers. Part of the explanation to this may lie in the difficulties companies face in internationalising and communicating beyond borders.

Table 111 | Relations abroad.

Formal and informal relations abroad	Formal	Informal	No
Customers	9%	9%	82%
Suppliers	20%	20%	60%
Competitors	4%	4%	92%
Consultancy companies	9%	9%	82%
Public sector	4%	0	96%
Foreign universities and research labs	0	9%	91%

INGINEUS Survey 2010.

Another explanation could be that a large part of this industry has a low pervasiveness and targets relatively local markets. Producing meat, milk and bread products is often a business for a market within a relatively close geographical proximity. By contrast, those companies in this industry that increasingly engage with biotechnology have products with higher pervasiveness, such as enzymes that can apply to a range of products and across locations. These companies are more likely to globalise by following their customers, i.e. lead firms in the global food industry.

6.4.1 Summary:

There is a strong sector embeddedness in this sectoral innovation system. Few companies engage in true GINs, and those that do are the large biotech-related companies.

6.5 Subject 6: Co-ordinating and communicating in GINs

It is difficult for the companies to engage internationally. As the national networks appear very strong, the embeddedness in the Danish system could be part of an explanation. This is mirrored in the survey, in which many companies reported ‘overcoming organisational barriers’, ‘changing the current location and related costs’ and ‘managing globally dispersed projects’ as the most important barriers to international innovation collaboration (see Table 112).

Table 112 | Factors representing a challenge or barrier to international innovation collaboration.

Answer Options	Extreme barrier	Serious barrier	Moderate barrier	Small barrier	Not a barrier
Finding relevant new knowledge	0	5	8	5	8
Overcoming organisational barriers	3	6	9	4	5
Changing the current location and related costs	1	4	11	3	4
Managing globally dispersed projects	1	9	7	1	5
Harmonising tools, processes etc.	0	7	9	3	4

INGINEUS Survey 2010.

The case companies have developed different ways of dealing with the co-ordination and communication in their different types of GINs. Companies I and II, as those mostly engaged in GINs, have both developed their own electronic IT system which facilitates communication across locations. These contain electronic notebooks and search machines for researchers to be able to follow other sites' research results. Still, both these companies report a limit to globalisation: 'every time we get a new site, communication gets more complicated' (interview, Company I). Company II has gone so far as to close down some of the smaller R&D sites in order to maintain a critical mass in researchers at its sites. Along with this strategy, the company has established an innovation communication committee to steer radical innovation centrally, as stated by a manager: 'this ensures that we have the same structure and project management across research centers' (interview, Company II). Along with the committee, the company has a search machine for identifying people by their competencies. This machine makes it possible to identify people across the company within certain specialised areas. Company I has a similar approach: 'The company has the intention of becoming global, but not of being everywhere' (Company I).

Research projects in Company I are generated across sites. While presenting one of their current core research areas a representative of the company stated: 'This project group consists of researchers from the facilities in the US, Japan, Denmark and China – and, to a small extent, India. Five geographical sites are simultaneously working on the same assignment. The group has the critical mass of people and cultural backgrounds that are seen as necessary for success' (interview, Company I). Part of the strategy behind this type of organising is to engage in the markets of future products, as this product does not yet have an established market. One of the problems of an international innovation model is company culture. It is indeed difficult for Danish companies to export 'the Scandinavian model' to other contexts: 'in India, failure is something that cannot be forgiven – but for us, innovation implies constant failures and mistakes. What we cannot forgive is having people doing nothing' (Company I).

For the two other companies, the strategies are slightly different, as they tend to focus on markets for innovation: 'we know where our core competencies are. We know our expertise and we do not need to expand it. Therefore, it is important to link into existing competencies elsewhere' (interview, Company III).

6.6 Subject 7: Prospective, impact from crisis

Our results show little impact of the current financial crisis. None of the companies intends to relocate production or innovation, 14% of the companies are considering increasing innovation, while approximately 10% of the companies in the survey are considering reducing innovation activities (see Table 113).

Table 113 |

How has the enterprise reacted to the current global economic crisis?	Response Percent
Few or no changes	75.0%
Increasing effort at innovation on our part	14.3%
A serious reduction of innovative activities	10.7%
Relocation abroad of innovative activities	0
Relocation of innovative activities to company from abroad	0

. INGINEUS Survey

The same picture was found in the case companies, all of which reported increased R&D spending. For Companies I and II, this is likely to be situated outside Denmark (interviews). One of the companies that is currently not collaborating much (Company IV) explained that 'the future will bring more long-term and dense collaborations rather than the current ad-hoc research collaborations' (interview). 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.

6.7 Subject 8: Looking forward, implications for policy

Implications for policy relates to all of the above. Companies expressed a need for more support for linking national clusters into international networks. As strong as these networks are in the Danish context, they are still difficult to expand at the global level. The perceived risks overshadow the benefits for these companies. Moreover, there is a need to generate attractiveness for foreign companies to invest in R&D in Denmark. This is a huge challenge: how to keep the position as a 'hub' within agro-food. The companies expressed difficulties in attracting foreign knowledge workers to Denmark. As was expressed in the cases above, it is a lot easier to attract the right people to other locations (e.g. the US, the UK, China, Japan). Moreover, some of the companies mentioned that they have difficulties in internationalising their research if this research involves public funding, as this is nationally bound to some extent. Table 114 reports the different needs for improvements of innovation activities, as posted by companies.

Table 114 | Companies' need for improvements for future activities.

Need for improvement for future innovation activities	Very high need	Moderately high need	Moderately low need	Very low need	Factor not needed
Practical support from centres for the internationalisation of innovation and technology transfer	4%	33%	21%	4%	38%
More public incentives and economic support	13%	21%	25%	8%	33%
Better access to international research networks	13%	17%	17%	13%	42%
Higher skills in the labour force	8%	29%	29%	17%	17%
More stringent regulations, practice and jurisprudence around intellectual property rights	13%	0	21%	8%	58%
Better and clearer rules regarding foreign direct investment and trade	0	29%	13%	4%	54%

More open and flexible migration policy regulations for employing foreign scientists/technicians/experts	0	13%	8%	13%	67%
Greater availability of risk capital for innovation activities with an international dimension	13%	8%	21%	13%	46%

INGINEUS Survey 2010.

According to the survey results in Table 114, companies in the Danish agro-food innovation system call for higher skills in the labour force as the most important area for improvement in Denmark. This contrasts with some of the finding earlier in this paper, that Denmark has highly qualified human capital within agro-food, but indicates their expectations for the future. Innovation is increasingly becoming a determining factor of competitiveness in the sector at the international level; hence, in order to keep up, developing the relevant skills is of major importance.

Two thirds of the companies reported some need for more public incentives and economic and practical support from centres for the internationalisation of innovation and technology transfer. This indicates that the companies are aware of the need to internationalise innovation; however, they are not able to go through this on their own, and they are not able to cover the risks without some publicly funded safety net. This is clearly based on the fact that these companies are predominantly SMEs with little access to risk capital, and need to cover investments within a relatively short time period.

A majority of the companies reported that they need better access to international networks. The means of these companies to get access is often through national research institutions – if not by pure luck. Mostly, actors in their networks at home refer companies to relevant partners abroad for specialised tasks. Hence, this relates to the internationalisation of research institutions and universities. This is crucial for the companies in the innovation system to be able to link into innovation networks that are not connected to their previous international networks, such as global production networks or suppliers.

6.7.1 Summary:

Currently, innovation policies related to the agro-food industry support national and local clusters and networks. This is a very strong asset for the Danish actors in this industry. Meanwhile, there is little support into the internationalisation of innovation in the industry. Companies have difficulties in accessing capital for innovation activities with an international dimension. Besides, some companies expressed a need to develop skills at home.

Conclusion

Agro-food has played a central role in the industrialisation and internationalisation of the Danish economy. Denmark was traditionally an agrarian society, which has developed into a more knowledge-based economy. Also, the agro-food innovation system developed from the traditional agrarian economy. Although this industry engages in research and innovation networks at home, these are, for the majority of the companies, limited to national actors. When it comes to market, however, the industry is highly internationalised and the majority of the companies, regardless of their size, export products predominantly within Europe. This is due to the attributes agro-food has on markets, namely local tastes etc., which are more similar within Europe than abroad.

There is a recent tendency to engage in global innovation networks, at least to some degree, among the large-scale companies. Since these predominantly include larger companies, and their activities are spread primarily within Europe, it is interesting to see whether this is a process that will spread into other actors in the Danish agro-food innovation system by centrifugal forces. This is the case for the majority of the companies in this industry.

In addition to this, there are some biotech-related companies that are reorganising their innovation activities at the global level. This is partly because of their high level of investments in innovation and the relatively small domestic market. These companies are increasingly specialised within certain niche products (enzymes, genomes, ingredients) that require knowledge-intensive investments. This necessarily links to the need to sell products in a larger market. Customers are also a very important factor for location of innovation. For some companies, globalisation is determined by their lead customers' globalisation of their markets (e.g. if they are the lead suppliers to companies such as Coca-Cola, Nestlé, Danone). If the Danish suppliers of ingredients want to maintain their position as core suppliers, they have to follow.

The drivers of internationalisation of R&D differ: for some products, the driving force is access to markets, i.e. exploiting innovation in the international market by smaller alterations in taste and texture (development); for others, the driving force relates to accessing knowledge that is not readily available to the company – supplementary knowledge in new, specialised locations. The result is two different modes of GIN formation in the Danish agro-food industry, according to the company type. The large-scale companies with innovation within biotechnology have developed into strong players in global innovation networks. These networks include actors from their value chains and also actors in research institutions and universities at home as well as abroad. Their engagement in these networks has certain spillover into the Danish institutions for food research, and the numbers of international publications, and publications with international co-authorship, are higher than OECD average.

Hence, one of the consequences of these large biotech companies' engagements in new configurations of innovation networks beyond the home and region are that other actors, such as local universities and consultancy firms, also internationalise their activities. As these institutions also collaborate with those companies that are not engaged in global innovation networks – i.e. the majority of this industry – there is likely to be some spillover in terms of knowledge. Our results also show that these, the least networked, companies are very much aware of the need for internationalisation but do not have the investments or courage to engage in these on their own.

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7 ANNEX 7: INTERRIM REPORT COUNTRY SECTOR REPORT AGRO SOUTH AFRICA

GIBS

Agroprocessing report for WP 9

South Africa

Tashmia Ismail and Helena Barnard

3/30/2011

Agroprocessing

Introduction

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 agri-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).

Methodology:

This report is based on the findings of two surveys. The first is the South African Innovation Survey (SAIS) which was conducted in 2005. The second and more recent survey, is the INGINEUS survey. In addition to the survey, case studies of three large multinational firms, South African Breweries, Danone and Novozymes were prepared.

A total of 2 627 enterprises were interviewed for the SA Innovation Survey in 2005. The results of the survey were extrapolated to the target business population of 31 456 enterprises based on the weights of 120 strata (Blankley and Moses, 2005). Of this national sample there were 1 628 domestic and 10 foreign agrofood processing firms involved in the manufacturing and processing of food. If we consider the estimate of 4000 agroprocessing firms as the population, the SAIS surveyed approximately 41% of the population.

The second set of results discussed in this report are based on the on the INGINEUS Agroprocessing sector survey which was conducted in South Africa early in 2010. The SA agro survey contributed 83 responses to the 1215 responses collected in the total INGINEUS survey which covered 3 sectors (Automotive, Agro processing and ICT). The sample was dominated by ICT firms, with the largest numbers of firm responses coming from the ICT sectors of India and China.

The SA survey was conducted in the agroprocessing sector which included the subsectors as outlined in figure 1 below.

Figure 1 | description of agro processing sub sectors covered by the INGINEUS survey

101	Processing and preserving of meat and production of meat products
102	Processing and preserving of fish, crustaceans and molluscs
103	Processing and preserving of fruit and vegetables
104	Manufacture of vegetable and animal oils and fats
105	Manufacture of dairy products
106	Manufacture of grain mill products, starches and starch products
107	Manufacture of bakery and farinaceous products
108	Manufacture of other food products
109	Manufacture of prepared animal feeds

The project was run as follows:

1. Databases were identified
2. An online survey tool was set up with an e-mail link facility.
3. Each contact (minus repetitions) on the database was called, given a description of the survey and its relevance and asked to participate.
4. The persons contacted who agreed to participate were then sent the survey link electronically.
5. Those contacts who agreed to participate but who failed to submit their survey responses were contacted again two weeks later. If they failed to respond to this reminder a final reminder was sent again 2 weeks later.

The Experian database had not been updated therefore many of the contacts were redundant. From the 1096 firms listed only 325 were contactable and agreed to have the survey mailed to them.

In order to raise the sample size several other sources were used to construct an additional composite database in order to raise the number of respondents. A further 24 responses were elicited with this approach. The paragraph below outlines phased approach used to to elicit the 83 responses which make up our sample.

Phased survey approach

Phase 1: The first database procured was the Experian database. **Experian** is a global information services company; they provide data and analytical tools to clients in more than 90 countries. They assist businesses in managing credit risk, preventing fraud, with target marketing offers and with automated decision making. They also help individuals to check their credit report and credit score as well as protect against identity theft.

This database consisted of 1096 firms, the distribution in terms of the sizes of the firms is contained in figure 2 below. The figure also shows this distribution as compared with the SARS database which is representative of the population of firms in the agro sector. **The Experian database is skewed towards larger firm sizes when compared against the population of agroprocessing firms.**

Phase 2: Absolute value of responses was deemed too low therefore a database was constructed using several other data sources.

Phase 3: In the constructed database all repeats from the previous database were excluded. The decision was also taken to eliminate all resellers of agro-processed products.

Phase 4: 172 additional firms were called and contacts made which gave permission for the survey to be sent to them. This garnered 24 additional responses bringing the total number of responses for the phased approach to 83 from 497 surveys sent out.

The response rate for the Agroprocessing INGINEUS survey was 16,7%.

Table 115| Experian database size of firms by employee number

Number of Employees	Experian Employees	Experian % of Companies (out of 1096)	SARS Employees	SARS %of Companies (out of 8506)
0	14	1,28	3842	45,17
Fewer than 10	162	14,78	2538	29,84
10-49	490	44,71	1543	18,14
50-249	309	28,19	443	5,21
250-999	94	8,58	89	1,05
1000-2999	14	1,28	29	0,34
3000-5999	6	0,55	9	0,11
More than 6000	7	0,64	13	0,15
Total Companies	1096	100	8506	100

Table 116| Databases used and responses received from each

Database	Sent	Responded
Experian	325	59
W. Cape	63	7
Tradepage	6	2

Search ZA Directory	17	5
Go Organics	25	8
Foodworld Directory.com	61	2
Total	497	83
Response rate 17%		

7.1 Subject 1: The present nature of sector activities in your country

Due in part to its history, we find that in the formal economy of South Africa, the agro sector is dominated by large scale commercial producers who feed raw material into the agroprocessing industry. When apartheid ended in 1994, decades of discriminatory legislation had left 87 percent of South Africa's farm land in the hands of its 13 percent white population. This resulted in a consolidation of the agro industry. 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 agri-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).

In order to put the size of the industry into context, we can compare it to Malaysia. The agri sector located in Gauteng is similar in size to the food processing industry in the whole of Malaysia. There are approximately 4 000 food processing companies currently operating in South Africa, of which roughly half are based in Gauteng. These companies employ around 50 000 of the estimated 183 000 people working in the sector. Table 117 below lists some of the large agroprocessing firms located in Gauteng province (DTI, 2010).

The competitive trade areas which are being explored nationally include: organics, essential oils, packaging, floriculture, trade in medicinal plants, natural remedies and health foods. Since these areas are classified as ’competitive’, and for ’trade’ we can expect for innovative activities to be present in the development of these products and for global best practice knowledge to flow into this particular section of the industry .

Global best practice also finds it’s way into the agroprocessing industry though large agroprocessing multinationals.The table below lists some of the large foreign owned agroprocessing firms operating in South Africa. All of the companies listed below have subsidiaries across the globe and act as conduits for information exchange across these multiple locations.

Table 117 | List of large agroprocessing firms in SA

Company	Country	Industries
Unilever	Netherlands	Processed foods
Coca-Cola	USA	Beverages
Parmalat	Italy	Dairy, beverages
Nestlé	Switzerland	Processed foods
Danone	France	Dairy
Kellogg	USA	Cereals, processed foods
HJ Heinz	USA	Processed foods
Pillsbury	USA	Beverages
Virgin Cola	UK	Beverages
Cadbury-Schweppes	UK	Processed foods, beverages
Minute Maid	US	Beverages
McCain Foods	Canada	Processed foods
Dole	USA	Fruit and vegetables
Del Monte	USA	Fruit and vegetables

Catmark	France	Fruit and vegetables
South African Breweries	UK	Beverages
Bulmers	UK	Beverages

http://www.dti.gov.za/publications/agroprocessing.htm#overview

The Agro processing sector is a diverse industry which involves multiple value chains. Because the growing of crops is a climate and a geographically dependant activity, we find that the agroprocessing industry has an attachment to physical locations. Produce harvested must be transported from these geographies into markets where they can be consumed, processed or exported into international markets.

A further critical consideration in the agroprocessing industry involves the perishability of the product. In order to prevent the produce from perishing it must be transported and sold quickly or processed to give the produce longevity. Because perishability is an issue it becomes important to locate the plant and process as close as possible to the supply of the raw produce.

The passages above highlight that the agroprocessing industry is heavily tied to the physical. Processing often involves capital expenditure on property, plant and equipment.

Another consideration when studying innovation activities in the agroprocessing sectoris that food products must also conform to many regulatory and legislative requirements because of the potential health impacts of ingestable goods. This means that the agrofood 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.

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.

Multinationals in this sector place 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.

Danish multinational, Novozymes, is one such supplier of specialised goods which are enzymes, for use in multiple agroprocessing 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 withstatd the higher temperatures of African summers. Novozymes conduct their R&D in India, China, Denmark and the USA. The Johannesburg office is largely focussed on sales into SA and Sub Saharan Africa.

The paragraphs above allow us to make some comparisons between the sectors covered in this study. Agroprocessing differs from the ICT industry where the tradeable good is often virtual. ICT is able to operate very loosely from institutions like ’regime 2’ which are not networked into or dependant on the local context (described in depth in the ICT report). The physicality of the agroprocessing sector and the strict compliance with institutions and their regulation mean that this ’regime 2’ type of arrangement is far less likely in the agro sector. The automotive industry is also tied to tangible goods such as car parts, here however the issue of perishability is of no concern.

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.

To understand how much innovation happens we can examine the results of the SAIS (2005). A breakdown of the SAIS agroprocessing firms into innovative and non-innovative firms shows that there are about 434 domestic innovative agroprocessing firms (27%). This is less than the national average of 50% of domestic firms from across all sectors. All 10 foreign firms surveyed were shown to be innovative (Table 118). Table 119 shows the INGINEUS (2010) survey results where 44% of firms confirmed R&D activity. As explained in the methodology section, the INGINEUS database was populated by a higher number of large firms than found in the population of agroprocessing firms in the country; this may in part explain the higher percentage of firms confirming R&D activity.

Table 118| Innovative and non-innovative agro food processing firms

	Innovative	Non-innovative	Total
Domestic	434	1 194	**1 628**
Foreign	10	0	**10**

Source: SAIS (2005)

Table 119| INGINEUS responses R&D activity

	Percentage of total responses	Number of firms
Yes	44.3%	27
No	55.7%	34

Source: INGINEUS (2010)

Whether or not a firm is standalone or part of a larger group will impact the networks and information sharing which the firm can tap into in order to innovate. SAIS (2005) showed about 30% of the domestic innovative firms reported themselves to be part of a larger group whereas all of the foreign firms were part of a larger group. Of the 63 firms which answered the INGINEUS questionnaire (Table 121), 77. 8% were standalone, 22.2% were MNC subsidiaries but none were MNC headquarters.

Table 120 | Part of a larger group

	Yes	No
Domestic	129 (30%)	305(70%)
Foreign	10 (100%)	0

Source: SAIS (2005)

Table 121 | INGINEUS organisational structure of firms

A standalone company?	77.8%	49
A subsidiary of a MNC?	22.2%	14
The headquarters of a MNC?	0.0%	0

Source: INGINEUS (2010)

In terms of **size**, measured by the number of employees INGINEUS (2010) results showed that:

-17.5% of the firm responses came from very large firms with over 1000 employees.

-the sample was dominated by firms with between 10 to 49 employees (18 firms making up 28% of the sample)

Table 122| Size of INGINEUS firms

3.1.1 Fewer than 10 FTE employees	12.7%	8
10 to 49 employees	28.6%	18
50 to 249 employees	20.6%	13
250 to 999 employees	20.6%	13
1000 or more employees	17.5%	11

Source: INGINEUS (2010)

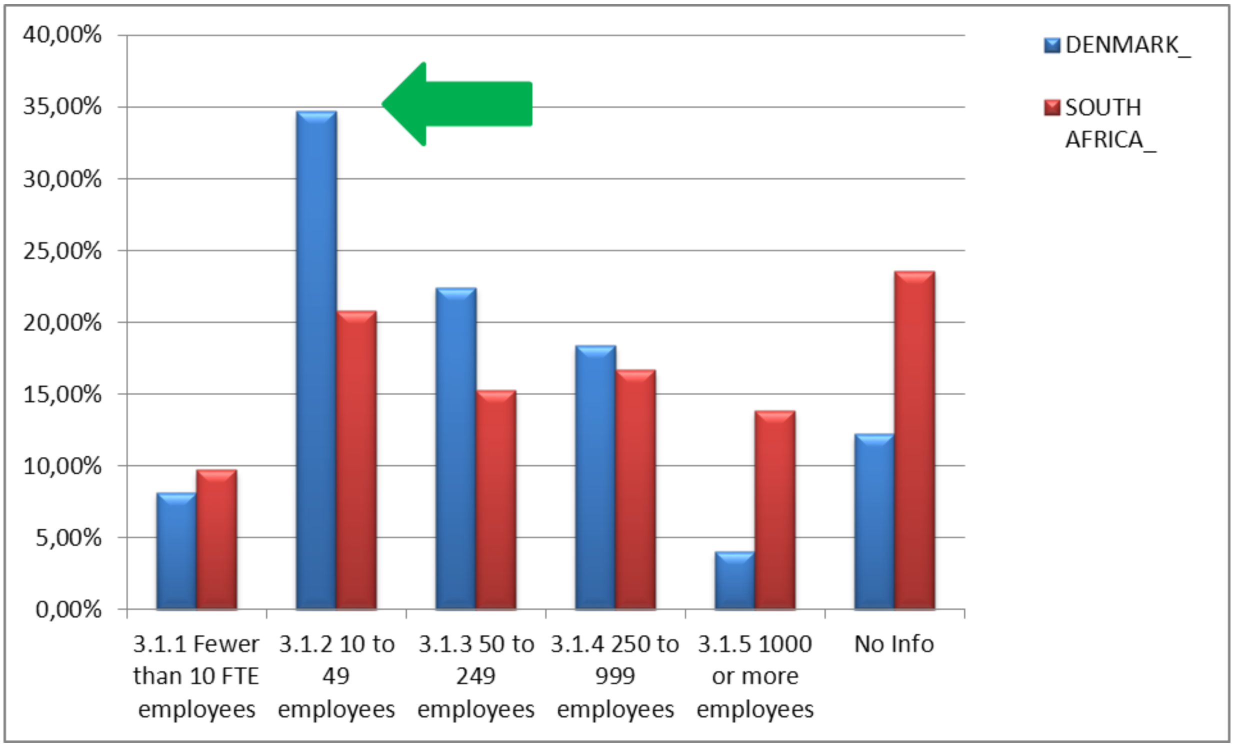


Figure 2: Comparison of firm size between Denmark and SA

Source: INGINEUS

The agrofood processing sector turnover was about R41 billion in 2004. This represents about 4.1% of the total turnover of the firms in the SAIS survey. Innovative agrofood processing firms alone contributed over 3.05% towards the total turnover while non-innovative agrofood processing firms contributed about 3.6%. The total turnover of both domestic and foreign agrofood processing firms is presented in Table 123 below.

Table 123 | Turnover of firms in the agroprocessing (R Millions)

	Domestic	Foreign
Non-innovative	R12 227	R0
Innovative	R29 668	R5 298

Source: SAIS (2005)

Agrofood processing firms spent about 1% of their turnover on innovation activities. About R 410 million was spent on internal R&D, external R&D, acquisition of machinery and acquisition of knowledge.

Table 124 | Agroprocessing expenditure on R&D (R Millions)

	Internal	External	Machine	Knowledge	Total
Domestic	R 105	R 4	R 246	R 22	R 377
Foreign	R 16	R 0.41	R 16	R 0.31	R 32
Total	R 121	R 4	R 262	R 22	R 410

Source: SAIS (2005)

Earlier in this section the importance of export markets in innovation activity was explained. The high international standards which firms must comply with in order to access foreign markets drives firms to innovate to meet these expectations. It is therefore important to note that the majority of firms surveyed in INGINEUS (2010) or 71% (44) had no sales activity abroad whilst 29% of firms had sales activity abroad.

If we look at Table 125 below, only 22.2% of the INGINEUS firms surveyed sold into export markets. Most firms (77%) sold within South Africa's borders. The INGINEUS results are corroborated by the SAIS results (Table 126 below), here 75% of firms sell within SA with 21% of firms selling into export markets.

For the INGINEUS firms the 3 most important destinations in terms of sales (Table 127 below) were in order, Western Europe, Africa and Central and Eastern Europe. SAIS shows Africa and Europe as the biggest export destinations. Understanding the level of international engagement is an important precursor to the establishment of GINS.

Table 125 | Agro enterprises market

4.1.1 Internal to your enterprise	0.0%	0
4.1.2 A regional market (local region in your country)	19.0%	12
4.1.3 Domestic market (rest of your country)	58.7%	37
4.1.4 An export market	22.2%	14

Source INGINEUS (2010)

Table 126 | Participation in markets: innovative firms

Market	Number of firms	Percentage
South Africa (Provinces)	133	0,3
South Africa (National)	199	0,45
Rest of Africa	31	0,07
Europe	21	0,05
United states	10	0,02
Asia	12	0,03
Other countries	17	0,04

Source: SAIS (2005)

Table 127 | INGINEUS survey important export markets

4.2.1 North America	32.0%	8
4.2.2 South America	12.0%	3
4.2.3 Western Europe	52.0%	13
4.2.4 Central and Eastern Europe	36.0%	9
4.2.5 Africa	44.0%	11

4.2.6 Japan & Australasia	8.0%	2
4.2.7 Rest of Asia	16.0%	4
4.2.8 Rest of the world (developing)	20.0%	5

Source: SAIS (2005)

Summary

In terms of numbers the majority of firms in the agroprocessing 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 were subsidiaries of multinationals, 17% of the firms were over 1000 employees and 21% of firms had between 250 and 999 employees. The SAIS (2005) survey shows us 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 were non innovative. Therefore the size and international focus of the firm will likely have important implications for GIN formation.

7.2 Subject 2: The nature of innovation in the sector

The Agro processing sector is a diverse industry which involves multiple value chains and multiple market types, we can therefore expect to find innovation in a range of places along this value chain. 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 occuring. The four by four model below captures the possibilities for a firm’s activities in the agroprocessing sector. Innovation in each quadrant is influenced more strongly by certain factors and less by others.

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 therfore 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 agroprocessing industry which has managed to compete in more developed international markets like the EU.

Products going to the EU would have to match or supercede 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 flavourings, nutrition and increasing the natural content of products especially in markets where health is valued such as the EU.

South African firms find it difficult to export processed product into the EU which protects its markets with tariffs and trade barriers. As SA’s trading links with China grow we expect to see pioneering SA firms entering this market as Chinese food production increasingly fails to meet the local demand which sees China importing food from global destinations.

International market & fresh product: This group of firms are driven by similar considerations as mentioned above 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.

Figure 3

	Local	International
Processed	Canned goods, beverages Dairies e.g. Clover, Danone Manufactured products: Capital/machine intensive Innovation more incremental on plant processes However also innovation in: biochem for e.g. flavour, capturing vitamins or fortifying, preserving, packaging Products incl. cereals, packet soups, health bars, yoghurts etc	Most demanding market International institutions require: - very high health and safety -exacting standards -perfect quality
Fresh	Fresh fruit Demand side-desire for fresh produce by consumers stimulates innovation Good logistics and transport capability necessary to deliver fresh produce successfully	e.g. Sudays River, Delmonte Export fruit to EU chains like Tesco's therefore we see Strong institutional effects on exacting standards encourage innovation in: -quality of fruit, -in the preserving process -storage/ transport (so it lasts the journey)

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. In areas such as

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. There are certain factors inherent in the nature of the agroprocesing industry which drive the innovation activity.

One of the most important factors is that the growing of crops is a climate and a geographically dependant activity, we find that the agroprocessing industry is ’attached’ to physical locations because of this. Produce harvested must be transported from these geographies into markets where they can be consumed, processed or exported into international markets.

A further critical consideration in the agroprocessing industry involves the perishability of the product. In order to prevent the produce from perishing it must be transported and sold quickly or processed to give the produce longevity. Sophisticated cold chains, supply chains, fleet management and transport logistics are examples of the areas firms must build competencies in. South African chain store Woolworths partly built its competitive advantage with an innovative cold chain design which ensures that their produce is always fresh. Because perishability is an issue it becomes important to locate the plant and process as close as possible to the supply of the raw produce. and Innovation activity can also be expected to involve processes which prolong the life of the produce.

The above factors highlight that the agroprocessing industry is bound to the physical in terms of geography, produce and the type of bulky manufacturing equipment the sector requires. Barriers to entry are significant with processing often involving high capital expenditure on property, plant and equipment.

For the reasons described above we observe that a large part of innovation in the sector can be divided roughly into two main areas:

1. logistical and transport and 2. preserving and processing.

Table below shows the results of Q6 which asks firms if they have innovated in the past three years (2006 to 2008). The results show that a large number of responses, 82, were recorded for the ’New or significantly improved methods of manufacturing or producing’, ’New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services’ and ’New or significantly improved supporting activities for your processes’. Even though a large number of innovations were recorded in total, most innovations fell into the “new to the firm” category while the “new to the world” category attracted the least number of responses.

The table below on responses to Q6 also shows a significant number of responses for innovation in ’New products’. This may be explained by the highly competitive food retail sector where customers are faced with multiple brands and choices of for example cereal, peanut butter and chocolate. Brands often introduce new products to sway customers’ brand preference and capture a greater market share. This stiff competition forces firms to continuously innovate around new products.

SAIS (2005) data confirms the INGINEUS findings around new products. An estimated 70% of domestic innovative firms in the agrofood processing sector have introduced new or improved goods; this is compared to about 80% of the foreign innovative firms that introduced new or improved goods. On the other hand, very few domestic firms, about 9%, introduced new or improved processes compared to 100% of foreign firms.

Table 128| Innovation activities (SAIS 2005)

	New or improved goods		New or improved process	
	Domestic	Foreign	Domestic	Foreign
Number of firms that introduced new product/processes	303	8	37	10
Innovative firms in agroprocessing	434	10	434	10
Percentage of innovative	0,7	0,8	0,09	1

agrofood processing firms that introduced new products/processes

Source: SAIS (2005)

In addition to new products, brands, especially multinational brands in this sector, place great emphasis on the protection of their brand reputation demanding consistency in their supply and often have 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) we see a pattern of large scale producers and specialised suppliers dominating the landscape.

Danish multinational, Novozymes, is one such supplier of specialised goods, to be more specific, enzymes, for use in multiple agroprocessing formulations and processes. R&D for Novozymes is however not carried out in South Africa. Some innovation does take place in Johannesburg, this is largely to localise the offerings for African markets, where for example the quality of flour used in the baking process is of a different quality. 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 focussed on sales into SA and Sub Saharan Africa.

Another important consideration when studying innovation activities in the agroprocessing sector is that food products must conform to many regulatory and legislative requirements because of the potential public health impacts of ingestable goods. This means that the agrofood 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. This means that firms need to build strong local networks and exchange information with governing bodies. The product in agroprocessing is seen by the consumer and many firms are in the public eye. This forces firms to be cautious in their operations as damage from a public relations point of view could have a very negative impact on the brand. This may be a factor in the level of innovation activity in this sector as compared to ICT and Auto.

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.

The paragraphs above allow us to make some comparisons between the sectors covered in this study. Agroprocessing differs from the ICT industry where the tradeable good is often virtual. ICT is able to operate very loosely from institutions like ’regime 2’ which are not networked into or dependant on the local context (described in depth in the ICT report). The physicality of the agroprocessing sector and the strict compliance with institutions and their regulation mean that this ’regime 2’ type of arrangement is far less likely in the agro sector. The automotive industry is also tied to tangible goods such as car parts, here however the issue of perishability is of no concern.

Table 129| innovation activity (INGINEUS Q6)

	New to the world	New to the industry	New to the firm	None	Response Count
6.1 New products	15.0% (9)	41.7% (25)	53.3% (32)	15.0% (9)	60
6.2 New services	2.0% (1)	16.0% (8)	50.0% (25)	40.0% (20)	50
6.3 New or significantly improved methods of manufacturing or producing	7.0% (4)	26.3% (15)	64.9% (37)	21.1% (12)	57
6.4 New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services	3.8% (2)	17.0% (9)	64.2% (34)	30.2% (16)	53
6.5 New or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems etc.)	5.5% (3)	9.1% (5)	70.9% (39)	25.5% (14)	55

In the INGINEUS survey 40% of firms produced their technological inputs in- house; this appears to be the most common form of knowledge sourcing.

Table 130 | Sources of knowledge (ING, 2010)

5.1 We produce most technological inputs in-house	40.0%	22
5.2 We buy most of our inputs from other branches of our own MNC	10.9%	6
5.3 We buy most of our technological inputs from non-MNC firms	18.2%	10
5.4 We buy most of our inputs from MNCs with which we are not formally connected	16.4%	9
5.5 We buy most of our inputs from public-sector organizations, e.g. research institutes, universities etc.	14.5%	8

Summary

Innovation in the agroprocessing industry is partly demand driven from 1) multinationals with strict requirements necessary 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.

This sector is also characterised 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.

7.3 Subject 3: The nature of knowledge

The agro sector has three distinct groupings of firms.

Group 1: This group includes the low skill, labour intensive sections of the industry which are largely traditional, hierarchical and often family owned. Examples include commercial farming activities which flow into less technologically sophisticated processes such as canning and juicing. Little opportunity for GIN formation is found here.

Group 2: The second grouping of firms in this sector are technologically advanced, large , and are responsible for a substantial part of the turnover in the agroprocessing sector. They often have a head office in an urban centre and multiple plants in different areas of the country to gain proximity to supplies of inputs. These firms often have large manufacturing capacity which they utilise to produce high volumes of branded goods which they sell to the end consumer through retail chains, ’mom and pop’ stores and ’spaza’s in the informal sector.

To make themselves more efficient, competitive and safe, these firms buy or build in house technologies. Often technologies are borrowed from other sectors and incorporated into the agroprocessing value chain. Examples are the advanced IT systems which certain dairies use to monitor and manage the dairy cows' health and milk production.

Global giants such as Nestle and Pepsico (Frito-Lay) have well developed inhouse R&D but also buy technology and the R&D outputs of other large multinationals such as BASF and Novozymes. The latter companies specialise in additives and complex molecules of active ingredients, such as a range of enzymes, nutritional complexes and preservatives to prolong the life or add flavour to the end product. The group of foreign multinationals do not have any of their main R&D sites located in the country. A shortage of engineers and biochemists, the high cost of labour and a small market disqualified SA.

An example of this type of relationship is Novozymes, who work closely with their clients such as Nestle and SAB in order meet the changing requirements of these multinationals. The INGINEUS data shows this type of client collaboration to be the most common form of collaboration in the survey (see figure 3 below).

Novozymes, despite having a strategy of expansion into the larger markets of Africa, did not see R&D ever moving from the main centres in the USA, Denmark, China and India. Strong communication channels were maintained with the head office in Denmark and employees regularly travelled between Denmark, South Africa and into other African states such as Nigeria. Research on the market needs in Africa were fed back to head office where R&D to meet those needs is undertaken. The SA office in Johannesburg employs two bio technicians in the small onsite laboratory. Novozymes have streamlined finance and IT operations to sites in India which manage these functions for subsidiaries across the globe through the web and e-mail. This was done to take advantage of the IT expertise and lower cost of IT specialists in India.

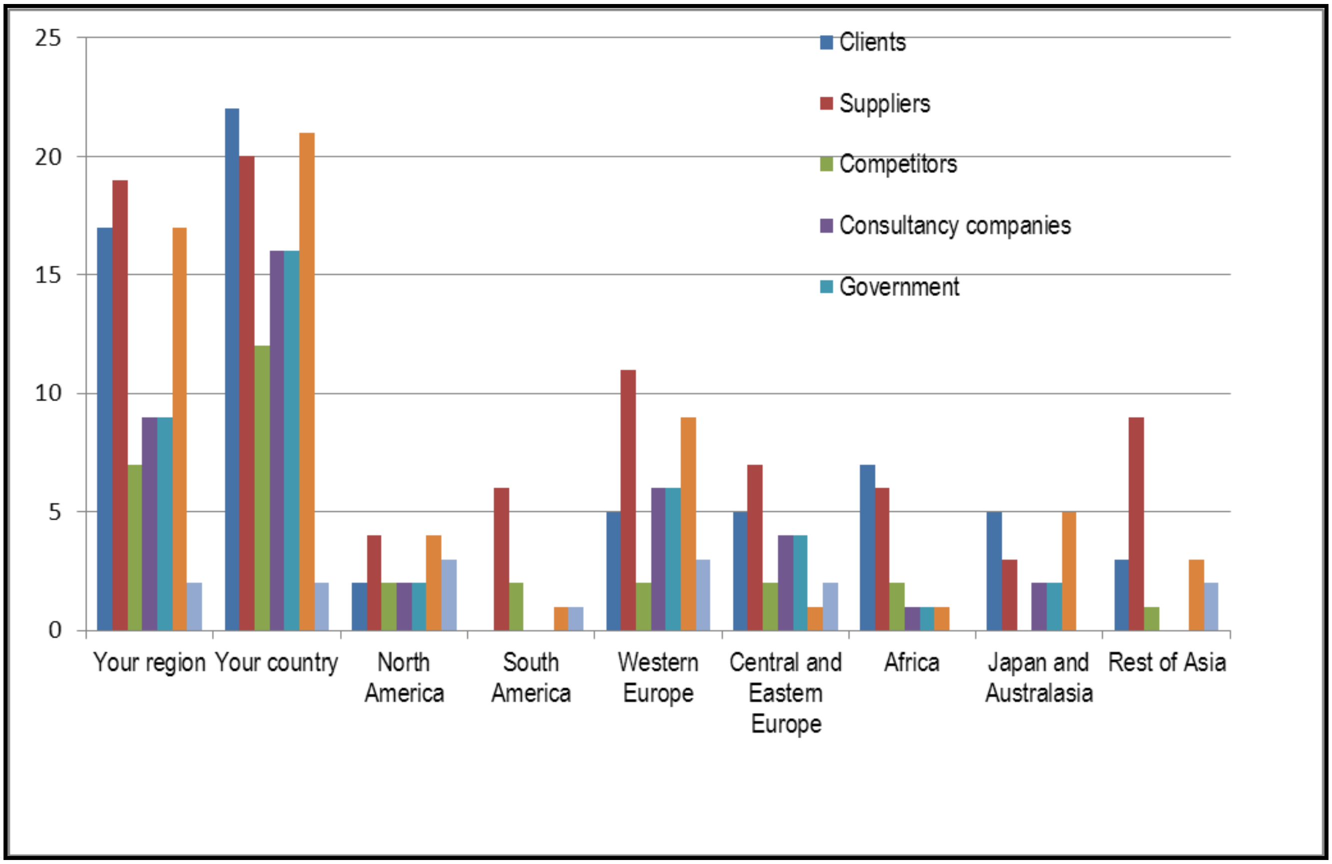
Large local firms such as dairy giant Clover, have R&D and manufacturing capacity locally. Clover partnered with Danone for several years before the joint agreement lapsed. Clover having expertise on local conditions, supply chains and a massive distribution footprint were ideal partners for Danone, relative newcomers on the local market. Danone in turn brought its significant R&D knowledge into the reciprocal arrangement. Thus knowledge sharing between local firm Clover and multinational Danone took place. Interestingly, Danone does have a strong laboratory team innovating on site at its Johannesburg plant. Our interviewee at Danone said that the local lab had produced formulations for specific yoghurts which had been rolled out globally. Thus there is evidence of locally developed knowledge entering global knowledge chains. The very sophisticated dairy products were not produced locally as the market was deemed to small to warrant the costly production process.

When Pepsico entered South Africa, with an eye on the snack food potential in the market, they opted to buy the largest local potatoe chip producer called 'Simba'. Foreign multinationals are able to tap into the knowledge of local firms and vice versa, through JV's and/or by acquiring the local firm.

Group 3: The third group are smaller, niche firms. These may be technologically sophisticated biotech type operations, or producers of poor quality product such as biscuits for the lower end of the market or developers of 'boutique' organic style products.   The higher tech firms in this group are the firms we are interested in as they often supply IP into larger firms. The results for the INGINEUS survey are illustrated in figure 3 below, they show that most collaborations occur domestically with clients and suppliers. These collaborators may be small, as described above or large like Novozymes or BASF.

In addition Table 130 (sources of knowledge) shows that 40% of firms source technology inhouse. However the second largest set of responses at 18% answered 'We buy most of our technological inputs from non-MNC firms', this supports the idea that smaller firms supply IP into larger firms. When this occurs with a multinational, the knowledge is carried globally by the MNC network. The greatest potential for GIN formation lies at the intersection between the third group of smaller, specialised suppliers collaborating with or supplying to large companies with a global footprint.

Figure 4: firm collaborations



Source: INGINEUS (2010)

Table 131 | South Africa counts for INGINEUS collaborations in geographical locations

	Your region	Your country	North America	South America	Western Europe	Central and Eastern Europe	Africa	Japan and Australasia	Rest of Asia
Clients	17	22	2	0	5	5	7	5	3
Suppliers	19	20	4	6	11	7	6	3	9
Competitors	7	12	2	2	2	2	2	0	1
Consultancy companies	9	16	2	0	6	4	1	2	0
Government	7	11	1	0	1	1	2	1	1
Universities/ institutes/labs	17	21	4	1	9	1	1	5	3
Other	2	2	3	1	3	2	0	0	2

Source: INGINEUS (2010)

Once again we examine the SAIS (2005) data, this showed about 2% of the domestic firms cooperated with universities in South Africa, Asia and other countries, way below the 16% national average. This means that firms in agroprocessing sector, when compared with other sectors, had far lower collaborations with universities. The highest cooperation is between firms and their clients and customers, with about 6% of firms indicating such cooperation. Only data for innovative firms are were available for this analysis. The trends suggested by the SAIS (2005) data was that agro-processing domestic firms cooperate less on innovation activities than the national average.

7.4 Subject 4: Locations and internationalization

South Africa is a dual economy with a developed, first world sector operating alongside an underdeveloped and informal sector. The developed side of South Africa and specifically of Gauteng is used as a port of entry into the larger and largely untapped markets in Africa. The number of firms and MNC's clustered in Gauteng (Johannesburg and surrounds) is testament to the value which this location holds. Locating themselves in Gauteng is the first step in the internationalisation strategy of many firms' into Sub Saharan Africa.

SAB are firmly established in SA and across several other African states and were often quite innovative and pioneering in the devlopment of their brand and footprint. More recently, Nestle has entered African markets outside SA and has prescence in several states. They are closely followed by suppliers such as Novozymes, whose internationalisation strategy is to follow and service their most lucrative clients.

Part of the value of locating in Johannesburg is the proximity to clients and suppliers. Novozymes describe that locating in Johannesburg made sense as the main offices of their largest local clients such as Nestle were located here. South Africa was also valued for its established and sophisticated banking sector. This gave firms a sense of security, enabled them to trade in large volumes and raise finance when required. Novozymes also mentioned the ease with which employees could travel from Johannesburg directly to Denmark. Most large global airlines fly to SA with routes and infrastructure well established. Communications equipment could run without interruption and the political stability were also cited as reasons for locating in SA.

Not all firms seeking to internationalise into Africa start in Johannesburg, as communications networks and political stability expand across the continent, some firms bypass the stiff regulatory conditions and high labour costs of South Africa.

In the examination of Table 132, attention is first be drawn to the relatively low response counts when compared with the sample size of 83 responses, over 80% of firms which answered did not offshore production or innovation. This is because only firms which indicated that they had offshored production and or innovation were eliminated in the first part of the question. Respondents marked all factors important to them. The most important **factor in offshoring production** was the availability of cheap resources followed by the availability of specialised knowledge.

Table 132 | Number of respondents indicating offshoring activity

Does your firm offshore (or has your firm offshored) production or any R&D activities	Response Percent	Response Count
Yes	19.3%	11
No	80.7%	46

In the **offshoring of innovation** however, ’access to knowledge infrastructure and services in the host region (R&D infrastructure, technical support services etc.)’ was most important followed by the ’opportunity to sell existing products and achieve greater access into new markets’ and the availability of qualified human capital at a lower cost than in your own country.

Table 133 | Location factors for offshoring of production & innovation

	Offshoring of production	Offshoring of innovation	Response Count
9.2.1 Availability of specialised knowledge in the host region	75.0% (6)	37.5% (3)	8
9.2.2 Availability of qualified human capital at a lower cost than in your own country	50.0% (2)	75.0% (3)	4
9.2.3 Access to knowledge infrastructure and services in the host region (R&D infrastructure, technical support services etc.)	45.5% (5)	81.8% (9)	11
9.2.4 Access to other infrastructure, cheaper production resources and services (land, inputs or unskilled labour, ICT, electricity, roads, airports, ports etc.)	83.3% (5)	33.3% (2)	6

9.2.5 Opportunity to sell existing products and achieve greater access into new markets	75.0% (6)	75.0% (6)	8
9.2.6 Incentives for the location of activities in the host region (e.g. favourable regulations, special tax regimes, testing facilities and trials etc.)	100.0% (3)	0.0% (0)	3
9.2.7 Efficient financial markets (including Venture Capital)	100.0% (2)	0.0% (0)	2
9.2.8 The level of ethical standards and trust	100.0% (2)	0.0% (0)	2
9.2.9 The enforcement of intellectual property rights	50.0% (2)	50.0% (2)	4

Table 134 | collaboration counts in geographical locations

South Africa counts for INGINEUS collaborations in geographical locations

	Your region	Your country	North America	South America	Western Europe	Central and Eastern Europe	Africa	Japan and Australasia	Rest of Asia
Clients	17	22	2	0	5	5	7	5	3
Suppliers	19	20	4	6	11	7	6	3	9
Competitors	7	12	2	2	2	2	2	0	1
Consultancy companies	9	16	2	0	6	4	1	2	0
Government	7	11	1	0	1	1	2	1	1

Universities/ institutes/labs	17	21	4	1	9	1	1	5	3
Other	2	2	3	1	3	2	0	0	2

The Table 134 above displays the inward national focus of firms in the agro-processing sector with the bulk of collaborations occurring within region and country. Interesting to note is that the next largest accumulation of responses was with Universities/institutes, suppliers and consultancy companies in Western Europe. This is predictable as Western Europe (along with China) is South Africa's largest trading partner. Nine of the companies in our sample were collaborating with suppliers in the 'rest of Asia'. This may signal the increasing importance of agri trading between SA and China, and the general and increasing shift of trade between emerging economies.

Six companies in our sample used consultancies from Europe. These may be multinationals intent on using home based/developed location services or they may be large local companies attempting to achieve European standards and credibility for their exports.

On the demand side, SA does not have a large enough market or high growth rates. Supply side issues include the lack of a large enough pool of skills, especially when compared with the likes of India or China. Skilled SA labour is expensive and scarce. SA also has very stringent regulation around Black Economic Empowerment and labour legislation which adds substantially to the cost of doing business in the country. Telecommunications costs are high when compared against a global average and the price of electricity is rising astronomically. The offshoring of innovation is less likely under these conditions.

However developed institutional systems, relative political stability, proximity to potentially lucrative markets and developed infrastructure are the location pull factors of South Africa.

7.5 Subject 5: Sector embeddedness in GINs

Table 135: Formal/informal linkages (e.g. research relationships) the enterprise developed with the following kinds of foreign organisations (Q 8)

Yes, Formal	Yes, Informal	Yes, formal	No	Response Count
8.1 Clients	28.0% (14)	44.0% (22)	34.0% (17)	50
8.2 Suppliers	34.5% (19)	52.7% (29)	25.5% (14)	55
8.3 Competitors	7.3% (3)	12.2% (5)	80.5% (33)	41
8.4 Consultancy Companies	39.1% (18)	21.7% (10)	45.7% (21)	46
8.5 Government	14.3% (6)	21.4% (9)	69.0% (29)	42
8.6 Foreign Universities/Research Institutions/Labs	14.3% (6)	35.7% (15)	57.1% (24)	42
8.7 Other	4.3% (1)	13.0% (3)	82.6% (19)	23

As was previously seen, the 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.

It is therefore not appropriate to say that the agro-processing sector as a sector is 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.

7.6 Subject 6: Coordinating and communicating in GINs

Table 136 | Factors representing a challenge or barrier to innovation collaboration

Extreme Barrier	Extreme barrier	Serious Barrier	Moderate Barrier	Small Barrier	Not a barrier at all	Rating Average	Response Count
11.1 Finding relevant new knowledge	4.3% (2)	15.2% (7)	37.0% (17)	21.7% (10)	21.7% (10)	3.41	46
11.2 Overcoming organisational barriers and gaining management acceptance	2.1% (1)	6.4% (3)	40.4% (19)	27.7% (13)	23.4% (11)	3.64	47
11.3 Changing the current location of operations and the associated cost thereof	13.0% (6)	32.6% (15)	23.9% (11)	13.0% (6)	17.4% (8)	2.89	46
11.4 Managing globally dispersed projects and cultural differences	7.0% (3)	20.9% (9)	37.2% (16)	20.9% (9)	14.0% (6)	3.14	43

11.5 Harmonising tools, structures and processes	2.3% (1)	9.1% (4)	36.4% (16)	40.9% (18)	11.4% (5)	3.50	44

In terms of the challenges re communication and coordination, the agro processing industry is not substantially different from other industries. The large scale nature of most of agro-processing is reflected in the challenge of relocating plants, but most of the challenges are similar to those experienced in other industries.

Novozymes in SA does not have a plant, and the case study sheds light on the main challenges experienced in terms of coordination.

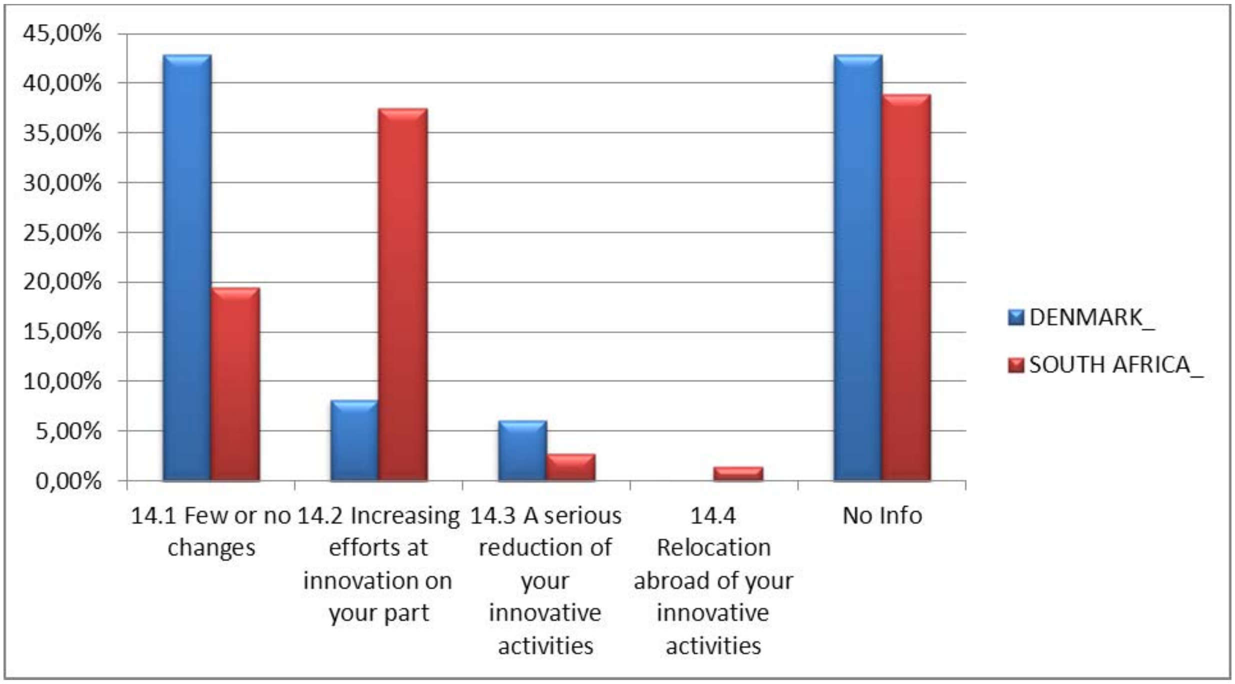
Internal company communication:

Novozymes continuously communicate ongoing strategies to the various subsidiaries. Regular management team meetings take place in Denmark at head office and employees fly regularly to Denmark for face to face meetings which are deemed important. International project teams move around globally. Although the intraweb is used, there is often a sense that ”a higher level of detail” is not known.

In South Africa, employees often feel isolated geographically from the rest of the organisation. Comments that this is the “tip of Africa, things don’t get down this far” have prompted the organisation to bring an expatriate manager into the country to ensure compliance with international strategy. The manager comments that ICT enablers like an intraweb and IT systems need to be slick and efficient to connect to the organisation and overcome the isolation.

To make people feel part of the organisation, the office in JHB was redecorated using Danish design principles to strengthen the Novozymes culture in Johannesburg.

7.7 Subject 7: Prospective, impact from crisis



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.

The financial crisis saw Danish multinational Novozymes streamline functions to save costs. Rather than replicating IT and finance functions across all its subsidiaries, the company centralised 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 cuttting back on replicated staff globally and hiring Indian labour which was cheaper, abundant and of suitable standard.

8 ANNEX 8: INTERRIM REPORT COUNTRY SECTOR REPORT AUTO GERMANY

The automotive industry in Germany

Eike W. Schamp

Introduction

Germany was one of the first countries where a substantial automotive industry had emerged at the beginning of the twentieth century. Hence, the automotive industry of today can be considered as a rather mature sector that faced in the past a good number of crises but also restructuration and rejuvenation. In fact, having survived rather well the Toyotism or “lean” production “revolution” at the end of the 1980s and subsequent smaller crises in the markets, several sources now claim a “second automobile revolution” which is in the making. Once again it seems that the fundamental principles of automobile production will change, both due to increasing environmental requirements in the developed markets and cost requirements following the relocation of the sector to Asia. Like the automobile research network of Gerpisa said in a recent call for papers for their conference in June 2011: “The current period is one of industrial transformation of a scale previously unimaginable”. Gerpisa doesn´t stand alone with this claim (see DB research 2009).

Thus, there is considerable pressure for innovation activities in the German automotive industry, and, as a result of the global relocation of the sector, for changes in innovation networks which may extend to become global. German OEMs and their largest system and components suppliers have considerably internationalised in recent decades, going to emerging economies such as, first, Mexico, Brazil and South Africa, then China, and currently India. At the same time, however, they grew up to large hierarchical organisations governing global production and innovative activities from a strong home base. Whether this strong base will be razed by an emerging new context in which new agents appear and strategies have to be shifted will be the main topic of this paper. The starting point for answering this question is an attempt to highlight some structural, situational and even strategic characteristics of the automotive industry in Germany and the particular current forms of GINs in the sector.

The paper will be mainly based on a review of current literature on the sector, on the Ingineus sectoral survey of 2010, some case study research and, last but not least, the use of different documents from the German association of automobile producers (VDA), universities and private research and marketing labs. A brief look at the methodology of the Ingineus survey deserves attention as it appears to offer very relevant but simultaneously limited information. 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 combining very different technologies from different sectors for automotive production, while small third tier suppliers stick to their technology but sell to very different markets. The data base was established using information from a private data provider, Hoppenstedt. This data encompass 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. 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 is partly due to the difficulties in official statistics to measure low tech, often experience based innovation (Hirsch-Kreinsen 2008). In total some 690 companies appeared at the list. However, in order to make the survey comparable to other countries and sectors, it later was extended to further 384 small companies with less than 50 employees. While the response rate for the companies above 50 employees was 6.8% – which still is rather low – the response rate of small companies was disappointingly at 1.6% (in figures: 6).

Thus, there are several caveats to the survey. To be precise, the survey was not on the few OEMs in Germany – BMW, Daimler, Ford, Opel (GM), and Volkswagen (including its brands Audi and Porsche). The automobile industry is largely perceived as giving rise to producer driven global value chains (Gereffi et al. 2005) which are hierarchically governed by the large OEMs (Sturgeon et al. 2008). The literature is full of studies on the different strategies and cultures of OEMs, sometimes making a difference between nations (e.g., Japanese and German companies compared with US-American) or understanding large OEMs as individual “elephants” (Boyer/Freyssenet 2000). In any case, they are the main drivers in globalization of the German automotive industry. Analysis of their strategies is based on desktop research covering the literature, documents and websites. In focussing on the automotive supplier industry, the survey mostly covered medium sized automotive companies and missed 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. In what concerns the first-tier companies, we add further information through desktop and some case study research. Furthermore, the low response rate requires careful interpretation and further, if anecdotal, evidence.

8.1 Subject 1. The history and present nature of sector activities

For many decades the automotive industry was one of the key sectors in the German economy. Total employment effects of all the different sectors around production and consumption of cars were estimated at 2.8 Million persons or 14% of Germany's total labour force in 2005 (Stat. Bundesamt Deutschland 2009). The sector provided for 20 % of the annual turnover of all manufacturing industries in Germany, in 2009 (VDA 2010). Although experiencing different crises in recent decades, among them the revolution in production technologies at the end of the 1980s ("lean production" or "toyotism") and the downturn after the reunification boom in 1993, the German automotive industry saw a steady growth in the recent decade. In 2008, i.e. before the recent financial crisis arrived at the real economy, Germany was the world's fourth largest producer of passenger cars (with 5.53 mil.), following Japan (9.93 mil.), the US (8.45 mil.) and China (5.68 mil.), and it currently is the fourth largest producer of commercial vehicles (as of 9 March 2011, see VDA 2011). While the crisis hit all the traditional automobile producers, China increased its production to become the world's largest producer in 2009 (8.38 mil.), followed by Japan (6.86 mil.), the US (5.58 mil.) and Germany (4.96 mil.; see VDA 2009). Germany's export rate in the automobile industry dropped from nearly 75% in 2008 to 69% in 2009, mainly because of its premium models became too expensive on most markets during the crisis, however, in 2010 production and exports of premium models regained momentum. 70% of Germany's export markets are European countries (2008 70,3%; 2009 68,2%), 10% the US (2008 12,6%; 2009 10,5%), and increasingly China (2008 5,3%; 2009 8,8%) (according to the VDA 2010).

Hence, Germany is Europe's largest producer and exporter of passenger cars and heavy duty trucks. Porter (1990) has early pointed to the "cluster" characteristics of the German automotive industry as there is 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). Added 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 electronical industries, textile and rubber industries, and plastics industries. While it seems that the automotive production penetrates large parts of the German economy (including the finance sector, trade, and varied services), its real size remains largely unknown because of difficulties in statistics. The share of the automobile industry in total value added of manufacturing industries rose from 10% to more than 14%

between 1981 and 2006 (Legler et al. 2009, 12). Compared to Western nations, Germany's economy is highly specialised on automobile production (19% of production capacities compared to 8% on average in Western industrialised countries; Legler et al. 2009, 14). This specialization has even increased in recent time.

It is quite difficult to get a concise picture of the organisational structure of the German automotive industry as it crosses several sectors in the official statistics (but see broader studies such as Schamp 1995). Some of the world's leading system suppliers are German. According to a recently published list of the top global 100 automotive suppliers (CAM 2010), a quarter of them is German, among them the world's second (Bosch company) and probably third largest (merger of Schaeffler and Continental) first tier suppliers. Others in the list such as ThyssenKrupp, ZF, Benteler, Hella, Mahle, Brose, Behr, Plastic Omnium, Getrag, Leoni, MannHummel, Draexlmaier, Freudenberg, Eberspaecher, Webasto, or Knorr-Bremse stand for world market leaders or seconds in their respective products (and technologies), all of them being multinational companies. Some of them are family based companies and form part of the so-called German "Mittelstand" which is famous for following long-term strategies. Additionally, most of the leading foreign suppliers are present in Germany. This is partly due to the very early involvement of American OEMs in Germany (Ford 1910, Opel 1927) which stimulated their home suppliers to follow, especially after WWII, and the more recent allocation of Japanese (Honda, Mitsubishi, Mazda) and Korean (Hyundai, Kia) OEMs' European headquarters and R&D centres in Germany.

Behind these well known German companies is a host of smaller automotive suppliers. Their number is estimated at one to two thousands, according to their share of sales in the automotive sector. These are mostly standalone companies, often family based. But the ageing of family entrepreneurs and the recent crises have caused (often foreign) financial investors and private equity companies to invest in these companies forming more or less loose groups of mostly small standalone companies. Both, financial investors penetrating the automotive industry and the current mergers among the very large system suppliers (such as Schaeffler and Continental, Mahle and Behr) point to the current pressure for reorganisation in the sector.

The organisational structure of the automotive industry is reflected by our own survey, as disappointingly limited the size of the survey may be. 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 (Table 137). Remarkeably some 84 % of responding firms nevertheless claim to have "a significant share of sales activities abroad".

Table 137 | Some characteristics according to the Ingineus/DIE survey

organisation	percentage	number	markets	percent age	number
standalone company	67,4	29	a regional market (local market in your country)	9,3	4
subsidiary of a MNC	23,3	10	domestic market (rest of the country)	62,8	27
headquarter of a MNC	9,3	4	an export market	27,9	12
answered question		43	answered question		43
skipped question		10	skipped question		10

Table 138

full time employees	percentage	number
10 to 49	14,3	6
50 to 249	35,7	15
250 to 999	26,2	11
1,000 or more	23,8	10
answered question		42
skipped question		11

According to size of companies and the structure of the automotive industry in Germany, it is a powerful sector even in political terms. In fact, VDA is a powerful association of automobile producers, most of the large suppliers included – but not the small ones –, that lobbys for preferential regulation (such as no speed limit at high ways). IGMetall is one of the world's strongest trade unions, and ADAC the most powerful association pretending to speak for automobile consumers. As conceived in the concept of a Porterian cluster, there is strong competition among the (innovating) OEMs and the (innovating) suppliers, strong support from factor conditions and strong political support from the state. Finally, it is said that German and European customers are rather demanding.

8.2 Subject 2. The nature of innovation in the sector

Following the report of Legler et al. (2009, 90), the automotive industry is extremely important for innovation in Germany, both in a quantitative and qualitative perspective. It is by far the largest sector in terms of R&D expenditures (20.0 billion € or 25 %) but it is not a high tech sector, given an average rate of R&D in turnover of 7.8% (ZEW 2009). Most of R&D expenditures are internal to the companies, even in the automotive sector where the principles of "lean production" have been extended to design and development of models (see Schamp et al. 2004).

Table 139 | R&D expenditures according to sectors in Germany, 2008

Sector	total	in %	internal	in %
	in billion €		in billion €	
Automotive industry	20	39	15,1	75,5
Electrical engineering	10,8	21,1	8,7	80,6
Chemical industry	8,3	16,2	6,7	80,7
Mechanical engineering	5,5	10,7	5	90,1
Business services	4,7	9,2	4,1	87,2

Source: Stifterverband 2010, 2

According to the recent ZEW analysis on the sector, the automotive industry is crucial in its importance to the German innovation system because of its linkages to other sectors (Legler et al. 2009, 107). Its key position is due, first, to its role as the largest client sector in the German economy with about 10% of total demand for supply, and, second, to stimulating 15% of all cross-sectoral impulses to product innovation and even 27.7% of cross-sectoral impulses to process innovation (Legler 2009, 107f.).

R&D expenditures in the sector have seen a steady rise. As a result, Germany's share in the R&D investment of OECD countries internal to the companies has increased from 10 percent during the 1970s over 16% to 18% in the 1980s and early 1990s up to nearly 25% recently (Legler et al. 2009, 92). This is partly due to the specialization of the German automotive industry on the sector of premium models where client's demand urges and profits enable companies to introduce innovation rather early.

Innovation, however, is not only based on R&D expenditures. Therefore, ZEW follows a broader concept to measure innovation expenditures, including, among others, costs of training, costs of market entry and other expenditures tied to the preparation of production and distribution of innovative products. Innovation activities in this sense have reached a peak in the German economy just before the crisis. The average rate of "innovators" as measured by the ZEW increased to 47% in 2008 (an annual plus of 3.5%). Among the so-called research-intensive industries, the vehicles construction sector (new classification including all vehicle production, i.e. cars, ships, trains, planes) figured fourth with about 75% innovating companies. The sector figures first, however, in innovation intensity (i.e. rate of innovation expenditures to turnover), share of new products in turnover (mainly imitating products), and successful process innovation (mainly for cost reduction) (Rammer et al. 2010). According to the same report, the increase of innovation activities in the German economy in the recent 12 years was mostly due to "large" companies (more than 500 employees) with a growth rate of 170% between 1995 and 2008 as compared to 30% for SMEs, and annual innovation expenditures in 2008 of nearly 95 billion € as compared to 33 billion €, respectively.

For further discussing innovation in the sector we prefer to go back to the 2007 data on innovation for two reasons. First, this was the last year before the financial crisis catched the sector which may better show the structural characteristics of the innovative strength of the sector, and, second, statistical classification was changed in 2008, combining production of automobiles, ships, trains and even airplanes in a new sector of "vehicle production" (in the following, see ZEW 2009). With more than 30 billion € in 2007, the sector spent by far the largest sum of expenditures for innovation in Germany (25% of the total). Innovation intensity as measured by the share of R&D expenditures of total turnover slightly increased to 7.8% which was the second largest (following the light engineering industry with 9.4%). But, of course, the automotive industry is extremely larger than this small sector. ZEW distinguishes four different forms of product innovation in its innovation panel, i.e. products new to the market (6%), products new to the market and to the firm (25%), products new to the firm (10%), and innovation neither new to the market nor the range (13%). Figures in the brackets show that most of innovation was new to the market and the firm. Process innovation mainly achieved both reductions in costs and improvements in quality (25%), compared to cost reduction (4%) or quality improvement (11%) only, respectively. The share of new products to annual turnover was 12% for products new to the market and 44% for copying innovation.

The bulk of investment into R&D comes from a rather small number of German multinational OEMs and first tier suppliers. Table 140 lists some large automobile OEMs and first tier suppliers by their (global) R&D expenditures in 2009.

Table 140 | R&D intensity of large OEMs and system suppliers as of 2009

company	R&D in billion €	in % of annual turnover
Volkswagen	5,4	5,8
Daimler	4,2	8
BMW	2,5	4,8
Bosch	3,6	9,4
Continental	1,4	6,7
MAN	0,5	4,2
Leoni	0,07	3,3
Mahle	0,25	6,4
Behr	0,21	8,3

Sources: annual reports (2010)

Concerning the organisational structure of the automobile innovation system, the “leanproduction revolution” had similar effects on the restructuring of design and modelling. OEMs outsourced development to large first-tier or second-tier suppliers but simultaneously maintained their control on design – resulting in a considerable increase of their main R&D centres. Just as in production a hierarchical pyramid of design and development processes came into being (fig. 2.1; see Rentmeister 2007, Jürgens 2004). OEMs and some of the largest system suppliers are the drivers of innovation in the automotive industry – themselves often driven by changing state regulation in, e.g., environmental and safety aspects. This means, at the opposite, that most of the first, second and in particular third tier suppliers do innovative activities in close contact to their customers. Only a very few large system suppliers such as Bosch were able to develop innovation of their own then offering the innovative products to their clients.

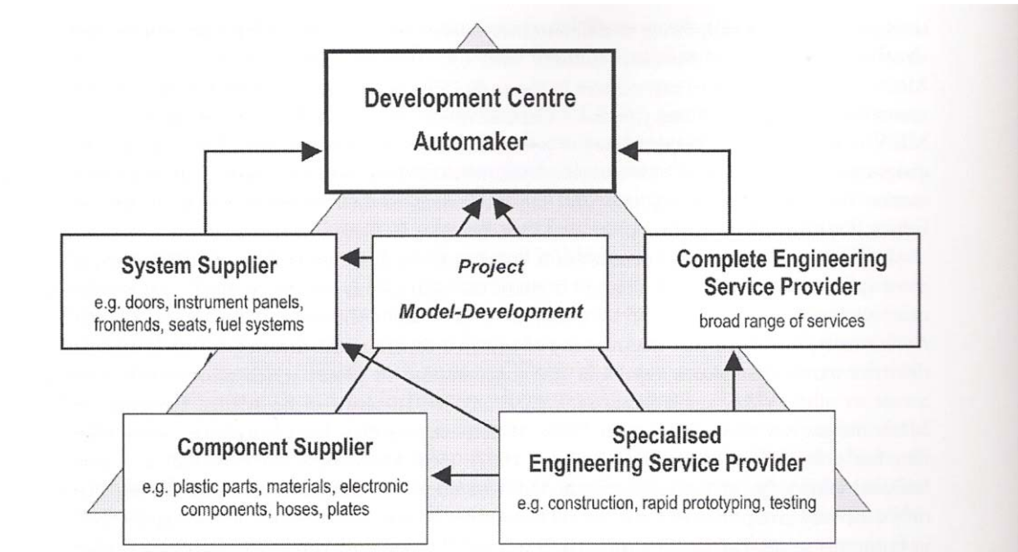


Figure 2. The network of firms in automobile design

Fig. 2.1: The design pyramid (Schamp et al. 2004)

When the ZEW study revealed an innovator’s rate of 75% in the vehicle production sectors, among them principally the automotive industry, this figure is reflected in our own survey which concerns mostly SMEs, as said before. With an average share of 72.1 % of all respondents doing R&D, even small and medium sized companies often claim to do research. Table 141 makes clear that here is a considerable heterogeneity among the automotive companies in the size of their R&D staff. In innovation, the absolute size of a R&D centre matters, 40 out of 53 companies in the survey reported having a staff in R&D. However, a staff of two to three persons over all company sizes and of 4 to 9 persons for mediums sized companies may indicate limited company resources for innovation “new to the market” or “new to the world". Nevertheless, the survey covered some small and medium sized companies (e.g. that small company of 10-49 employees, having a R&D staff of 20 persons) and some large companies with relatively large R&D staff.

Table 141 | R&D staff according to the size of the company, in absolute numbers (Ingineus/DIE survey, Q 3.1 and 3.3.1)

R&D staff	10-49 employees	50-249 employees	250-999 employees	1000 and more employees	total number companies
2 to 3	4	10	1	2	17
4 to 9	-	2	3	-	5
10	1	1	2	-	4
20 to 50	1	1	2	1	5
50 to 100	-	-	2	2	4
200 to 300	-	-	1	2	3
1,000	-	-	-	2	2
					40

Remember that R&D is only part of all the innovation activities as seen by the ZEW. However, these figures correspond with the relatively high share of respondents claiming to produce most of technological inputs in-house (Table 142).

Table 142 | The most important sources of technology, Ingineus/DIE survey Q. 5

	Share	number
We produce most technological inputs in-house	75	30
We buy most of our inputs from other branches of our own MNC	2,5	1
we buy most of our inputs from firms which are not MNCs	5	2

we buy most of our inputs from MNCs with which we are not formally affiliated	12,5	5
we buy most of our inputs from public-sector organisations	5	2
answered question		40
skipped question		13

According to our survey, innovation resulting from R&D and various other kinds of innovative activities is both in products and processes. However, its character is less new to the world or industry and more new to the firm, i.e it may predominantly have an adaptive character (Table 143).

Table 143 | Kind and areas of innovation, 2006 to 2008, Ingineaus/DIE survey Q 6

	New to the world	New to the industry	New to the firm	none
1. new products	8	19	17	7
2. new services	3	7	9	13
3. new or significantly improved methods of manufacturing	1	15	20	5
4. New or significantly improved logistics, distribution or delivery methods for your inputs, goods and services	0	4	13	14
5. New or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems etc.)	1	1	14	10
total	13	46	73	49

8.3 Subject 3. The nature of knowledge

As has been stated time and again, the automotive industry is a cross-sectoral industry. While being considered as a medium tech, sometimes “mature” industry, some sectors involved in the production of cars can have a very high-tech character. 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 (VDA 2008, 18).

Knowledge creation in these technological fields is science based and often performed at technical universities and other public institutions of basic research. Recent debate in social sciences on knowledge and knowledge processes points to a diversity of “knowledge” and “technological regimes” according to dimensions such as origin and character of knowledge, ease of market entry, etc. Two recent typologies of knowledge seem to compete to each other but simultaneously overlap to some degree. The first makes a difference between two ideal modes of learning in innovation processes, i.e., a science and technology based mode (“STI”), on the one hand, and an experience-based mode by doing, using and interacting (DUI) on the other (Jensen et al. 2007). In the second typology, Asheim et al. (2007) developed three classes of knowledge according to the weight of science based, experience based and creativity based dimensions, i.e. analytical knowledge, synthetic knowledge and symbolic knowledge, respectively. There were attempts to classify industrial sectors along these forms of knowledge and innovation. An outstanding example for science based and analytical knowledge creation seems to be the biotechnology sector, according to various studies (e.g., Moodysson et al. 2008). The automotive sector has been largely seen as a sector of DUI innovation and synthetic knowledge as engineering seems to be largely based on experience and innovation most often takes place in combining different elements of technology. These classifications have helped to develop a general geography of knowing and innovation. To put it bluntly, science based innovation and analytical knowledge are said to refer to codified, mobile knowledge and, hence, favour global knowledge networks, mainly external to the company. While doing and using innovation and synthetic knowledge make use of tacit knowledge which often is seen as local, immobile and transferable only by personal exchange and mobility, and, hence, require local networks, mainly internal to the company.

However, these clear-cut differentiations may not directly apply to all sectors of the automotive industry. Because of the cross-technological character in the “sector”, all these forms of knowledge and innovation apply to different degrees and at different places in product and process development of the automotive industry. A closer look to the process of innovation from the company's perspective may better describe the diversified nature of the industry's specific knowledge bases. In the early 2000s, OEMs such as Audi, Ford and Volkswagen as well as first tier suppliers such as Continental Automotive Systems have re-organised innovation and introduced new organisational forms and tools in innovation management (for details see Blöcker et al. 2009, 19 ff.). Although in different terms and different organisational models, a differentiated innovation management process has been established along several stages of knowledge development, i.e. pre-competitive knowledge, proprietary knowledge, product and process innovation proper, and product adaptation. The different stages require different innovation management processes and different kinds of innovation networks. As one company from our case studies puts it, it recently introduced a five-point phasing in innovation management, from getting impulses from everywhere possible – internal and external to the company – via forming the (technological) idea, analysing its feasability, to developing a model and, finally, designing the final product. During these stages in knowledge development, both the kind of knowlegde (science based, experience based) and the knowledge networks (external, internal to the company) change in character. Fig. 3.1 offers a simplified model of this idea. OEMs and suppliers participate in numbers of innovation networks simultaneously and on different stages of the process. These networks may be vertical, horizontal and lateral at the same time (such as Innovationsallianz Automobilelektronik, see Blöcker et al. 2009, 19).

Fig. 3.1: Types of knowledge in stages of the innovation process

Stages in the innovation process	Knowledge base of learning	Internal and external agents in knowledge networks
Pre-competitive knowledge / searching impulses	STI	Universities, public research labs (Fraunhofer), conferences, documents, competitors, etc.
Proprietary knowledge	DUI	Own R&D lab
"innovation"		Production site(s)
adaptation	Learning by interaction	Customers, universities (for process innovation)

Thus, knowledge in the automotive industry stems back to very different organisations in very different technological fields as new product development focuses more or less on combining different technologies in product systems. 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.

Subject 2 has revealed a strong hierarchical organisation of model development in the automotive sector (see fig. 2.1). From this we might assume that different companies at different positions in the design pyramid make use of science based and experience based knowledge in different ways. Universities are said to be one of the major sources for science based knowledge. Although there is no study on linkages between companies and universities regarding innovation available and we were unable to pursue a sound analysis of these, there is ample anecdotal evidence on close ties between some universities and colleges and some large companies in the automotive industry, both OEMs and system suppliers. Most large technical universities in Germany have an institute on automobile technology, and most such institutes have good connections to particular OEMs and system suppliers, not forceably the nearest one. And those institutes are embedded in global scientific networks acting both as global “antennas” for knowledge and as global organisers of knowledge pipelines (see subject 5). The same applies for most of the research labs of Fraunhofer Society, a German institution on industry specific applied research.

While these global networks function as transmitters of basic knowledge which has to be appropriated, adapted and combined in order to become useful knowledge for product design, medium and small (component) suppliers more often have good contacts to the nearest applied university for the adjustment of processes. There are many regional “cluster” associations where the automotive industry is spatially concentrated, in North-Rhine Westphalia, Saxony, Frankfurt RhineMain region, Stuttgart area, to name a few. It is not unusual that applied universities have precise programmes of applied research for the cluster firms, mainly in process innovation and application of products. These contacts are promoted by a strong support from political programmes, on the level of the Länder, the Federal State and the EU. In fact, there are many programmes requiring collaboration between firms and research labs and universities. It seems, however, that these are territorially bound either to the region or the nation (see Blöcker et al. 2009). There is scant evidence of collaboration across national borders, not to speak about continental borders.

In the phase of proprietary knowledge formation (see fig. 3.1) most companies in the German automotive sector prefer a strategy of safeguarding knowledge processes in-house. Even German multinationals allocate their basic research centre which is responsible for accumulating pre-competitive and fundamental proprietary knowledge near to their headquarters. And, regardless of the type of innovation strategy, companies rely predominantly on in-house knowledge inputs and a close control of cooperation in innovation processes through their R&D centres at home. This is what can be derived from a recent case study from Oliver Wyman, a management consultant (fig. 3.2). Their findings do matter as the total automotive supplier sector spends the double of the OEMs in R&D expenditures in Germany, according to this study.

Fig. 3.2: Types of suppliers (Burgard/Danneberg 2010, Oliver Wyman)

Type	Knowledge input	Strategic target	Case
Radical innovator	Particular know-how in-house	Premium segment	Siemens VDO
Accumulator of functions	Keeps know-how in-house	Premium segment	Gentex
Combiner of systems	Extends its activities through R&D cooperation	Premium segment	ZF
Champion in processes	Cooperation	Low cost	ElringKlinger
Niche supplier	Very specialized, selective Cooperation	Premium segment	Elmos
Forming modules	Know-how combiner	Premium segment	Brose

8.4 Subject 4. Locations and internationalisation

In the recent two decades the German automotive industry has become the main driver in foreing direct investment from Germany. Within a few years, its share in German FDI in manufacturing rose tremendously from 18% of total investment in 1995 to nearly 30% in 1998. Since then, it has a constant share of 30 to 35% in manufacturing FDI or 8 to 10% of total FDI (Legler et al. 2009, 86f.). The automobile industry invests, however, in very different activities abroad, such as services (trade, maintenance, finance) or input sectors, and in varied organisational forms.

Table 144 | Amount of direct and indirect FDI of German investors in the automotive industry, 2005 to 2008, in Mill. €

	Total	in Europe	in the US	Japan	Brazil	Mexico	China	India
2005	101,4	33,2	54,4	2,3	1,9	1,8	2,3	0,09
2006	95,4	36,3	45,5	2,1	1,8	1,7	2,7	0,1
2007	96,9	39,3	40,7	2,5	2,5	1,6	2,8	0,4
2008	99,2	43,9	39,1	1,6	3,1	1,8	3,7	0,4

Source: Deutsche Bundesbank 10/2010 (section 3a, direct and indirect FDI according to countries and sectors)

This has to be qualified, however, in different aspects. First, one of the main drivers in going global is Volkswagen, Germany's largest volume producer. Foreign investment in automobile industry goes from mere re-assembly (ckd or skd) to fully integrated production plants. Rather early, Volkswagen established fully integrated plants in Latin America (Mexico, Brazil) and China (as a joint venture), while other German OEMs only invested in North America. The pattern of all types of production plants is by far larger, however. Often in a follow-the-client strategy, first and second tier suppliers established their own foreign subsidiaries, mostly in neighbourhood to the German OEM assembly plants. While internationalisation of production seems high, it reproduces the hierarchical production system of the home country, Germany.

As a result, German OEMs while establishing some kind of "R&D centres" abroad maintained their core R&D at home as did the German suppliers. In the aftermath of the recent crisis, US-American OEMs Opel and Ford allocated even global design responsibilities for medium sized volume cars to their German R&D centres. Thus, while the automotive industry at home spends the bulk of R&D expenditures of all manufacturing industries in Germany (35 to 38%), the share of R&D abroad in the automotive industry was only 15.6 % in 2007 – which still sums up to 52% of the total of foreign R&D expenditures of the German industry. Compared to nearly 70% of R&D abroad of the German pharmaceutical industry, these are rather low figures (Belitz 2010, 9).

In recent time, internationalization of R&D has been particularly reduced in Germany's automotive industry, according to Belitz (2010, 6). Recent figures in R&D expenditures of German automotive companies reveal a reduction in foreign R&D and an increase in domestic R&D from 2005 to 2007 (Belitz 2010, 7). With a share of 15.6% of total R&D expenditures abroad the German automotive sector`s R&D seems to be rather home-based. Unfortunately, there are no further statistics on destination countries of foreign R&D expenditures for the sector. All sectors together, international innovation activities are predominantly based on European countries (60%) and the US (31%). Within Europe, foreign R&D expenditures were spent to 14% in Switzerland, 13% in France, 10% in Austria, 6% in UK (6%) and 4% in Italy (as of 2005, see Belitz 2010, 7). As foreign direct investment of the German automotive industry mainly is in Austria, UK and Eastern Europe, the spatial distribution of foreign R&D expenditures in the automotive industry is clearly different from these figures. Asian Tigers and China now have a similar percentage of R&D expenditures abroad as Japan (5%, respectively).

There is a clear international division of labour in R&D and product development. Most often, OEMs have relocated production of "old" models to foreign subsidiaries in industrializing, "low cost" countries. Such were the case with the relocation of production of the famous beetle to Mexico or the Santana model to China (both Volkswagen). For the global division of labour in R&D of a premium OEM, BMW is a case in point. Model design principally takes place at the large Munich R&D centre which has more than 6,000 engineers. Here, as elsewhere around the R&D centres of OEMs in Germany, "clusters" of offices and subsidiaries of engineering service companies and first tier suppliers have emerged, forming a complex but focused web of interrelations among each others in cooperation and competition with the OEMs R&D centre (see Rentmeister 2007, Schamp et al. 2004). In these "clusters", both quasi-hierarchical control by the OEMs R&D centre on innovative acitivities and knowledge exchange to suppliers and service firms based on experience take place. BMW runs additional R&D offices whose aims are to collect information about changing requirements in large markets: in Silicon Valley for technology, design and emissions, in Tokyo and Beijing for technology respectively, and in Singapore for design (Richter/Harting 2007). This spatial organisation clearly reflects the idea of large "world region" markets such as the Americas or East Asia where the philosophy of car making seems to be similar across various (neighbouring) states. Another case in point is a large system supplier with an analogous spatial division in R&D, allocating market observation to R&D centres in Brazil (South American market) and

South Korea (East Asian market including Japan and China) while concentrating basic (strategically important) R&D at home.

Looking at our own survey on medium sized suppliers, almost 50% claim to have located production or R&D abroad. But this statement has to be qualified as probably most of the locations are European and R&D most often is oriented to application (Table 145).

Table 145 | Offshoring, DIE/Ingineus survey

	percent	number
Has offshored production or R&D	48,7	19
Has not offshored production or R&D	51,3	20
Answered question		39
Skipped question		14

Table 146 presents some evidence on the motives for offshoring. As could be expected, the main motives are cost driven such as availability of qualified human capital at a lower cost and further infrastructure, at the one hand, and market access, on the other. The latter includes relocation of production in a "follow-the-client" strategy which is quite common in the automotive sector. While a cost-driven relocation strategy for production activities might look for locations in close neighbourhood to the EU because of transportation costs, as in Eastern Europe or North Africa, the follow-the-client strategy more often applies to large overseas markets such as North America (including Mexico), Brazil, China or India.

The question is whether the geography of international R&D investment is similar to FDIs in production and other activities. Most literature on the location of international investments in R&D makes a clear separation of market-seeking investments and resource-seeking investments (for German multinationals see Ambos 2005). According to Ambos' study on 49 very large German multinationals international R&D investments have tremendously increased during the 1990s, mostly in America and Europe. Market seeking investment still was dominant while resource seeking investment jumped considerably after the midst of the 1990s. Resource seeking investments resulted in closer relationships to local research institutions and universities and required more advanced academic training (in terms of PhDs). Ambos' study pointed to some interesting, yet open questions concerning the organisation of international R&D such as a national culture of internationalisation strategies – German MNCs behave more similar to Japanese than to Swedish MNCs according to Ambos –, different local ties according to world regions and increasing tension of "managing dual embeddedness (i.e. within local community as well as the internal firm network)" (Ambos 2005, 407). This will be further discussed in the next sections. Our case studies on the location of R&D services abroad suggest that, first, resource-seeking investment strategies in terms of getting to know new technologies seem to be rather an exception, but, second, large first tier suppliers increasingly make use of low cost engineering capacities for more or less standardised tasks in R&D in India.

Table 146 | Motives of going abroad, DIE/Ingineus survey

	Offshoring production	Offshoring innovation	Number
1 Availablity of specialised Knowledge in the host region	4	6	
2 availability of qualified human capital at a lower cost than in own country	16	9	
3 access to knowledge infrastructure and services in the host region	0	5	
4 access to other infrastructure,cheaper production resources and services	8	1	
5 Opportunity to sell existing products and achieve greater access into new markets	12	4	
6 Incentives for the location of activities in the host region (e.g. favourable regulations, special tax regimes, testing facilities and trials etc.)	6	2	
7. Efficient financial markets (including Venture Capital)	0	0	
8. The level of ethical standards and trust	2	0	
9. The enforcement of intellectual property rights	0	1	
10. Following clients who are outsourcing i.e. 'follow sourcing'	11	4	
11. Other total	0	0	
Total	59	32	

8.5 Subject 5. Sector embeddedness in GINs

Further studies reveal a strong home base of innovative activities in the German automotive sector. Kinkel and Zanker (2007) have recently studied the global locational strategies of German automotive suppliers, based on a number of case studies. Their analysis underlines the argument that the German automotive sector is rather home-based. Kinkel/Zander develop three types of automotive suppliers, first, the "home-based player" – who may even produce abroad, e.g. in the US or China, but whose focal strategy is oriented towards a strong home base –, second, the "cost-oriented producer abroad", mainly relocating production to low-wage countries, and, third, the "market and client driven producer abroad" who often follows the client (OEM) to foreign locations. Using the 2003 ISI survey on innovation in production both authors estimate that 73 percent of the automotive suppliers belong to type 1, 10 percent to type 2, and 17 percent to type 3 (p. 78).

Type 1 and type 3 companies are very strong in R&D, spending up to 10% of turnover to R&D annually. Kinkel/Zanker develop good reasons for allocating central R&D processes to the German headquarter location, however:

- First, their case study companies mainly produce for German premium OEMs and, secondly, for volume OEMS. Proximity to the focal R&D centres of these lead clients seems necessary, as mentioned above (see also Schamp et al. 2004).

- Second, automotive suppliers find the best of environments for R&D in Germany, with a highly qualified staff availability (mostly engineers etc.), a sophisticated university landscape nearby, and increasing efforts of the companies to come into special relationships with this.

- Third, automotive suppliers have their own lead plants in Germany and, therefore, dispose of a "local" competence in the development of complex products.

Thus, close proximity to own R&D and to the lead plant where the highly qualified labour force has a good potential for learning and co-development, favours the spatial concentration of innovation processes at home. Kinkel/Zanker (2007, 143) put the question whether at least the type of "market and client driven producers abroad" will relocate innovation processes to the markets abroad if production abroad reaches a certain minimum threshold. They state, however, that there still is no substantial evidence for this process.

Hence, one may conclude that most of the innovative German automotive suppliers may be embedded in innovation networks. But these are “local”, not “global”. This is supported by the recent Oliver Wyman study mentioned before (Fig. 3.2) emphasizing the focus on in-house knowledge and the premium OEMs as strategic targets. A trend towards de-anchoring to some kind of global innovation networks is not yet to be seen.

Although not representative, our own survey reveals a clear allocation of dispositive functions in German automobile companies to the headquarter’s location (see Table 147). If product development is allocated to different locations these are predominantly in developed regions and countries. There has been only once mentioned product development at a developing country. German automotive suppliers seem to be very reluctand in outsourcing, and if so, they only outsource in and to developed countries, according to our survey. There is a substantial relocation of marketing and sales functions, operational and procurement functions as well as human resource management and after sales services to subsidiaries, both in developed and developing countries, but not in innovative activities. These figures underscore the dominance of a strongly “home-based” type of German automotive supplier.

Table 147 | Please describe, where in your firm following functions are carried out (subsidiaries of your firm included).

	Own location	Subsidiary at developed location	Subsidiary at developing location	Oursourced in own country	Outsourced to another developed country	Outsourced to a developing country	No.
1. Strategic Management	36	1	0	1	0	0	
2. Product Development	36	10	1	0	2	0	
3. Marketing, sales	35	9	2	1	0	0	
4. operations	31	18	5	0	2	0	
5. procurement, Logistics, distribution	32	15	3	1	0	0	
6. corporate governance	35	9	1	2	0	0	
7. human resources	34	13	3	1	0	0	
8. technology	34	14	1	1	0	0	
9. firm infrastructure	32	10	1	1	0	0	
10. customer and after sales services	35	11	4	2	0	0	
Answered skipped	36						
	17 ??						

"Embeddedness" of innovative activities in the automobile sector means close relationships to customers and suppliers. Table 148 makes clear that such vertical relationships are mainly developed "at home", i.e. own region and own country, and to a diminishing degree to countries of similar market structures such as Western Europe and North America.

Table 148 | Regarding the development of the most important innovations of your enterprise – who did you actively involve in this process within the last three years?

Partner used	Own region	Own country	Western Europe	Central/ East.Europe	North America	South America	Japan/ Australasia	Asia, other	Africa	N
Customers	22	24	14	4	12	0	3	5	0	
Suppliers	17	17	12	4	3	0	1	7	0	
Competitors	1	3	1	0	1	0	1	0	0	
Consultancy companies	5	12	3	1	2	1	0	0	0	
governments	2	3	2	0	0	0	0	0	0	
domestic univ./Research labs	12	14	4	1	1	0	1	0	0	
foreign universities/ research inst.	2	1	4	0	2	0	1	0	0	
other	0	0	0	0	0	0	0	0	0	
total answered skipped	61	74	40	10	21	1	7	12	0	

Analyzing innovation networks to third parties in the German automotive industry by case studies, Dilk et al. (2008, 324) support this conclusion in claiming that "innovation networks with a vertical strategic direction are dominant", added by "often, cooperation with regional universities" and research institutions such as Fraunhofer Institutes. Most innovation networks appear to be national in character. Additionally, Blöcker et al. (2009) identified different kinds of regional networks with different drivers, different management strategies and combined targets in several automotive cluster regions in Europe. They state that regional innovation networks often have an experimental character, try to explore new ways in innovation and, therefore, are very risky. As a result, regional innovation networks mainly belong to the pre-competitive stage of innovation management (Blöcker et al 2009, 236).

While companies seem to be very cautious in allocating proprietary knowledge abroad other organizations, among them universities, are more open to establish knowledge networks across the world. Quite clear, this refers to knowledge in the pre-competitive realm. German technical universities have good contacts to their counterparts all over the world, and so have the university departments in the field of automotive research. Again, there is only anecdotal evidence available on the organisation of "global" networks in automotive research and education. Following the example of Stanford University, the technical university of Munich has organized, at an annual basis, an international programme for advanced students in the automotive sector where small teams of students work on a particular theme at foreign universities such as Mexico or Tongji/Shanghai. The organiser tries to integrate at least one automotive company from Germany and one from the host country. To give an example of issues: in 2008/9, the theme was mobility in megacities in 2025. That means that uniquely topics in the pre-competitive space of innovation activities are chosen (personal interview).

8.6 Subject 6. Coordinating and communicating in GINs

One factor in favour of the local embeddedness and strong home base in innovative activities in networks is the rather "soft" and trust-based character of knowledge exchange in innovation processes. From their case study, Dilk et al. (2008, 326) come to the conclusion that the main factor for success or failure of a project pursued by innovation networks is "mutual trust" based on "cultural" proximity. They claim that human resource departments in the companies have not yet sufficiently developed management tools to overcome these social and cultural barriers over long distances.

Our own small survey adds empirical information to these claims. Asked where the main barriers are for mutually producing a commodity or service the companies identified barriers particularly in "managing globally dispersed projects and cultural differences" and in the task to find "harmonising tools" and overcome the sunk costs of the current locations (Table 149).

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Table 149 | Which of the following factors were according to your experience a barrier or obstacle for your decision to produce a commodity or a service with firms, universities or other organisations abroad? Q11

	Share stating moderate or higher barrier	Extreme barrier	Serious barrier	Moderate barrier	Small barrier	No barrier	Number of cases
Finding relevant new knowledge	64,5	0	9	11	6	5	31
overcoming organisational barriers and gaining management acceptance	51,6	2	4	10	9	6	31
changing the current location of operations and the associated costs thereof	82,8	4	11	9	4	1	29
managing globally dispersed projects and cultural differences	80,6	7	9	9	4	2	31
harmonising tools, structures, and processes	80,6	3	11	11	4	2	31
answered							31
skipped							22

So, one conclusion is that automotive companies mainly seek to control innovation processes through (internal) hierarchy. External communication to knowledge creating organisations such as universities and basic research institutes is mainly organised through the R&D centre at the site of the headquarter, even if this communication extends globally. The company's R&D labs in other world market regions are rather outposts for collecting relevant information for the R&D centre at home. They may contribute, additionally, to slight adaptation of products to the local market. Only very large volume OEMs such as Volkswagen or system suppliers such as Bosch may allocate specific R&D tasks to one or two of their R&D centres abroad. The reluctance of smaller automotive companies to collaborate with organisations abroad is clearly shown in Table 149 Obviously, companies are less afraid of overcoming organisational barriers but more of the investment and management costs of relocation. And it seems as if they find sufficient knowledge relevant for innovation at home.

This can be exemplified with evidence from our case studies. Even the largest system suppliers allocate basic research and development at home and only relocate more or less standardized (software) services to R&D in emerging economies. Some of them have recently introduced organisational structures concerning a new type of “competence management” and “knowledge management”. Most of them claim to be at the beginning of managing knowledge and competence globally, in a stage of learning without disposing of a settled organisational form yet. New instruments to overcome the perceived cultural barriers in international communication for innovation are currently developed. One of the medium sized system suppliers which feels to be one of the world market leaders in his segment has several production units in East Asia, Latin America and the US. Recently a small R&D centre has been established in India. The company carefully prepared communication between the R&D centre at home and in India in selecting one or two Indian engineers, appointing one in Germany as the gatekeeper to India while training the other in Germany for a while and then sending him back to India where he can act as gatekeeper from Germany. This is how various automotive companies behave. They look for trained persons knowing both languages and philosophies of working. As discussed in subject 3, the predominant type of synthetic knowledge required to the sector matters. There is a need for engineers being trained in their field of technology. This makes it inappropriate to the companies to appoint foreign or immigrant students from German universities directly. Companies instead prefer to go into the host country or to appoint experts from competing companies.

8.7 Subject 7. Prospective, impact from crisis

In 2008 and 2009, the financial crisis extremely affected the automotive industry in Germany. Passenger car OEMs had to reduce production by approximately 25%, commercial vehicle OEMs by 52 %, suppliers lost orders nearly overnight, in some fields up to 70%. VDA (2010, 14) reported an overall decline of the production index in the sector from a peak in February 2008 of 116.8 to 87.9 in February 2009 and a “recovery” to 96.4 by November 2009 (2005 = 100). Suppliers sometimes faced a decline in turnover by 50% and more, on average the sector lost 25% (VDA 2010). Oliver Wyman (2009), the specialist on the automotive sector among the consultants, gave a warning in early 2009 that “50 to 80 suppliers could collapse in 2009 endangering 100,000 jobs”. Some of the largest mergers seemed to come to a halt, among them the merger of Continental and Schaeffler. Numbers of small and medium sized suppliers went bankrupt, partly because financial investors (foreign private equity agencies) no longer were prepared to bear the losses.

But in 2010, German OEMs and most of the large suppliers returned to full production. Several factors contributed to the quick and unexpected recovery of the sector. First, Federal government subsidized private households for the purchase of a new car (so-called scrapping incentive for buying a new car). This applied, however, only to small cars and, therefore, was mostly in favour of foreign OEM companies from Southern Europe and Asia. Additionally, the tax system for passenger cars was changed in favour of new cars with less polluting motors. Second, Federal government extended labour market regulation subsidizing reduced working hours at the companies up to two years. This enabled firms to reduce lay-offs, safeguard their qualified labour force (or even train it) and restart production quickly. Third, German premium OEMS – and their premium suppliers – profited from rising exports in 2010. Thus, the shock of the crisis was extreme but short. The supporting socio-political environment enabled companies to behave “pro-actively” in the crisis which is reflected by our own survey in early 2010 (Table 150). About 36 % of responding companies reacted by increasing efforts on innovation while the number of defensive and “downgrading” actions such as reduction and relocation abroad of innovative activities was rather low. In sum, it seems that the crisis did neither have a substantial direct effect on production nor on changing innovative behaviour in the automotive industry. The crisis did not stimulate automotive companies to change innovation networks, neither locally nor globally.

Table 150 | How have you reacted (or are planning to react) to the current global economic crisis? Q 14

	percent	number
Few or no changes		5
Increasing efforts at innovation on our part		19
serious reduction of own innovative activities		5
relocation abroad of our innovative activities		3
no info		21
total		53

However, fundamental problems of the German automotive production system have not been resolved. Restructuring at the fringes of the automotive production pyramid is continuing. In the crisis, independent assemblers of niche models such as Karman have disappeared as the OEMs have relocated production in-house. Small and medium sized second and third tier suppliers still are under stress which results in mergers, bankruptcies and closures. Second-tier suppliers attempt to merge in order to get the status of a first-tier supplier (such as Mahle/Behr), and even first-tier-suppliers merge in order to become globally competitive (such as Schaeffler/Continental). The likelyhood for enhanced global innovation networks in the automotive industry will not increase, however, with restructuring at home.

8.8 Subject 8. Looking forward, implications for policy

For many decades, the automotive industry has been characterized by incremental innovation in a rather stable technological regime. We do not deny considerable innovation in product technologies and organisation during the recent twenty years. The “revolution” of the early 1990s brought about modular design, simultaneous engineering in design, flexible production, increased outsourcing and the emergence of a hierarchical pyramid of the automotive production system (often termed post-fordist production), among others. However, in technological terms, extant technologies mostly have been improved and supplemented by electronic devices. This production system still is bound to the domestic market, in terms of client’s wishes. In Germany, the industry has developed into a system producing premium goods, of high quality and high prices. The question arose already before the crisis as to how long this technological and production regime might survive, given shrinking domestic markets and changing consumer requirements in fast growing but less wealthy export markets. The crisis, although seemingly easily overcome, might have marked a turning point in the technological regime. Proff (2010), for example, sees two options for further growth in the German automotive industry, i.e. engagement in BRIC countries where China and India are the most promising target areas, and increased innovation in electro-mobility. Both options would mean a weakening of the German production sites as both require a low cost strategy, a shift of innovative activities to other sectors and countries. Thus, the danger of becoming an old industry, with shrinking markets and shrinking innovative activities, is looming. While we currently cannot speak of global innovation networks in its proper sense in the German automotive industry, these options would, in the long run, reverse the location of innovative activities and promote innovation in emerging countries.

Media and literature are full of similar previews at present. In a similar vein as Proff (2010), the coming Gerpisa Conference in June 2011 will discuss the question whether there is “the second automobile revolution on the way”? However, remind the crisis in the sector of the early 1990s when markets broke down and Japanese competitors became the forerunners in modern, flexible process organisation (“Toyotism”). At this time, observers asked whether the Stuttgart area, Germany’s strongest automobile production region with two premium OEMs and most of the largest first tier suppliers today, would share the fate of the Ruhr Area as “old industrialised region”. Ten years later, it was the most prospering centre of the German automotive industry, and the Stuttgart region still is one of the strongest economic regions today. If observers of today’s development in the automotive sector claim for a radical shift in technology and geography, we still face a strong production system, successful in exports, a strong base of Germany’s economic power, increasing internationalisation with a strong control from the home base, and the home base as a particular base in knowledge and innovation of the sector. There is almost no relocation of central innovative activities abroad in these “old” technologies.

This is underscored by our own survey. Asked for fields where future innovation activities could be supported from policy companies mainly point to improving skill formation and regulation upon intellectual property rights (see Table 151: 11 cases saying “very high need”). Interestingly enough, they do not claim for another migration policy in favour of “expert immigration”. Instead, anecdotal evidence from our case studies and from the media reveal a strong preference for an improved skill formation at home, sometimes realized by own investment efforts into linkages both covering education and research to (nearby) universities.

Table 151 | To what extent do you see the necessity to improve following factors for your innovation activities in the future? Ingineus/DIE survey, Q 13, frequencies

	Very high need	Moderately high need	Moderately low need	Very low need	total
1. Practical support from centres for the internationalisation of innovation and technology transfer	2	19	4	2	27
2.More public incentives and economic support	5	17	5	0	27
3. Better access to international research networks	6	16	6	1	29
4. Higher skills in the labour force	11	17	3	0	31

5. More stringent regulations, practice and jurisprudence around intellectual property rights	11	12	5	2	30
6. Better and clearer rules regarding foreign direct investment and trade	6	12	5	2	25
7. More open and flexible migration policy regulations for employing foreign scientists/technicians/experts	2	13	9	2	26
8. Greater availability of risk capital for innovation activities with an international dimension	5	15	2	2	24
Total	48	121	39	11	219

The literature on innovation in the automotive sector is full of future prospects on environmental aspects. As long as European governments (including the EU Comission) are the main drivers of environmental regulation concerning climate change and European consumers are as challenging as they are today, we can assume that innovative activities will remain bound to the current production and innovation regions within Europe. Certainly, dominance in innovation activities depends from highly educated persons in a satisfactory number. Companies start to become aware of possible shortages in electronic and mechatronic engineers, for example. As numerous examples show, however, they develop a host of instruments to strengthen the education base at home, in close cooperation with local universities. Obviously, this company policy fosters a long-term likelyhood for the centralization of innovation at home, again.

Let us, finally, return to the pyramidal order of the automotive production system and its changes. It is sometimes said that the powerful OEMs increasingly outsource innovative activities to their first and second tier suppliers and to engineering services companies. A brief look at the latter reveals that engineering services companies still serve the national market in Germany. Instead, first and second tier automotive suppliers have developed to more or less large multinationals. Consequently, they are more prone to form global innovation networks. However, our analysis has shown that these companies still prefer a “traditional”, home-based strategy of allocation of innovative activities. This seems to be in contrast to recent studies suggesting an “organisational decomposition of the innovation process” (Schmitz/Strambach 2008) and the assumption of deepening global innovation networks. These studies suggest that global relocation of innovative activities and global innovation networks replace home based innovation more than supplement it. However, as mentioned before, there are technological and strategic differences among sectors. We may hypothesize that the DUI mode of knowledge creation in the automotive industry leads companies to stick to their traditional innovation environment and to learn very cautiously how to relocate some innovative activities to emerging economies. As a consequence, companies in our own case studies follow a trial and error process in developing new tools in knowledge management for overcoming cultural and organisational barriers abroad. In other words, they do not (yet) push forward a strategy of global innovation networks.

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9 ANNEX 9: INTERRIM REPORT COUNTRY SECTOR REPORT AUTO ITALY

AUTOMOTIVE IN ITALY

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Filippo Chiesa

Introduction and methodology

This report draws a picture of the Italian Automotive industry, with particular reference to the innovation and internationalisation process, to assess the extent to which firms in this industry are part of Global Innovation Networks. To this end, we exploit 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 to a total of 1865 firms. The samples is representative of the universe of the Italian automotive industry, which is composed of about 2,600 corporations. 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.

The analysis will highlight that substantial heterogeneity exists within the industry and the knowledge and opportunity regimes as well as the characteristics of GIN may be sharply different according to the segment of the industry. In particular, we will identify five industry clusters: the OEM (original equipment manufacturers), which are split into those supplying (i) modules (MOD) and (ii) systems (SYS) to the final good assemblers; (iii) firms providing engineering and design activities (ED); (iv) specialist firms, which supply parts and components with a high degree of innovativeness and specificity (SPEC); (v) sub-contractors, which produce more standardised parts and components[55].

[55] To illustrate the type of activities carried out by the firms in the different clusters, parts and components supplied by SPEC and SUB include power supply, steering, suspension and brakes, clutch, lightning, vehicle bodies. MOD and SYS produce integrated electronic modules, aluminum, plastics and stainless steel units, security systems, electrics and electronics modules, air and comfort systems, drive and brake systems. ED firms provide style consultancy, product and process engineering, dedicated product platforms, prototyping, logistics, product testing.

In Section 2 of this report we exploit the survey to provide a picture of the type of firms active in the automotive industry in Italy and their main reference market. In section 3 we focus on the nature of the innovation process, while Section 4 highlights the characteristics of the internationalisation process. Section 5 will address the extent of inter-firm collaborations and embeddedness into GINs. Section 6 and 7 discuss the impact of the crisis on the firms strategies and the future prospects for the sector. Section 8 concludes.

9.1 The present nature of sector activities

The most peculiar characteristic of the Italian automotive industry is that there is only one large final good producer in the country: the FIAT Group. This shapes the characteristics of supply chain, since for a large number of firms FIAT is the major client and the geography of production. Since a large proportion of the activities of the FIAT group is located in Turin and the Piedmont region, the automotive industry is also concentrated in the same areas. Table 152 shows this feature rather clearly: 40% of the firms are located in Piedmont and account for approximately 50% of employment (more than 84,000 people employed out of a total of 171,000 in Italy as a whole in 2009) and turnover.

Table 152 | Estimate of 2009 revenues and number of employees in the automotive sector in Italy and in Piedmont

ITALY	# companies	Employees 2008	Employees 2009	Turnover 2008	Turnover 2009	Auto turnover 2009
	100 %	100 %	100 %	100 %	100 %	100 %
Piedmont	0,4	0,5	0,49	0,51	0,51	0,5
Rest of Italy	0,6	0,5	0,51	0,49	0,49	0,5

In describing the nature of Italian automotive supply chain we have to bear in mind that, as in the rest of the Italian economy the average size of the enterprises is relatively small: as documented in Table 153, about 70% of the companies employ less than 50 people (or, as other figures would show, have a turnaround that does not exceed 10 million euros) and the average firm size is below 150 employees.

However, small and micro firms are relatively more frequent among sub-suppliers (SUB) and engineering & design firms (ED), where the average size is well below 100 emlpoyees, while in the case of OEM (SYS and MOD) medium-sized and large companies are more frequent.

Table 153 | Distribution of the sample firms by size class and sector cluster

	ED	MOD	SYS	SPEC	SUB	Total
Less than 10	15.6%	8.0%	16.4%	11.3%	22.2%	18.7%
10 to 49	50.3%	28.0%	13.1%	48.1%	55.3%	51.3%
50-249	27.0%	24.0%	21.3%	32.3%	18.4%	22.7%
250 to 999	5.4%	40.0%	26.2%	6.5%	3.5%	5.7%
1000 or more	1.8%	0.0%	23.0%	1.7%	0.5%	1.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
N. of firms	406	26	67	299	1067	1865
Avg. # of employees	87.5	204.6	1447.8	236.4	63.6	144.6

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

Not only Italian companies are small, they are also farly independent. Table 154 shows that 71% of firms are controlled by individuals: just one enterprise out of five belongs to a national or international industrial group. In recent years researchers have begun to notice some weak signs of aggregation among firms, but in general, the Italian entrepreneurs prefer to stay independent and wait to see their competitors fail, gaining their market share instead of buying them out or cooperate with them. The key role of Piedmont in the industry is confirmed by the fact that in this region the share of Italian headquarter and foreign-owned firms is higher than in the rest of Italy (11% vs. 4% and 7% vs. 4%, respectively).

Table 154 | Distribution of the sample firms by ownership type and sector cluster

	ED	MOD	SIST	SPEC	SUB	Total

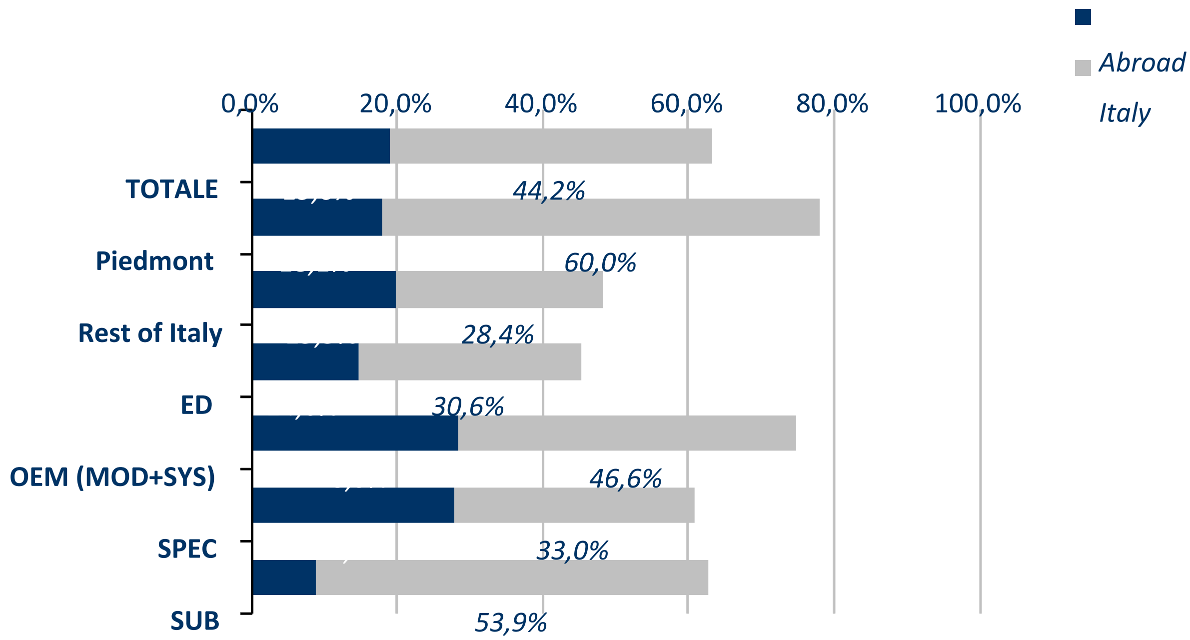
N. Parent companies	7%	12%	22%	11%	7%	8%
N. controlled by Italian group	8%	0%	12%	7%	6%	7%
N. foreign-owned w/out strategic automony	4%	15%	21%	3%	2%	4%
N. foreign-owned with strategic automony	3%	31%	30%	5%	2%	4%
Owned by individuals	67%	42%	7%	64%	79%	71%
Owned by public company	11%	0%	7%	10%	4%	6%
	100%	100%	100%	100%	100%	100%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

However, significant differences emerge also in this regards when we look at the different industry clusters. Affiliates of foreign multinationals account for about 50% of firms in the OEM cluster (MOD and SYS). In order to account for this specificity, in the following analysis we will include separate statistics also for foreign-owned firms.

It is impossible to understand the Italian automotive industry, without taking into account the role of the FIAT group (which includes Alfa Romeo, Lancia, as well as the high-end brand Ferrari and Maserati), which is the only carmaker producing vehicles in Italy.

Table 155 | Total turnover broken down by the share of (direct or indirect) orders orders from firms within the FIAT Group (in Italy or Abroad)



The figure above shows that the dependence of the Italian automotive industry from the FIAT group is substantial 100 euros of revenues in the sector, 44.2 are due to orders within national borders that are – directly or indirectly – linked to Fiat, another 19 euros are due to orders from FIAT production plants abroad (up from 13.6 in 2008). This increase in Fiat's importance is probably due to the fact that last year the group's brands outperformed the competition in the European market (+6.3%, compared to an average -1.6% decrease from 2008 to 2009 in the whole continent). It should not come as a surprise to know that firms in Piedmont show a higher dependence on order from domestic plants of the FIAT group. Substantial reliance of domestic order from FIAT can be seen also for sub-suppliers, while OEM and E&D tend to serve foreign plants. This can be a sign of the higher competitiveness of these producers, which are not easily substitutable by FIAT, which then uses them also when producing abroad.

Summary 1

The nature of Automotive component sector activities in Italy

Italian firms in the automotive sector are, as most Italian firms, relatively small and independently-owned. Foreign-owned firms are few and concentrated among OEM producers. Market opportunities in the industry are largely shaped by the role of the FIAT Group accounts for a large share of average sales. Identifying 4 different market clusters in the industry, we notice that sub-contractors (SUB) are selling a large part of their output to FIAT's domestic plants. Instead, OEM -which include producers of modules (MOD) and systems (SYS) - and SPEC are also suppliers to FIAT's foreign plants. Engineering and Design (ED) firms are the least dependent on FIAT, probably because they are more diversified also in non-automotive sectors.

9.2 The nature of innovation and knowledge in the sector

Despite the challenges of a difficult year (2009), it seems that Italian automotive enterprises were able to avoid sacrificing research and development. While R&D expenditure was reduced in absolute terms, the decrease was in line with the fall in revenue, or relatively smaller: the percentage of sales revenue spent on research and development activities in 2009 was 2.6%. However, behind this average there is a significant change in the distribution of R&D expeditures. If we compare the distribution of firms by R&D intensity in 2009 with the same distribution for 2008 (Table 156), we can notice that during the crisis the number of firms investing more than 5% of their revenues on R&D activities dropped by almost 3 percentage points (from 10% to 7%), while the share of firms investing between 2 and 5% fell by 6 percentage points. Conversely, the percentage of firms that spent less than 2% has increased from 63,8% to 73,6%.

Table 156 | Investments in R&D 2008 – 2009

	2008	2009
Less than 2%	0,638	0,736
Between 2% and 5%	0,262	0,194
Between 6% and 7%	0,027	0,009

Between 8% and 10%	0,07	0,057
More than 10%	0,002	0,002
Total	1	1

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

If we analyse the behaviour of the firms active in the different market segments defined earlier, we can notice that the propensity to invest in R&D (more than 2% of their sales) is particularly low among the SUB (10%) and the MOD (23%). Interestingly, in the latter group the R&D intensity (among the firms investing more than 2% of their sales in R&D) is particularly low (3.7%) and this may be due to the fact that these firms belong to international firms which have their research centres in an other countries, and the R&D carried out in Italy is mainly adaptation of foreign technology. However, a closer look at the data reveals that this is not a general pattern, since foreign-owned firms are on average very keen on investing in R&D in Italy.

The companies most engaged in R&D are E&D and SPEC, since in order to compete they are forced to innovate.

Table 157 | Investment in R&D, by sector cluster and foreign ownership

	All firms						Foreign-owned
	ED	MOD	SIST	SPEC	SUB	Total	
% firms investing more than 2% in R&D	44%	23%	51%	85%	10%	31%	65%
Share of R&D/Sales	5.4	3.7	5.1	5.9	4.8	5.5	5.1

(in firms investing 2% or more)

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

As for the the extent and type of innovation activities, Table 158 highlights that 65% of firm engaged in some innovation over the last three years, and, consistently with the previous evidence SUB are the least innovative firms, while SIST and SPEC (together with foreign-owned firms) are much more likely to engage in innovative activities. Process innovation is the most common form of innovation in all clusters, while the extent and type of product innovation differ across industry segments: products new to the market are mainly introduced by ED and SPEC (and foreign-owned firms). SUB declare a high propensity to innovate products, but only 15% of firms in this cluster actually introduce radical innovation. As a confirmation of the relatively marginal innovation in this group of firms, only of innovators 7% actually apply for a patent. Conversely, 36% of system integrators (SIST) actually patent their product. This tells us something on the differentiated types of knowledge incorporated in innovation in the different clusters. SYS firms produce more codifiable knowledge which is more easily appropriated by patents. In other clusters, such as the engineering and design (ED), despite a very high propensity to introduce radical product innovation, tacit knowledge is crucial and more easily appropriable but the innovating firm.

Table 158 | Share of firms by type of innovation, sector cluster and foreign ownership

	All firms						Foreign
	ED	MOD	SYS	SPEC	SUB	Total	
Innovating firms (a)	71%	77%	84%	85%	55%	65%	85%
% firms doing process inno as a share of (a)	75%	84%	86%	84%	84%	82%	86%
N. firms doing product inno new to the firm as a share of (a)	52%	25%	37%	56%	49%	49%	51%
N. firms doing product inno new to the firm new to the mkt as a share of (a)	30%	16%	19%	27%	15%	22%	26%
N. firms applying for patents as a share of (a)	18%	16%	36%	19%	7%	14%	21%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

The investments on research, development and innovation have their outcome in the composition of total revenues. As shown by Table 159, 1 euro out to 5 derives from innovative products, and this rate reaches 50% if we focus on companies such as Engineering and Design, and 27% for OEM that are more exposed to the international competition. The rest of the revenues comes from mature products (or services) which still allow sufficiently high margin (about 50% of the total turnaround), while the remaining 33% of turnaround derives from products that have narrow margins, and thus need that need to be substituted or updated in the near future. It is rather interesting to note how this distribution of the revenues differs across clusters: ED firms rely mostly on innovative products. This is consistent with the idea that in this cluster, products and services are highly customized and thus necessarily they tend innovative. Not surprisingly, SUB firms have the lowest share of sales from truly innovative products, and most revenues comes from mature products, where cost effectiveness is the key competitive advantage. Instead, it is rather surprising that for SPEC firms, which have a high propensity to patent and introduce radical innovation, 47.8% of the revenues is due to products where margins are narrow. This may have to do with the fact that these firms face a high international competition, and even for new products the market power is limited to a relatively short time window, thus firms need to introduce new products as a faster rate.

Table 7 - Turnaround by type of products (as a share of 2009 revenues).

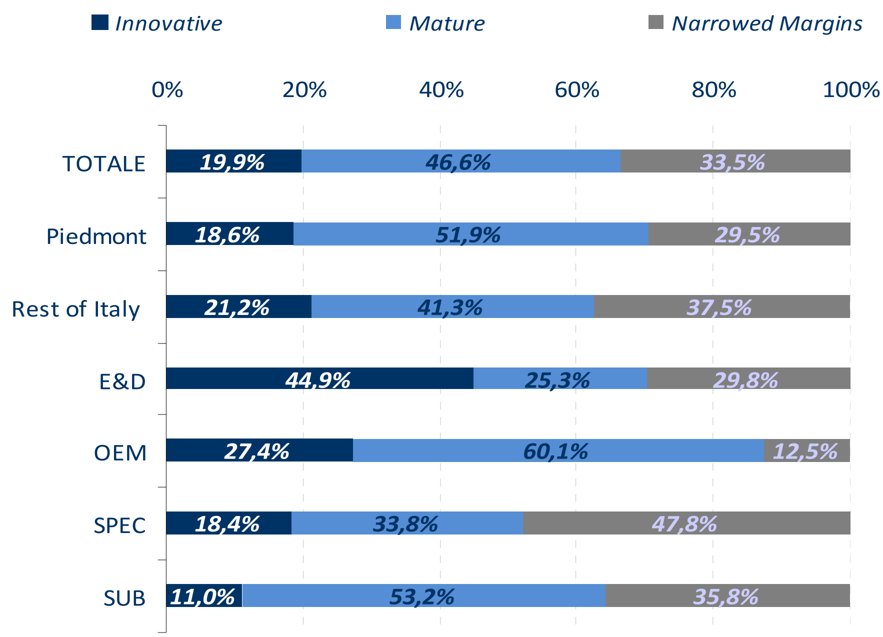


Table 160 helps us understand the sources of knowledge for innovation in the Italian automotive sector. Information internal to the firm or the group is the most frequent source of knowledge used for innovation. This is true for all clusters within the industry, but it appears particularly relevant in the case of foreign-owned firms. This is consistent with the idea that Italian affiliates of foreign multinationals use knowledge from their internal R&D labs, but also from the parent companies and from other affiliates. As a matter of fact, one key advantage of being part of a multinational network is exactly the ability to leverage knowledge generated elsewhere in the group, and contextualize it in local markets. The second most important source of information are clients, and this is particularly the case for OEM (MOD and SYS). This is consistent with the idea that these firms are large, internationalised and networked firms, which can leverage their presence in many markets, and their relationships with important customers (which are mainly the carmakers) all over the word. As a matter of fact, as we will show in the next section, these firms have a substantially higher propensity to rely on international links with other firms and institutions.

Universities and research centers are source of information for 16% of firms, but this share is much smaller among SUB firms, while collaborative research projects with other firms is slightly less common but more evenly distributed across clusters. Suppliers are a source of information for less than 10% of firms, and SYS firms stand out again as the group relying more to this source of knowledge. In sum, a rather differentiated pattern emerge within the industry in terms of the extent to which innovation results from networking with other firms and institutions. SYS firms appears the more networked firms, due to the fact that they need to combine different technologies into a complex system. To this end, they heavily rely on information from suppliers of different pieces of the systems they produce and clients which provide feedbacks on the specific needs to adapt a system to their particular product. At the same time, substantial collaboration with Universities is needed in order to have access to the latest technologies.

Table 159 | Sources of information for innovation, by sector cluster and foreign ownership (share of firms)

	All firms						Foreign
	ED	MOD	SYS	SPEC	SUB	Total	
Internal to the enterprise or group	86%	75%	80%	79%	75%	79%	87%
Clients	25%	50%	45%	32%	34%	32%	35%
Universities, research centres	22%	0%	40%	23%	9%	16%	23%
Research projects with other enterprises	10%	0%	10%	14%	11%	12%	11%
Suppliers	8%	0%	15%	10%	8%	9%	10%
Competitors	2%	0%	0%	3%	1%	2%	0%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

Comparing data from the 2010 and 2009 survey, we uncover a trend of increasing networking: 30% of the sample firms state they clients an important source of knowledge in 2010, compared to only 20% one year before; while 10% mention suppliers as a source of knowledge, compared to 5.3% year before. Partnership with other companies also appear an important (and slighty increasing) source of knowledge (10.6%, compared to 7.5%). Even if the cooperation level with partners or others infrastructures is still limited it has increased in the last 3 years: the growth is still very slow but there are signs that some firms starting to understand that in order to overcome some structural weaknesses due to the relatively small size, it is necessary to join ideas, investment and infrastructures**.**

It is also worth mentioning that in the last two years the rate of companies that carry on internal R&D activities rose from less than 70% to more than 95%: this means that every company has understood that some kind of research and development activity is necessary. Even companies that do not have a design or development process, they devoted some efforts to scouting the market, new products, the quality of their product or the efficiency of they production process. However, some of these internal activities are not systematic, and they often do not occur in R&D lab. For example, during an interview an entrepreneur said that he had improved the melting process by reading over a technical manual from his former high school studies. Thanks to that knowledge he had sensitively reduced the cost of his process to building some parts of the gear box for a client such as Porsche. This anecdote underlines the strategic role that the industrial culture played for many local Italian clusters (not only in the automotive industry). That culture has created a class of people sharing the same values and technical knowledge from the very years of their technical high schools. Recently talking with a southern entrepreneur she said that she is engaged in improving the technical structures (laboratory) in the local high school because she is aware of the importance that this first step has in the production of knowledge and local industrial culture.

9.2.1 Summary 2

The innovation process of in the Italian Automotive component sector

Innovation and knowledge development appear markedly different across industry clusters. SUB and MOD have a low propensity to invest in R&D, introduce radical innovation, and patent their new products and processes. Consistently with the nature of their innovation activities, these firms' product portfolio include mainly mature products. On the contrary, ED and SPEC have the highest propensity to invest in R&D and introduce radical product innovation, but the latter derive a large share of sales from product with narrow margins, probably due the fact that they face a high international competition. Due to the more codifiable nature of technology, SYS have the highest propensity to patent their new products and processes.

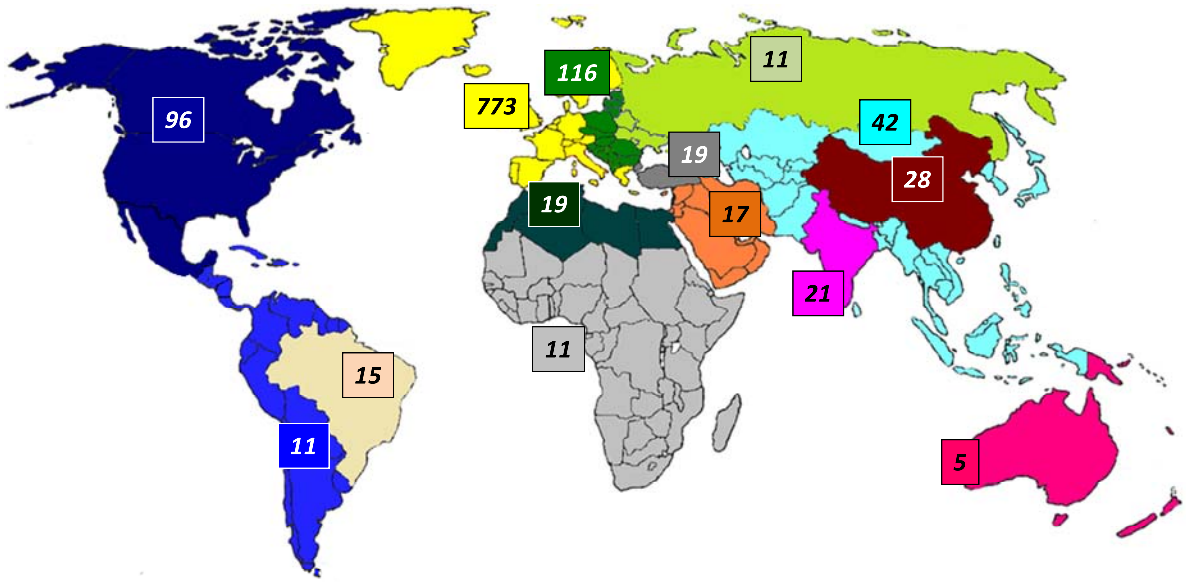
Differences in the innovation process emerge also when we look at the sources of information for innovation. While clients are the most important external source of information for all firms, this is particularly the case for OEM firms, which have to customize their products to the specific needs of their clients. ED and SPEC, which operate closer to the technological frontier (as indicated by the intensity in radical innovation reported above), have a higher propensity to collaborate with University and research institutes. On average, SYS firms, which are the firms which need to combine different types of knowledge and technologies into complex and modular products, are the more networked firms.

9.3 Locations and internationalization

Despite their relatively small size, Italian automotive firms established a rather strong presence in international markets. According to our survey, 62.5% of the firms were able to sell their products and services abroad and on average export accounted for 28% of total sales. Although the largest destination markets are usually within Europe, firms are engaged in export activities also towards non-European countries.

In Figure 1, we map the response of firms to a question regarding the three most important foreign markets. The bulk of these top destinations are in Western and Eastern Europe (773 and 116 instances), North America (96) and Asia (including Cina and India). However, distance seems to matter, as North African countries is indicated as a top market in 19 cases, while India, which should be a far more attractive market appears only 21 times, and China 28.

Figure 1 – The top 3 foreign markets (number of occurrences reported by exporters)



As already show throughout this report, the average hides significant differences across industry clusters: SUB are the least internationalised firms, while SPEC and SYS are more export oriented. In particular, SPEC appear the more likely to engage in export activities, but SIST denote a remarkable export intensity. Furthermore, if SUB, which instead appear more reliant on national clients belonging to the FIAT group. Conversely, export intensity is higher for SPEC and SYS. Interestingly, SPEC have the highest average share of export, but lowest share of sales to foreign firms belonging to the FIAT group: the high export intensity of SPEC firms is mainly due to sales to clients outside the FIAT group. Results suggest, as expected, a correlation between innovation and exporting activity. As a matter of fact, SPEC and SYS are both the more likely to be innovative and to be exporters. In line with this interpretation, also foreign-owned firms in Italy appear to be among the more innovative and export-oriented firms.

Table 160 | Exporting activity, by sector cluster and foreign ownership

	All firms	Foreign

	ED	MOD	SYS	SPEC	SUB	Total	
%. exporting firms	70.4%	69.2%	71.6%	78.6%	54.3%	62.5%	74%
Avg. Share of Export Sales	32.0	34.9	36.4	36.5	23.5	28.0	38.1
Avg. Share of sales to foreign clients belonging to FIAT group	*23.0*	*32.1*	*36.3*	*21.3*	*24.9*	*24.5*	29.1
Avg. Share of sales to foreign clients outside FIAT group	*39.7*	*32.7*	*42.7*	*40.2*	*36.7*	*38.3*	42.2

The internationalization of automotive producers has been marked by an increasingly direct presence with production plants abroad in the past few years. The number of plants that were opened and closed in different geographical areas during the year shows that the biggest positive balance is beyond national borders. Table 161 provides details on the share of firms which were already multinationals in 2008 (i.e. they reported that their company had employees abroad) and those that become multinationals in the last two years, or increased their presence abroad, by opening new plants abroad. Only 2.3% could be defined as multinationals in 2008 but, once again, behind this average we have SUB, among which less than 1% are MNCs, and SYS and SPEC, where multinationals are much more frequent. Interestingly, firms opening new plants abroad are as much as existing MNCs, suggesting that in the last two years the Italian automotive industry have experienced a significant trend towards international production, which characterizes all industry clusters.

Table 161 | International production, by sector cluster and foreign ownership

	All firms						Foreign
	ED	MOD	SYS	SPEC	SUB	Total	
% firms with employees abroad (MNCs)	3.4%	3.8%	6.0%	4.7%	0.8%	2.3%	5%
% firms opening plants abroad	3.0%	3.8%	9.0%	5.0%	1.6%	2.7%	1%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

9.3.1 Summary 3

The degree of commercial and productive internationalization in the Italian Automotive component sector

Exporting is frequent, but most firms serve nearby markets (mainly in Europe) and a large part of exports is directed towards FIAT plants abroad. Emerging markets are served only by a handful of firms. Instead, opening plants abroad (i.e. becoming multinationals) is very rare. This reveals that Italian firms in this industry may face substantial difficulties in overcoming the cost and uncertainty of doing business abroad and prefer to go the easy way, instead of targeting the most profitable markets and engage in more commitment intensive internationalization. A clear link emerges between innovation and internationalization: SUB and MOD are the least internationalized, while SPEC and SYS, which are also the more active in radical innovation, have a remarkable propensity to export and open plants abroad.

9.4 Sector embeddedness in GINs

Italian internationalisation in automotive cluster is still characterised by the first internationalisation stage: commercial relationship, often driven by the main Italian or foreign historical client. Not many companies have plants abroad, even if, as we noticed above, their number is increasing.

If we look at internationalisation in a broad sense, and extend beyond exporting and producing in plants owned by the company, we get a more articulated picture. Table 162 reports the share of companies that report carrying out business activities abroad, not necessarily within the boundaries of the firm. We report results for Italian-owned firms and for foreign-owned separately, in order to avoid inflating results with data on affiliates of foreign multinationals in Italy, which are clearly more likely to be part of a group which carries out business activities abroad. As a matter of fact, foreign-owned firms have a very high propensity to carry out business activities abroad (i.e. in their headquarters or other affiliates of the group. Interestingly, Italian affiliates of foreign multinationals report a relatively low propensity to do product innovation and technological development abroad. This may indirectly support the idea that these firms invest in Italy to tap into specific sources of knowledge (from clients, suppliers and research institutions). On the contrary, only about 2% of Italian-owned firms carry out any activity abroad. The business functions which are more frequently performed abroad, are strategic management, product innovation and marketing, while technological development is the least likely to be carried out abroad. These results suggest that only a handful of Italian are actually carrying out activities abroad, but those few of them are really embedded in global production and innovation networks. Still the core of technological developments rely on activities carried out in Italy. In other words, one could have expected that firms would be less keen on internationalising strategic activities, while the evidence says otherwise: firms are almost equally likely to perform marketing, product innovation logistics and production activities abroad. Differences across cluster are again striking: while up to 5% of ED carry out activities abroad, only about 1% of SUB do. Furthermore, the latter are more likely to do logistics abroad, ED concentrate on marketing and customer services abroad.[56]

Table 162 | Firm propensity to perform business activities abroad, by sector cluster

	Italian-owned						Foreign
	ED	MOD	SYS	SPEC	SUB	Total	
Strategic management abroad	4.1%	0.0%	25.0%	2.4%	1.2%	2.4%	66.7%
Marketing, sales, customer svcs. abroad	5.1%	0.0%	31.3%	0.8%	0.7%	2.2%	62.8%
Product innovation abroad	4.1%	0.0%	18.8%	2.4%	1.2%	2.3%	25.6%
Logistics abroad	2.6%	0.0%	25.0%	0.8%	1.4%	2.0%	39.7%
Production abroad	3.1%	0.0%	25.0%	2.4%	1.1%	2.1%	43.6%

[56] SYS firms show high propensity to perform business activities abroad, but we prefer not to comment too much on that, given that only 16 Italian-owned SYS firms are in the sample, as opposed to 563 SUB, 124 SPEC and 196 ED.

Technological development abroad	2.0%	0.0%	25.0%	0.0%	0.7%	1.3%	28.2%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

The embeddeness of Italian automotive firms in GIN can also be assessed exploiting the information on the sources of information for innovation. This aspect has been analyzed also in Section 2 (Table 159), but here we focus on the propensity to rely on foreign sources of innovation. Table 163 report the share of firm reporting foreign sources as a share of all firms that use each specific source of information for innovation. Here again we distinguish Italian-owned firms from affiliates of foreign multinationals in Italy. The propensity to use foreign sources is the highest in the case of information coming from clients and competitors, while it is lower for sources of information within the group. This is consistent with the idea that the internal network of Italian firms abroad is limited, but they exploit non-equity relationships to establish a global external network with clients and competitors abroad which foster their innovation activity. Furthermore, the relatively low propensity to engage in research projects with other enterprises abroad is consistent with the idea that this networking is mostly informal, and does not fall into formalized joint research projects. Interestingly, this pattern is rather homogenous across industry clusters, despite the high heterogeneity within the industry, which we have documented in the previous sections. As one would expect, foreign-owned firms have a higher propensity to rely on foreign sources of information within the group (i.e. the headquarters' research labs), and have a higher propensity to establish links with foreign Universities (i.e. in the home country). The tendency to embed in informal global innovation networks appear mostly as an Italian characteristics, while foreign multinationals have a relatively high propensity to engage in joint research projects with other firms abroad. This is consistent with a tradition of informal cooperation among Italian firms, which is the type of interactions we observe among clients-suppliers and competitors in industrial districts.

Table 163 | Firm propensity to utilize foreign sources of information for innovation, by sector cluster and foreign ownership

	Italian-owned	Foreign

	ED	MOD	SYS	SPEC	SUB	Total	
Internal to the enterprise or group	6.1%	0.0%	11.1%	6.0%	8.6%	7.3%	20%
Research projects with other enterprises	9.1%	--	50.0%	11.1%	14.3%	13.6%	43%
Clients	40.0%	50.0%	50.0%	50.0%	40.5%	43.1%	50%
Suppliers	10.0%	--	--	23.1%	38.1%	27.3%	33%
Competitors	33.3%	--	--	75.0%	0.0%	44.4%	--
Universities, research centres	12.0%	--	25.0%	10.7%	27.3%	16.5%	43%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

9.4.1 Summary 4

Embeddeness in GINs in the Italian Automotive component sector

Only a handful of firms carry out some business activity abroad, but those few engage in a variety of activities, ranging from strategic management, marketing, product innovation, production and logistics. Thus, these firms appear rather embedded in GPNs and GINs. However, the propensity to internationalize core technological development activities is still lower than for the other business activities. This may reflect the fact that Italian prefer to concentrate the activities which are perceived as strategic for their competitive advantage. Consistently with previous evidence, SUB are the least prone to offshore activities, while ED are the more likely to perform activities abroad. It is worth mentioning that these firms are not particularly internationalized, in terms of exports and/or foreign production. However, these firms are mainly providing services, so for them internationalization may take more subtle forms, which may not be captured by standard measures.

The embeddeness of Italian automotive firms in GINs, can also be measured by their propensity to use foreign sources for innovation. This is the highest in the case of information coming from clients and competitors, while it is lower for sources of information within the group. This is consistent with the idea that the internal network of Italian firms abroad is limited, but they exploit non-equity relationships to establish a global external network with clients and competitors abroad which foster their innovation activity. Furthermore, the relatively low propensity to engage in research projects with other enterprises abroad is consistent with the idea that this networking is mostly informal, and does not fall into formalized joint research projects. Interestingly, this pattern is rather homogenous across industry clusters, despite the high heterogeneity within the industry, which we have documented in the previous sections. The tendency to embed in informal global innovation networks appear mostly as an Italian characteristics, while foreign multinationals have a relatively high propensity to engage in joint research projects with other firms abroad. This is consistent with a tradition of informal cooperation among Italian firms, which is the type of interactions we observe among clients-suppliers and competitors in industrial districts.

9.5 Impact from the crisis

Beginning in the fall of 2008, the financial crisis spread to the market for durable goods and, eventually, cyclical goods like cars and other motor vehicles. After 6 years of worldwide market growth, the trend turned on its head leading to new-vehicle sales decreasing from more than 62 million in 2007 to approximately 57 million in 2009. Production came to an even worse standstill; after the record-breaking output levels of 73 million units in 2007, 2009 recorded a mere 61 million. In one year (2009), the decrease in the number of units produced was almost 10 million (-13.5% compared to 2008).

Within the context of a widespread crisis, not all continental and national markets behaved in the same way. Amongst mature markets, some suffered substantial losses (-21.4% in the United States) while others were able to limit the damage (-3.4% in Western Europe) thanks to government incentives on the purchase of new cars and commercial vehicles. On the other hand, the most important emerging markets (except for Russia’s -48%) continued to record positive growth rates, ranging from India and Brazil’s +11% to China’s 45.5%. In fact, their share of the total new-vehicle sales in the world went from 29% to 36% in only twelve months.

And what’s in store for the near future? While the International Monetary Fund expects world GDP to bounce back to 4.6% this year, most operators suggest 2010 will be a year of transition for the automotive sector, marked by government incentives gradually running out and consumer confidence still affected by the uncertainty of recovery and the high levels of unemployment. New-vehicle sales are not expected to return to pre-crisis levels (2007) much before the end of 2011 or the beginning or 2012.

It rather well known that the global crisis hit the automotive industry more than any other in manufacturing: in 2009 production dipped by 10 million units worldwide, and by -17.6% in Italy compared to 2008. Consequently, the Italian sector's revenues decreased by 15.8% during 2009, going from 49.6 billion euros in 2008 to 41.7 billion euros. The crisis has hit the sector in a similar way across territories and market segments: in Piedmont turnover dropped by 16.5% compared to 2008, and the fall ranged between 13.6% for modules and systems suppliers, to 17.1% in the case of specialists. More in-depth analyses suggest that only the major companies were able to cut losses, as they could count more updated and innovative products.

The markets' prolonged halt brought productive capacity utilization under 70%, far below the level allowing for profitability (which is around 80%), with inevitable consequences on the financial results achieved by both assemblers and component manufacturers. During the two years under examination, the 10 largest automotive groups recorded an overall 38% decrease in their stock market value. The 12 largest groups in the world in terms of sales suffered losses for 26.2 billion euros in 2008 and 2.7 in 2009, with a 13.9% decrease in revenues in the same year.

As reported in the last Observatory on the Italian Automotive industry, exports, which are worth over 42.6% of total revenues, decreased at about the same rate as total revenues: -15% on average, and -12% for Piedmontese enterprises. The latter, however, confirmed they have established a stronger presence in international markets, as 69% of them were able to maintain orders from abroad (compared to 58.5% in the rest of Italy). At the same time, dependence on Fiat rose, reaching 63.2 euros out of 100 (compared to 47.8 in 2008).

The causes for this, however, can be considered more temporary than structural, as it is the result of an increase in market share of the Fiat Group in 2009). In Piedmont, the same figure rose to 78.1. R&D expenditure did not falter: while decreasing in absolute terms, its reduction was proportional to revenue, if not relatively smaller. Finally, Fiat's plan for 2010-2014 holds great opportunities for the whole automotive sector: if only three quarters of its goals are achieved, Italy's output in 2014 would reach almost 1.5 million motor vehicles – returning to levels last recorded in 2002, 18% above the average output of the last decade.

Unlike in past years, the reduction in revenues affected all analyzed Italian territories and product segments equally; the range of variations spans from -13.6% (modules and systems suppliers) to -17.1% (specialists). Enterprises headquartered in Piedmont record a 16.5% decrease, not far from the rest of Italy's -14.9%.

By breaking this down, we can note that exports (worth over 42.6% of the sector's total revenues) decreased by 15% on average in the sample and by 12% in Piedmont, in line with total revenues.

To overcome this very tough period Italian automotive enterprises show coherent responses with their characteristics described before. From Table 164 we see that they mainly plan to invest in production rationalisation (56.6%) and look for new clients (55.1%). One out of three invest in new or better product: to push product's innovation more than 1 out of 4 asking public authorities to have grants. Only 12% are looking for agreements or projects with other enterprises, and 1 out of 5 indicates the intention of invest in workforce training. Relatively unfrequent is to rely on delocalisation (2.4%). However, some differences exist across industry clusters: OEM (ED and SYS) firms, which are the largest and more internationalized firms, display a higher propensity to react by delocalizing production, while SUB which, as we have illustrated in this report, are usually smaller, less innovative and more inward-oriented, do not see delocatisation as a viable option. This is consistent with the idea that internationalisation of production is a costly strategy, and not all firms may embrace it.

Table 164 | Firms' reaction to the economic crisis, by sector cluster and foreign ownership

	All firms						Foreign
	ED	MOD	SYST	SPEC	SUB	Total	
Rationalize production	49.7%	69.2%	64.3%	59.3%	57.7%	56.6%	66.2%
Search new clients	53.8%	38.5%	32.1%	61.7%	55.2%	55.1%	44.6%
Launch better product	36.7%	7.7%	21.4%	36.4%	30.8%	32.5%	35.1%

Training personnel	23.6%	23.1%	32.1%	13.0%	16.3%	17.9%	29.7%
Look for partnerships	12.6%	7.7%	7.1%	17.9%	9.6%	11.7%	9.5%
Delocalise production	0.5%	23.1%	10.7%	3.1%	1.9%	2.4%	12.2%

Source: INGINEUS Survey on the Italian Automotive Components Industry (2009 and 2010)

As for the requests for public intervention, firms ask for measures to reduce their clients insolvency by achieving more certainty in payments (68.9%) and guarantee fund for their debts (36.4%). Funding for innovation and workforce training are perceived as relatively less important to help firms face with the crisis.

9.6 Looking forward

While the crisis obviously affected the Italian automotive sector's results, we must note that some enterprises were able to face it: 24% of the sample stated that revenues in 2009 were in line (or higher) with those of 2008. From a more in-depth analysis of interviewees who claimed an increase in revenues, we can note that they are particularly active in the field of innovation (80%), both for cost reduction and productivity increase (63%) and for product improvement or new product development (about 40%). These enterprises not only have ideas, but patent them (11.6%, compared to 4.9% in the whole sample) to defend completely new products (20%, compared to 13.4% in the whole sample). They are more sensitive than average to partnerships with other enterprises and suppliers, and to cooperation with universities. Many of them were given an advantage by a higher degree of product and client (both in Italy and abroad) portfolio diversification, and by a market presence that proved more solid than others': ranging from cars to the aftermarket. These enterprises focus on green technology products more decisively than average (36.2% of them, compared to 22.6% of all interviewees).

Another positive feature that seems important is size. Breaking down the variations in

revenue in the sample by size class shows that last year large enterprises lost 13.8%, medium ones lost 20%, small ones lost 21% and micro ones lost 18.4%. Large enterprises have a product portfolio that is more up to date and rely on products that are not competitive 12 anymore only for one fourth of their revenues (the figure is 50% of revenues for micro enterprises). This can be tracked back to the fact they have more resources to put into R&D (2.8% compared to 2% in micro and small enterprises), and have a stronger penetration in international markets.

These will all be ingredients for success, to use in order to seize the opportunities that

will emerge from the new phase Fiat is opening: supposing at least three quarters of its goals are achieved, Italy's output in 2014 would reach almost 1.5 million motor vehicles – returning to levels last recorded in 2002, 18% above the average output of the last decade. The group has 26 billion euros on budget for investment capital expenditure in the next 5 years, plus R&D and Chrysler investments; including Chrysler's activities, it will purchase over 60 billion euros in goods and services. And this is an opportunity the Italian automotive sector is certainly capable of seizing.

9.7 Concluding remarks

This report investigates the characteristics of the Italian automotive industry with special reference to the innovation and knowledge generation process, the degree of internationalisation and the embeddedness of firms into GINs. Exploiting a collaboration with the Chamber of Commerce of Turin, which administers every year a survey to a large and sample representative of universe of the Italian producers of automotive components, we were able to collect data on 1865 firms over two years (2008 and 2009). Following an established methodology of the Chamber of Commerce of Turin we identified 5 industry clusters within the industry: the OEM (original equipment manufacturers), which are split into those supplying (i) modules (MOD) and (ii) systems (SYS) to the final good assemblers; (iii) firms providing engineering and design activities (ED); (iv) specialist firms, which supply parts and components with a high degree of innovativeness and specificity (SPEC); (v) sub-contractors, which produce more standardised parts and components. Results reveal that it would be misleading to consider the industry as whole, without recognizing the peculiarities of individual clusters within the sector.

Market opportunities in the industry are largely shaped by the role of the FIAT Group, which accounts for a large share of average sales, but this is differentiated across clusters. While SUB are selling a large part of their output to FIAT's domestic plants. Instead, OEM and SPEC are also suppliers to FIAT's foreign plants.

Splitting the industry into the 5 clusters allow us to appreciate that SUB (which is the largest cluster, accounting for about 60% of all firms, and featuring mainly small-sized firms) and MOD (a small cluster with medium-sized firms), produce rather standardized products and are the least innovative and internationalized. Consistently with the nature of their innovation activities, these firms' product portfolio include mainly mature products. In these clusters neither GPNs nor GINs can be detected. On the other hand, SPEC and SYS produce highly innovative products, tailored to the specific needs of individual customers, which also require extensive networking with Universities and other firms. Due to the more codifiable nature of technology a different types of knowledge and technologies into complex and modular products, SYS have the highest propensity to patent their new products and processes and are the more networked firms. ED firms is a peculiar cluster, since it is probably the more diversified also in non-automotive sectors. For this reason ED firms are the least dependent on orders from the FIAT Group. Furthermore, these firms provide mainly services, which are most often radical innovations, but that not always can be patented, and which stem mostly from within the group and rarely from networking activities.

10 ANNEX 10: INTERRIM REPORT COUNTRY SECTOR REPORT AUTO BRAZIL

WP 9 Country sector report:

AUTO IN BRAZIL

Gustavo Britto

Eduardo Albuquerque

Otávio Camargo

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10.1 Introduction

The objective of this report is to analyze the dynamics of GIN formation in the Brazilian Automotive sector. WP9 aims to answer two key questions. First, what GIN patterns, if any, can be observed in the country. Secondly, to what extent the observed patterns are determined by the sectoral dynamics.

The report presents empirical evidence collected from a variety of sources, introduces a preliminary interpretation of the key patterns observed in the data, and advances a discussion of the limits of GINs in the country.

The analysis of collected data suggests that the GIN identified in Brazil shows an immature (incomplete) and intermittent structure. This thesis is supported by data from the National Innovation Survey (PINTEC), the INGINEUS innovation survey and by eleven case studies carried out for WP5 and WP6.

Data from PINTEC reveals that the automotive sector has traditionally been one of the largest investors on innovation measured, both as expenditures with innovative activities and on R&D specifically, within the manufacturing industry. The levels of expenditure shows a growing trend since 2003, reflecting the sectors' stage of development as will be seen in section two of this report. However, the R&D effort is still concentrated on large automakers and a handful of (multinational) systems and parts suppliers.

The dynamics of the GIN is largely primarily determined by the leading multinational automaker and, to a lesser extent, by isolated initiatives of multinational suppliers, both of which operate under the restrictions of the local branches' position in their respective global division of labor. The progression of the local GIN towards a pattern akin to that observed elsewhere, mostly in the ICT sector in Asia, depends crucially on substantial changes in the local institutional arrangements and as well as on supporting policies.

The report is divided in five sections including this introduction. Section two brings details on the data used throughout the report. Section three is composed of an overview of the recent history of the automotive sector in the country and in the State of Minas Gerais, in particular. Section four presents key indicators from PINTEC in order to present a clear picture of the state of innovation in the auto sector as well as recent trends in the last decade. Section five follows with a detailed analysis of the data from the INGINEUS survey. Finally, section six includes the general analysis of GINs formation and dynamics in Brazil.

10.2 Data Sources

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). This data is key to demonstrate the relevance of the automotive sector in terms of innovative effort in comparison with the manufacturing industry as a whole. The second source is the INGINEUS survey. In Brazil, companies located in the State of Minas Gerais compose the survey sample. The state is home of large multinational automakers and of a significant part of their supply chains. Finally, the analysis also benefits from six case studies that focused on the formation of GINs broadly speaking, and on further five case studies that focused on aspects of competence building within GINs.

INGINEUS Survey Sample

The survey was carried out on a sample of firms, which was created based on three distinct sources:

(a) The Annual Registry of Social Information (RAIS)

RAIS is a registry of social and balance sheet information collected by the Labour and Employment Ministry and it is mandatory for all firms formally registered in the country. The dataset is made available by the Ministry annually with a two-year lag.

From the dataset all manufacturing firms classified as pertaining to the automotive sector, defined by the company’s highest source of revenue, from the state of Minas Gerais were extracted, provided the firm declared over 30 employees.

The total number of firms classified in the automotive sector in Brazil is 2,625. Out of these, 233 companies are located in the state of Minas Gerais. Of these companies, 107 (46%) have employed, in 2008, 30 workers or more.

(b) Auto-parts Union Contact List (SINDIPECAS)

From experience, the number of firms which are part of the automotive chain of production tends to differ from the companies which are formally classified as part of the sector. This problem is particularly important for companies that produce a large number of goods making the formal classification less meaningful. For this reason we anticipated our case study (GIN of local FIAT) in order identify companies that are part of the chain of production.

One of the possible sources is the Auto-parts Union. The Union keeps a database of all affiliates companies. The downside of this source is its maintenance, given that the companies' details are update sporadically. Regardless, we took on the information available and updated the details using information available online.

(c) Other known suppliers

Further to the Union List, we had already gathered data from interviews with employees of a few key companies in the automotive sector. These interviews rendered a number of contacts of local suppliers. These contacts were added to the sample.

Sample Size, Procedures and Results

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 from companies that closed between the last year of availability of the date sources and the present day, companies without complete contact information (name, address, sector, phone number and potential interviewee).

10.3 The automotive industry in Brazil: a general outline

The automotive industry was established in Brazil during the second half of the 1950s, having experienced continuous growth until the early 1980s. During this period, there were two market cycles of growth with diverging characteristics, the first ranging from 1957 to 1967 and the second one from 1968 to 1980. The former comprehended the establishment of vehicle production proper, while the latter completed the process of building the automotive industry as a whole, with the arrival of other important multinational corporations. The 1980s was marked by a strong contraction of the automotive industry's activities, due to the severe economic crisis that that Brazilian economy was facing.

The manufacturers and the auto-parts companies installed and developed themselves via two different processes which led to distinct market structures – although they were obviously interrelated. The manufacturers segment was characterized by few large multinational companies, while the auto-parts companies constituted a more fragmented structure of small local enterprises. Their structure was competitive.

IN the 1990s a series of market-oriented reforms was implemented. Chief among them, the trade liberalization and the monetary stabilization warranted a steady recovery of vehicles production from 1993. The decade was also characterized by a strong investment cycle. However, with the beginning of the Asian Crisis, in 1998, the Brazilian automotive industry experienced a period of recession and instability that lasted until 2003. From this year on, its production and sales presented strong growth, with the rate of capacity utilization nearly reaching its limit.

As a consequence, starting in 2006/2007, a recovery of investments could be observed. The current perspectives, however, point to an increase of the production through new investments. The projections indicate that the production capacity, which went from 2.0 to 3.5 million vehicles with the investments of the 1995/2001 period, will reach 6 million units in 2013.

10.3.1 Structural changes in 1990s

The configuration of the Brazilian automotive industry, during the 1990s, is the result of a combination between the country's internal reforms and the industry's changes globally. The latter brought about a new international character to the vehicle industry market structure. The companies and a global industry consolidated themselves, and the global production chain was established. These changes imprinted transformations to the production, organizational and market structures of the Brazilian automotive sector, as well as to the insertion of the country's industry in the world industry and commerce.

The changes and the growth of the vehicle production industry during the 1990s led to the entry of new companies to the market. Their relative market shares also changed, but, nevertheless, the concentration structure was not significantly altered. As to what regards the auto parts sector, the restructuring of the industry, with the denationalization and concentration process, caused expressive changes in the market structure.

Although the Brazilian economy has undergone a process of economic liberalization, its automotive industry was subject to a set of policies and interventions during the 1990s. They were decisive for the realization of new investments and for the expansion of the production. These policies and interventions comprise the Automotive Agreements[57], the formation of Mercosur and the institution of the Automotive Regime.[58]

From 1991 to 2001, the manufacturers invested 17.5 billion dollars, while the auto parts companies invested 11.9 billion dollars (Anuário Estatístico/Anfavea, 2009). During the 1990s the manufacturers presented two clear-cut investment cycles.

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[57] These agreements were the product of sectoral chambers with the participation of the government, companies and workers, in accordance to the Law No. 8,178 of March 1991. The agreements determined the reduction of prices, taxes and margins, besides the development of new forms of consumer finance. There were also established goals for the creation of jobs, for raising real wages and for investments to be done by the companies.

[58] The Automotive Regime's main objective was to promote the growth of production and Brazilian exports, as well as the realisation of new investments. The measures sought to facilitate the imports of the companies that raised their exports and invested in the country. This would be done by means of a reduction of the import tax. On the other hand, the measures determined nationalisation indexes for the final vehicle assembly and for the acquisition of capital goods, raw materials and auto parts. The Regime's strategy sought to link the imports volume to the expansion of local production and of exports.

The first cycle, which extended from 1990 to 1994, aimed essentially at the rationalization and technological modernization of the existent industrial park. The second cycle, ranging from 1995 to 2001, encompassed investments both from established manufacturers and from entrants. Those that were already established invested to increase their installed capacity, to specialize in small vehicles and to obtain larger and more efficient production scales. Whereas the smaller investments made by the entrants was compatible with an entry strategy based on producing smaller quantities.

The investments brought along innovations in the production process. The new plants followed lean production flexibility criteria, adopting multi-tier or hierarchical supply chains for components and parts. This means it was possible for the manufacturers to reduce the initial investments and share the enterprise risks with the first-tier suppliers.

In relation to the auto parts industry, the investments, although high, were smaller than those of the manufacturers. This is due to the high growth of auto parts imports. A characteristic of the investments in this industry was the intense mergers and acquisitions process it presented. This process led to the denationalization and concentration of the Brazilian auto parts industry, in tandem with the capital concentration and centralization movement this industry experienced internationally

The investments made in the Brazilian automotive industry, during the 1990s, produced as their main result the installation of new and up-to-date production plants. This reduced the technological gap existent in relation to the plants of the developed economies, entailing the growth of the Brazilian production capacity. It is estimated that the national production capacity, which was of approximately 2.0 million units in 1995, reached 3.5 million in 2001.

Regarding foreign trade, the 1990s represented a structural shift that led to a new international insertion of the Brazilian automotive industry. The trade opening gave rise to an expressive modification of the automotive industry's balance of trade throughout the decade. Imports and exports grew considerably to a new level. As a result of expressive investments and of this new scenario, there was a significant growth of intra-industry and intra-company trade.

(number of vehicles*)

Table 165 | Production, Licensing, Exports and Imports – 1990 to 2008

YEAR	PRODUCTION	LICENSING	EXPORTS	IMPORTS	NET QTY.
1990	914,466	712,741	187,311	115	187,196

1995	1.629.008	1.728.380	263,044	321,011	(57.967)
2000	1.691.240	1.489.481	371,299	146,14	225,159
2001	1.817.116	1.601.282	390,854	158,331	232,523
2002	1.791.530	1.478.621	424,415	103,806	320,609
2003	1.827.791	1.428.610	535,98	67,909	468,071
2004	2.317.227	1.578.775	758,787	56,451	702,336
2005	2.530.840	1.714.644	897,144	80,356	816,788
2006	2.612.329	1.927.738	842,837	130,411	712,426
2007	2.980.108	2.462.728	789,371	264,475	524,896
2008	3.215.976	2.820.350	734,583	334,955	399,628
2009	3.182.923	3.141.240	475,325	436,861	38,464

Source: ANFAVEA (2009). (*) Sum of total automobiles, light commercial vehicles, lorries and buses.

During the 1990s the new investments occurred associated with a process of relocating the automotive industry in Brazil. This meant a decentralization of the industry, moving away from the São Paulo Metropolitan Region towards São Paulo's inland and to the states of Minas Gerais, Paraná, Santa Catarina and Rio Grande do Sul. Nevertheless, this decentralization must be seen as geographically limited and selective in terms of the sectors it reached. It was stronger with the manufacturers, while with respect to the auto parts companies it only occurred in the sectors with lower technological content (Camargo, 2006).

10.3.2 The 2000s: recovery and new investment cycle

During the 2000s there were relevant changes to the worldwide automotive industry. The stagnation of the developed countries' markets and the growth of the emerging markets led to a relative shift in the geographical importance of the markets, as well as changes in the international competition pattern.

China became the world's second largest market in 2008, behind the USA and directly ahead of Japan. In terms of production, China also comes in second, while Japan assumes the first position and the USA falls to third. The breakneck growth of the Chinese automotive industry, at 21% per year between 2000 and 2008, puts Asia as the leading continent, with 43% of the world vehicle production, above North America and Europe.

Taken together, the growth of China, India, Eastern Europe and Latin America led to a strong expansion of the emerging markets. These countries' share in world production rose from 21.8% in 2003 to 33.2%, in 2007, according to OICA (International Organization of Motor Vehicle Producers). The largest share of the world market still is, however, concentrated in the developed countries. The growth of vehicle production and sales in the developing countries has contributed to an expressive decline in the inhabitants per vehicle ratio. Nevertheless, the potential growth of these markets is enormous, and they are where the larger manufacturers have been trying to expand.

With respect to the market structure, the growth of the Japanese and Korean companies, and the entrance of new Asian companies in the global market, have heightened the global competition. Despite the relative loss of the North American and European companies, the market structure is still very concentrated – the four leading companies (Toyota, GM, Volks and Ford) control approximately 50% of the world market.

In Brazil, the Asian crisis interrupted the growth of production in 1997. At that time, both the manufacturers and the auto parts companies were midway through a set of investments that would, as has been said, raise the installed production capacity to 3.5 million vehicles per year in 2001.

With the crisis, the Brazilian automotive industry experienced a period of instability between 1998 and 2003. The rise of the interest rate, the energy crisis and the Argentinean crisis led to a contraction of the internal and external market. Idle capacity surpassed 40%, and the manufacturers accrued heavy losses during the period.

From 2004 onwards, with the inflation controlled and a reduction of the interest rate, the Brazilian economy started growing again and the automotive industry began a new expansive phase. Both the internal and the external markets contributed to the growth of production. Internally, the light vehicles sales were stimulated by the rise of employment and of total wages. More than 70% of the sales were made via financing, leasing, purchasing pools and extension of the payments dates. The sales of lorries and buses, however, followed a distinct logic, for they are capital goods, and the decision to buy them possesses the characteristics of an investment. The existence of favorable financing options was also an important element, nonetheless.

Exports also grew, given the favorable external scenario. Although they have contributed to smoothening production oscillations, what has been sustaining the growth of production is domestic demand, responsible for more than 70% of the growth.

Besides the importance of real income and adequate finance, the price-sensibility has also proved a significant element for raising the internal demand. This was demonstrated with the recent reduction of the IPI (Industrialized Products Tax) in facing the current economic crisis.

From 2003 to 2008 the production of vehicles went from 1.8 to 3.2 million units, which meant an average yearly growth rate of 12%. The production of 3.2 million vehicles in 2008 made Brazil the sixth largest vehicle producer of the world, behind Japan, China, the USA, Germany and South Korea. With this production, Brazil reached a 4.6% share of the world output. The revenue of the manufacturers in Brazil was of US$ 65.6 billion in 2008 (ANFAVEA, 2009).

As to what regards the market structure, it is noticeable that the sharper fall of the CR4 (concentration ratio of the four largest companies), measured by sales, occurred during the 1990s, when new manufacturers entered the Brazilian market. The CR4 went from 0.992 in 1990 to 0.877 in 2001, whereas from 2002 to 2008 it went from 0.867 to 0.859, indicating a situation of relative stability.

Table 166 | Relative Share of the Manufacturers in Internal Sales

(automobiles and light commercial vehicles) (%)

YEAR	Fiat	Ford	GM	Peugeot	Renault	Toyota	VW	CR4
1990	15,8	18,9	25,5	0	0	0,8	39	0,992
1995	26,5	11,9	21,9	1,1	0,7	0,8	36,3	0,966
2000	26,7	8,9	24,4	2,3	4,2	1,9	29	0,889
2005	21,7	10	19,2	3,7	2,5	2,4	37,3	0,883
2006	23,1	9,2	19,8	3,8	2,5	2,2	36,3	0,883
2007	25,8	9,3	18,7	4,1	2,8	1,8	33,9	0,878
2008	24,9	9,3	18,7	4,2	3,8	1,9	33	0,859

Source: ANFAVEA (2009)

In 2008, the auto-parts industry in Brazil comprised approximately 500 companies, with a total of 207 thousand employees. Its revenue amounted to US$ 39.3 billion. The distribution of companies according to the origin of their capital indicates that 59% of them were of national capital, while 30% were of foreign capital. Despite this fact, 87% of the revenue belonged to the latter, and 13% to the former. The production went 67% to the manufacturers, 13.5% to exports, 11.5% to replacement and 8% to inter-sectoral demand.

With respect to the investments, it can be seen, according to the data in Table 167, that after a sharp decline during the 2002-2005 period, there is a recovery and growth tendency starting in 2006. A new investment cycle is expected, leading to an increase of the production capacity in the following years.

Table 167 | Investments of the manufacturers and of the auto parts companies

		(US$ million)
YEAR	MANUFACTURERS	AUTO PARTS
1991	880	764
1995	1,694	1,247
2000	1,651	1,1
2005	1,05	1,413
2006	1,451	1,3
2007	1,965	1,35
2008	2,913	1,5
2009	2,518	900

Source: ANFAVEA (2009) and SINDIPEÇAS (2009).

According to the BNDES Sector Report No. 7 (july/2008), it is estimated that between 2008 and 2011 the automotive industry will invest approximately US$ 20 billion. The manufacturers will invest 68% of this amount, and the auto parts companies the remainder. The manufacturers' investment will be divided 39% into expansion of the production capacity and 61% into the development of new products. The survey also verified that an expressive share of the new investments aim at enlarging the motor production capacity. However, a new work from BNDES – "Vision of Development" –, published February 2009, revised the investments forecast for the automotive sector, reducing them by 33%.

The industrial and technological policy for the automotive sector, announced by the government in the beginning of 2008 – therefore, prior to the crisis –, determined a new investments. A set of policies was published under the title "Productive Development Policy" (*PDP*), which established a group of targets and challenges for the whole automotive industry. The targets were:

5. to invest a sum total of US$15 billion from 2007 to 2010 and US$ 19 billion from 2011 to 2013;
6. to reach the production of 4 million units in 2010 and 5.1 million in 2013;
7. to increase the vehicle production capacity to 4.7 million in 2010 and to 6 million in 2013;
8. to reach the vehicles exports target of 930 thousand units in 2010 and 1.08 in 2013;
9. to reach a share in world exports of 5.5% in 2010 and of 6.5% in 2013;
10. to raise the industry's ratio of RD&I expenses to revenue to 2% in 2010 and to 2.5% in 2013.

The challenges were: a) raising the production capacity; b) deepening and modernizing the productive chain; c) increasing and improving project engineering; d) increasing the exports volume. The third point is based on the Automotive Engineering Support Programme (*PAEA*), which offered R$ 1 billion in financing. The programme finances items such as the payment of engineers in a specific technological development project, basic projects, development of prototypes and new products, specification of parts and components, acquisition of precision materials (mainly national ones) and the construction of development centers.

10.3.3 Research and development activities

The technological change process in the automotive industry follows well-known trajectories. It occurs essentially by means of incremental innovations in processes and products, which is characteristic of mature industries with large companies (FREEMAN; SOETE, 1997).

Regarding the production process, what could more recently be seen was the dissemination of flexible production, during the 1990s, with the adoption of the lean manufacturing principles (just-in-time, *kanbam*, total quality, multi-tier or hierarchical supply chains etc.) adapted by each manufacturer (FREYSSENET, 1998). With respect to 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. Whereas with respect to the design and the introduction of accessories there were changes, following orientations based on different moments of the automobile's history.

The new technologies of the automotive industry can currently be classified in four large groups: a) alternative propulsion forms, using electrical, hybrid and 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 (CARVALHO; PINHO, 2009).

The concept of the automotive vehicle is being geared towards smaller automobiles, of lower cost and consumption and reduced CO_2 emissions. There are strong motives behind this: the environmental preoccupations regarding the necessity of reducing CO_2 emissions; the rise of oil prices, raising the economic viability of alternatives; and the shift of the markets towards the developing countries, which entails the need of developing a product different than that oriented to the developed countries (CASOTTI; GOLDENSTEIN, 2008).

The technological innovation activities have been, in recent years, influenced by the international oligopolistic competition process. This affected how the product development activities are organized 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.

The competitive strategy is based on the product portfolio and on the priorities in relation to the many market segments, for the competition is different in each market segment or niche. Different competitive strategies can lead to different ways of organizing the global product development activities. Another important element acting upon the organization of activities is the existence of technological capacities in the branches.

Amongst the companies established in Brazil, Fiat, Volkswagen and GM have adopted a strategy with greater decentralization of product development activities. On the other hand, Ford has adopted a strategy of greater centralization of its research and development activities, notwithstanding some recent evidence of changes in the company's strategy.

Fiat has followed a decentralization trajectory oriented by a competitive strategy attributing greater importance for volume and diversity, in addition to greater attention to the segment of small economy cars – which is also considered an entrance segment. The experience and accumulation of capacities, initially with the participation in the development of the Uno and then of the Uno Mille, contributed to the development of the Palio project. This was an initiative of the headquarters, aimed at creating a vehicle for the developing countries' market. The Palio platform, originally created in Italy, was then transferred to Brazil, where it was later re-styled and had its derivatives developed. The technological capacities grew with the accumulation of knowledge related to the development of this kind of product (DIAS, 2003; CONSOMI; QUADROS, 2003).

The situation of the newcomers (Renault, Toyota, Honda, PSA, Peugeot-Citroën and Daimler-Chrysler) is distinct. The GPD activities are centralized at the headquarters, where conception and planning of the products, as well as their adaptation to local conditions, are carried out. What explains this centralization of development activities is the small production scale and low sales in the Brazilian market (CONSONI; QUADROS, 2003).

In regard to the auto parts companies, Dias & Galina (2003) sought to demonstrate that there are similarities to the manufacturers' process of GPD decentralization. The restructuring of the Brazilian auto parts industry led to a process of concentration and internationalization. This impacted the product development activities of the auto parts companies. In the case of national companies acquired by MNCs, the activities where initially centralized at the headquarters, so as to avoid duplication and to reduce costs. On the other hand, certain auto parts MNCs, as happened with some manufacturers, sought to maintain and increase the GDP activities already being performed.

The decentralization of GPD activities and the intensity of the participation of the branches therein depend on the competitive strategy adopted by the corporation, on the characteristics and the segment of the product and on the technological capacities of the branches. Moreover, there are important differences in the competitive strategies and how they integrate and locate the GPD activities. If, on the one hand, competition entailed the necessity of creating adequate forms of organizing the GPD activities, on the other hand the investments and efforts of the branches in such activities (when there was a decentralized process integrated with the headquarters) served as an important instrument of local competition.

10.3.4 The Automotive Industry in Minas Gerais

Minas Gerais is an important unit of the Brazilian Federation, contributing with approximately 10% of the country's GDP. The automotive industry came to the state fundamentally with the installation of Fiat, in 1974. The manufacturer established itself vertically, which is to say that the installation of auto parts companies was not very significant then. The intervention of the public sector was critical for the definition of Fiat's location. The state government offered a set of fiscal, financial and infrastructure incentives, and even became a partner of the enterprise.

Fiat was able to increase its market-share, when the presence of three large manufacturers (VW, GM and Ford) was already well established. This increase can be essentially attributed to the following: the initiative in developing the technology for its "economy car", the introduction of the ethanol motor and pioneering the adoption of a flexible production structure.

The Italian manufacturer restructured its production process between 1989 and 1996. During this period Fiat adopted the flexible manufacturing system, introducing new methods of organizing and managing the production. The restructuring led to less vertically integrated activities and an expansion of the production. As a result, the local auto parts industry grew. The edition of the Palio model, in 1996, was the most visible result of this process.

The growth of the auto parts industry is also due to a second effort on the part of the state government, wishing to attract auto parts companies during Fiat's restructuring. Incentive and financing programmes were created for companies who established themselves in the state. Furthermore, the growth of the automotive industry in the state was also a result of the geographical decentralization process, which led the economic activities away from the São Paulo Metropolitan Region, where the production and distribution costs had grown. These factors together brought about the growth of the automotive industry in the state.

The auto parts industry in Minas Gerais, according to the list of Sindipeças-MG, comprises approximately 200 companies. The issue "Performance of the Auto Parts Sector – 2009", published by the national Sindipeças, indicates that Minas Gerais represents 10.4% of the industry's revenue, 11.8% of the employees, 9.3% of the industrial plants, 8.8% of the exports and 12.9% of the imports.

Fiat, alongside all other manufacturers in Brazil, experienced a period of instability between 1998 and 2003. The production had reached 619 thousand vehicles in 1997, only to fall to 358 thousand in 2003. But Fiat presented a renewed growth of its production from 2004 onwards, reaching 722 thousand units in 2008.

At the end of 2007, Fiat Group announced an investment plan in Brazil for the 2008-2011 period. They predicted a total investment of approximately R$ 6.0 billion, an amount that will probably maintained in spite of the crisis. These investments seek to increase the production capacity and the development of new technologies and products.[59]

The production capacity of the plant in Betim city is being increased, from 677 thousand to 740 thousand vehicles per year. Fiat Powertrain is also increasing its motor production capacity, and it may become the largest motor producer in Latin America. There is also forecast for Iveco, a branch of the Fiat Group that

[59] Besides the R$ 5.0 billion indicated at Table 3.3, the group also intends to activate the agricultural and construction machinery plant of Case New Holland (CNH) and the new replacement parts distribution centre in Sorocaba (SP). These investments amount to R$ 1.0 billion.

produces SUVs and lorries, of a significant increase of the production capacity. It shall go from 30 to 50 thousand units per year.

In relation to the R&D activities, Lemos's *et al* (2000) work on the production system of Fiat's supplier network showed that during the 1990s, with the trade opening and the increase of foreign companies in the country's market, the R&D activities in the region were reduced. They were transferred to other countries and centralized at the headquarters' departments, so as to avoid the duplication of efforts and costs. The data indicated that only eighteen suppliers possessed patents registered in Brazil. Moreover, Fiat's engineering department, which employed 400 persons before the economic opening and the appearance of the "global car", was reduced to less than 100 employees.

The centralization of these activities at the headquarters was a decisive element in explaining the low integration between the manufacturer and the auto parts companies, as well as between the companies and universities or public research facilities.

However, more recent studies (Dias, 2003; Dias; Salerno, 2003; Consoni; Quadros, 2003) indicate a reversal of the situation. During the current decade there is occurring a process of decentralization, and technological innovation activities in the branches of Fiat and of other manufacturers have been increasing. Nevertheless, these studies indicate that, although with differences between them, the growth of R&D activities is related mainly to product development, with little or no efforts directed to research. The latter remains concentrated at the headquarters.

10.4 National Innovation Survey indicators for the automotive sector

This section brings an overview of the state of innovation in the Brazilian automotive industry. The tables and charts presented below summarize information from the Brazilian National Innovation Survey (PINTEC) from 2003, 2005 and 2008. The indicators cover four basic types of information. The first is the expenditure on innovation, which is also used to build indicators of innovative effort. The second type of information, available for 2005 and 2008 only, separates internal R&D from total expenditures with innovation. The third set of tables and charts comprises information on personnel employed on R&D activities. The final set of charts brings information on the main partners for innovation.

10.4.1 Expenditure on Innovative Activities

Table 168 to Table 170 below show data on net income from sales and on expenditure with innovative activities, including internal R&D for selected sectors of the manufacturing industry. As can be seen, there is an asymmetry between the automotive sector's share on total net sales and its share on both total expenditures and on expenditures with R&D. In 2003, the sector's shares were 9,1% and 14,4%, respectively. An opposite trend can be observed for a number of sectors. For the Foods Products, for instance, the observed shares were 17,8% and 13,5%, respectively.

Theses differences are even more pronounced when expenditures on internal R&D are considered. In 2003 the auto sector accounted for a quarter this type of expenditure in the entire manufacturing industry. Even with the rest of the sectors catching up, the automotive sector increased its relative share to 29% 2008. Another important trend is the concentration of R&D expenditures *within* the automotive sector. Over 80% of the sector's R&D was carried out by Motor Vehicles. However, Parts and Accessories have also increased their internal expenditure with R&D during the same period.

Table 168 | Firms sales net income and spending on innovative activities, 2003 - Brazil

Selected activities	Sales Net Income		spending on innovative activities			
			Total		Internal R&D	
	Total	%	Total	%	Total	%
Manufactured Products	721 098 432	100	17863564	100	3932083	100
29 Motor Vehicles, trailers and semi-trailers	65580885	9,09	2566205	14,37	429867	26,01
29.1 Motor Vehicles	42270013	5,86	1988571	11,13	880338	22,39
29.2 Bodies (coachwork)	3499404	0,49	80197	0,45	17069	0,43
29.3 Parts and accessories for motor vehicles	19811468	2,75	497437	2,78	125189	3,18
30 Other transport equipment	12919609	1,79	1112488	6,23	527878	13,42
10 Food Products	128 430 042	17,81	2417948	13,54	128004	3,26
11 Beverage	16851692	2,34	215186	1,2	18889	0,48
20 Chemicals and chemical products	86732192	12,03	1692226	9,47	384940	9,79
24 Basic Metals	53592411	7,43	904224	5,06	130261	3,31

Source: IBGE, PINTEC (2003, 2005, 2008).

Notes: Values are in US Dollars (thousands). Activities classification according to CPA 2008.

Table 169 | Firms sales net income and spending on innovative activities, 2005 - Brazil

Selected activities	Sales Net Income		spending on innovative activities			
			Total		Internal R&D	
	Total	%	Total	%	Total	%
Manufactured Products	766 441 673	100	21491674	100	4483407	100
29 Motor Vehicles, trailers and semi-trailers	86213349	11,25	3812681	17,74	1078610	24,09
29.1 Motor Vehicles	49105984	6,41	2725643	12,68	904475	20,17
29.2 Bodies (coachwork)	4128790	0,54	89745	0,42	17110	0,38
29.3 Parts and accessories for motor vehicles	32978576	4,3	997293	4,64	157025	3,5
30 Other transport equipment	15328262	2	932223	4,34	493354	11
10 Food Products	127 394 698	16,62	2140179	9,96	168233	3,75
11 Beverage	17902908	2,34	383009	1,78	18837	0,42
20 Chemicals and chemical products	85128056	11,11	1857056	8,64	435836	9,72
24 Basic Metals	62254774	8,12	1264105	5,88	113055	2,52

Source: IBGE, PINTEC (2003, 2005, 2008).

Notes: Values are in US Dollars (thousands). Activities classification according to CPA 2008.

Table 170 | Firms sales net income and spending on innovative activities, 2008 - Brazil -

Selected activities	Sales Net Income		spending on innovative activities			
			Total		Internal R&D	
	Total	%	Total	%	Total	%
Manufactured Products	903 532 585	100	23501882	100	5781349	100
29 Motor Vehicles, trailers and semi-trailers	111 638 661	12,36	3879000	16,51	1684035	29,13
29.1 Motor Vehicles	67229768	7,44	2823815	12,02	1352361	23,39
29.2 Bodies (coachwork)	5609232	0,62	140605	0,6	44314	0,77
29.3 Parts and accessories for motor vehicles	38799661	4,29	914579	3,89	287359	4,97
30 Other transport equipment	17515458	1,94	890945	3,79	353905	6,12
10 Food Products	151 827 308	16,8	3165859	13,47	362077	6,26
11 Beverage	21567316	2,39	486194	2,07	18207	0,31
20 Chemicals and chemical products	92874093	10,28	2326748	9,9	547127	9,46
24 Basic Metals	76713391	8,49	2016077	8,58	161367	2,79
Source: IBGE, PINTEC (2003, 2005, 2008).						
Notes: Values are in US Dollars (thousands). Activities classification according to CPA 2008.						

The data confirms the relevance of the automotive sector within the Brazilian manufacturing industry both in terms of revenue (and output) growth and of innovative expenditure. As could be seen in section three, the entrance of new MNCs in the local market as well as falling import tariffs coupled with the growth of the market itself has kept pressures on automakers to innovate.

Table 171 helps the discussion bringing rates of innovative effort, given by the ratio of expenditure with innovative activities to net revenue, for selected sectors of the manufacturing industry. This indicator, which can also be broken down just for R&D, allows for a comparison between sectors as well as the identification of trends. As can be seen, the innovative effort is significantly higher than the national average, being surpassed only by capital-intensive sectors such as other transport equipment, which included the entire naval industry.

Table 171 | Rates of innovative effort and R&D effort, Brazil – years of 2003, 2005 and 2008 version

Selected	2003		2005		2008	
	innovative	R&D	innovative	R&D	innovative	R&D
Manufactured Products	2,48	0,55	2,8	0,58	2,6	0,64
29 Motor Vehicles, trailers and semi-trailers	3,91	1,56	4,42	1,25	3,47	1,51
29.1 Motor Vehicles	4,7	2,08	5,55	1,84	4,2	2,01
29.2 Bodies (coachwork)	2,29	0,49	2,17	0,41	2,51	0,79

29.3 Parts and accessories for motor vehicles	2,51	0,63	3,02	0,48	2,36	0,74
30 Other transport equipment	8,61	4,09	6,08	3,22	5,09	2,02
10 Food Products	1,88	0,1	1,68	0,13	2,09	0,24
11 Beverage	1,28	0,11	2,14	0,11	2,25	0,08
20 Chemicals and chemical products	1,95	0,44	2,18	0,51	2,51	0,59
24 Basic Metals	1,69	0,24	2,03	0,18	2,63	0,21
Source: IBGE, PINTEC (2003, 2005, 2008).						
Notes: Activities classification according to CPA 2008.						

The R&D effort is, as expected, lower for all sectors. However, it is useful to show that Motor Vehicles concentrates the bulk of the R&D carried out in the automotive sector. It is also interesting to remark that the downward trend observed from 2005 to 2008 is easily explained by the fast rate of revenue growth in the sector, which outpaced the rate of growth of both innovation expenditures in general and of R&D in particular. The

Another importance piece of information comes from the difference between the rates of innovative and R&D effort. Since the former includes acquisition of machinery, the data suggests that a large part of the innovation effort has an imitative character. Notwithstanding this fact, for the automotive sector the gap between the two indicators is less the national average, indicating that the segment has moved on to a qualitatively superior form of innovation.

10.4.2 Internal R&D expenditure

The data from Brazilian National Innovation Survey (PINTEC) concerning internal R&D expenditures is restricted to the 2005 and 2008 surveys. Thus, the analysis is limited by the short time span between the surveys. Hence, this section will only describe the main features of the internal R&D investments.

From 2005 to 2008, expenditures on internal R&D have increased by 26% in volume among the companies from the manufacturing sector. There is a clear concentration in continuous activities rather than occasional ones – increasing from 94% to 97% of entire internal R&D investments. The automotive industry accounts for over almost a fifth of the total internal R&D expenditure in Brazilian industry today.

In the automotive sector, the growth of internal R&D spending surpassed 50% in dollars. This growth largely explains the increase of the participation of the share of the auto sector on total internal R&D expenditures. Another very important aspect from the data regards the Parts and Accessories sub-sector. Internal spending on R&D grew not only grew by over 80% in the period for companies in that sector, but was also concentrated on continuous activities, indicating a qualitative change during between the survey years.

Table 172 | Spending on internal R&D activities, 2005

Selected activities	Total		Continuous Activities		Occasional Activities	
	Total	(%)	Total	(%)	Total	(%)
Manufactured Products	4483470	100	4205078	93,79	278392	6,21
29 Motor Vehicles, trailers and semi-trailers	1078626	24,06	1057825	98,07	20801	1,93
29.1 Motor Vehicles	904488	20,17	904488	100	0	0
29.2 Bodies (coachwork)	17111	0,38	16758	97,94	353	2,06
29.3 Parts and accessories for motor vehicles	157027	3,5	136579	86,98	20448	13,02
30 Other transport equipment	493361	11	481749	97,65	11612	2,35
10 Food Products	168235	3,75	124090	73,76	44146	26,24
11 Beverage	18838	0,42	17674	93,82	1163	6,18
20 Chemicals and chemical products	435842	9,72	415425	95,32	20417	4,68
24 Basic metals	113057	2,52	111430	98,56	1627	1,44

Source: Cedeplar/UFMG based on IBGE, PINTEC (2008).

Notes: Values are in US Dollars (thousands). Activities classification according to CPA 2008.

Table 173 |Spending on internal R&D activities, 2008

Selected activities	Total					
			Continuous Activities		Occasional Activities	
	Total	(%)	Total	(%)	Total	(%)
Manufactured Products	5781352	100	5598528	96,84	182824	3,16
29 Motor Vehicles, trailers and semi-trailers	1684035	29,13	1672756	99,33	11280	0,67
29.1 Motor Vehicles	1352362	23,39	1352362	100	0	0
29.2 Bodies (coachwork	44314	0,77	41107	92,76	3207	7,24

29.3 Parts and accessories for motor vehicles	287359	4,97	279286	97,19	8073	2,81
30 Other transport equipment	353905	6,12	349296	98,7	4608	1,3
10 Food Products	362077	6,26	358986	99,15	3091	0,85
11 Beverage	18207	0,31	16562	90,97	1645	9,03
20 Chemicals and chemical products	547128	9,46	520037	95,05	27091	4,95
24 Basic metals	161367	2,79	154975	96,04	6392	3,96
Source: Cedeplar/UFMG based on IBGE, PINTEC (2008).						
Notes: Values are in US Dollars (thousands). Activities classification according to CPA 2008.						

Thus, despite the limited period covered by the survey, it is possible to notice the increasing importance of R&D activities for the automotive industry, especially in comparison with the manufacturing sector in Brazil. Considering the fact that the most of the companies in the industry are multinationals, the R&D effort also tend to concentrate even more in such companies, which can be read as a characteristic of such activities within Brazilian industries.

10.4.3 Funding, Educational Levels and Collaborating

Another important aspect form innovation in the country is the sources of funding for R&D. According to data, from 91,050 companies in Brazil, 2.07% (1,889) are multinationals (MNC´s). These companies account for 44.5% of the entire R&D expenditure in Brazilian industry (or US$ 1.4 billion, approximately). Additionally, for both MNC´s and domestic companies, R&D funding composition is basically internal (93% and 92% respectively), with very little participation of other private or public funding. Considering the use of available capital in internal and external R&D among domestic and MNC´s, most of the companies use it for internal R&D. However, there is an evidence of public funding use for external R&D by MNC´s (27% of public funding usage), and private funding use also for external R&D by domestic companies (15.2%), as shown in Table 174 and Table 175.

Concerning the automotive industry, the data available does not include the sub-sectors, only the motor vehicles, vehicles and semitrailers. The sector represents 2.4% of all the companies surveyed by PINTEC 2005, and 2.5% of manufacturing sector. However, it accounts for 24.2% of the entire R&D carried out in the manufacturing industry. Additionally, almost 90% of R&D in the sector comes from MNC´s and only

10% from domestic companies. This is key information to understand GIN formation in the sector, as will be seen in the next section.

R&D funding composition is similar among domestic and MNC´s (92% and 87% of internal funding, 1% and 2% of other private funding and 7% and 11% of public funding respectively). The use of capital for internal and external R&D is not significantly different from the industry as a whole.

Finally, the share of MNC´s capital for R&D in the manufacturing industry in the automotive sector, grouped by the funding source shows that 93.0% of the public funding for manufacturing is absorbed by MNC´s, 63.1% of private funding and less than 50% of the internal funding. The comparison with the beverage and food sector is merely illustrative, given the low share of the sector in manufacturing R&D (4.1%).

Table 174 | R&D Funding resources and type of Capital, 2005

Selected activities	Foreign Capital - Own Funding							
			Internal P&D Funding			External P&D Funding		
	Total	(%)	Total (U$)	(%) Sector	(%) kind of R&D	Total (U$)	(%) Sector	(%) kind of R&D
Manufactured Products	1842	2,07	1304419923	36,99	42,11	230828642	6,86	53,82
29 Motor Vehicles	153	6,89	599854640	70,24	79,83	67828362	8,03	66,09
30 Other transport equipment	28	4,72	8855091	2,43	2,62	529189	0,16	2
10 Food Products	114	0,98	45777959	31,66	34	2887814	2,09	29,1
20 Chemicals and chemical products	272	7,16	322569746	39,53	47,28	106344651	13,39	79,46
24 Basic metals	36	2,43	50634136	34,68	38,86	11843731	8,32	75,46
	Foreign Capital - Private Funding							
	Internal P&D Funding			External P&D Funding				
	Total (U$)	(%) by Sector	(%) kind of R&D	Total (U$)	(%) by Sector	(%) kind of R&D		
Manufactured Products	21470878	0,61	0,69	682356	0	0		
29 Motor Vehicles	13514580	1,58	1,8	471497	0,06	0,46		
30 Other transport equipment		0	0		0	0		
10 Food Products	156552	0,11	0,12		0	0		
20 Chemicals and chemical products	75570	0,01	0,01		0	0		
24 Basic metals		0	0		0	0		
	Foreign Capital - Public Funding							
	Internal P&D Funding			External P&D Funding				
	Total (U$)	(%) by Sector	Total (U$)	(%) by Sector	Total (U$)	Percentage by kind of R&D		
Manufactured Products	67910153	1,93	2,19	25067186	0,71	5,84		
29 Motor Vehicles	61656888	7,22	8,21	24779748	2,9	24,14		
30 Other transport equipment		0	0		0	0		
10 Food Products	644552	0,45	0,48	1323	0	0,01		
20 Chemicals and chemical products	74871	0,01	0,01		0	0		
24 Basic metals	3726348	2,55	2,86	115517	0,08	0,74		

Table 175 | R&D Funding resources and type of Capital, 2005

Selected activities	National Capital Own Funding							
			Internal P&D Funding			External P&D Funding		
	Total	(%)	Total (U$)	(%) by Sector	(%) by kind of R&D	Total (U$)	(%) by Sector	(%) by kind of R&D
Manufactured Products	87361	97,93	1568284159	44,47	50,62	160889955	4,56	37,51
29 Motor Vehicles	2061	93,11	72131766	8,45	9,6	9472693	1,11	9,23
30 Other transport equipment	561	95,28	317490201	87,13	93,96	24971308	6,85	94,23
10 Food Products	11474	99,02	78606711	54,37	58,38	6657379	4,6	67,08
20 Chemicals and chemical products	3529	92,84	294746709	36,12	43,2	21764145	2,67	16,26
24 Basic metals	1434	97,57	75353235	51,62	57,83	3553014	2,43	22,64
	National Capital Private Funding							
	Internal P&D Funding			External P&D Funding				
	Total (U$)	(%) by Sector	(%) by kind of R&D	Total (U$)	(%) by Sector	(%) by kind of R&D		
Manufactured Products	17968028	0,51	0,58	3225202	0,09	0,75		
29 Motor Vehicles	376880	0,04	0,05		0	0		
30 Other transport equipment	5955041	1,63	1,76	998510	0,27	3,77		
10 Food Products	3261316	2,26	2,42	217501	0,15	2,19		
20 Chemicals and chemical products	2739616	0,34	0,4	470310	0,06	0,35		
24 Basic metals	194081	0,13	0,15	77632	0,05	0,49		
	National Capital Public Funding							
	Internal P&D Funding			External P&D Funding				
	Total (U$)	(%) by Sector	(%) by kind of R&D	Total (U$)	(%)by S ector	(%) by kind of R&D		
Manufactured Products	117802281	3,34	3,8	8215895	0,23	1,92		
29 Motor Vehicles	3887144	0,46	0,52	76732	0,01	0,07		
30 Other transport equipment	5581177	1,53	1,65		0	0		
10 Food Products	6209195	4,29	4,61	160744	0,11	1,62		
20 Chemicals and chemical products	62063281	7,6	9,1	5258442	0,64	3,93		
24 Basic metals	388161	0,27	0,3	104804	0,07	0,67		

Table 176 | Number of employees in P&D in Brazilian companies 2005 and 2008

Selected activities	2005						2008					
	Number of employees	(%)	Companies with internal R&D				Number of employees	(%)	Companies with internal R&D			
			Number of companies	Number of employees in R&D					Number of companies	Number of employees in R&D		
				Total	percentage of ratio of the total employees in R&D in manufactured products	percentage of ratio of the total employees in the industrial sector				Total	percentage of ratio of the total employees in R&D in manufactured products	percentage of ratio of the total employees in the industrial sector
				-3						-3		
Manufactured Products	5949017	100	5028	47360	100	0,8	6852023	100	4168	47223	100	0,69
29 Motor Vehicles, trailers and semi-trailers	371734	6,25	189	6530	13,79	1,76	478688	6,99	217	8817	18,67	1,84
29.1 Motor Vehicles	97633	1,64	22	4466	9,43	4,57	114835	1,68	17	4899	10,37	4,27
29.2 Bodies (coachwork)	51670	0,87	31	331	0,7	0,64	69433	1,01	66	611	1,29	0,88
29.3 Parts and accessories for motor vehicles	222431	3,74	136	1733	3,66	0,78	294419	4,3	134	3307	7	1,12
10 Food Products	1157066	19,45	401	2694	5,69	0,23	1308081	19,09	405	2195	4,65	0,17
11 Beverage	106407	1,79	48	211	0,45	0,2	126022	1,84	24	227	0,48	0,18
30 Other transport equipment	82774	1,39	74	3770	7,96	4,55	91730	1,34	23	4663	9,87	5,08
20. Chemical and chemical products	330732	5,56	964	6199	13,09	1,87	256841	3,75	686	3935	8,33	1,53
24. Basic metals	194390	3,27	90	1600	3,38	0,82	235514	3,44	58	1560	3,3	0,66

Table 177 and Table 178 below show data on personnel employed in R&D as well as educational breakdown. As can be seen, from 2005 to 2008 the number of employees dedicated to R&D activities remained stable in the manufacturing industry. This is a reason for concern given the high rates of output growth observed in the period.

However, the sectoral break shows once more a distinct trend in the automotive sector. In this sector, the number of employees in R&D grew by 35%. It is important to note that most of the growth in the sector comes from the sharp increase in the number of employees dedicated to innovative activities in the sub-sector Parts and Accessories, which almost doubled the number of employees.

Another concerning indicator is the number of employees with high school degrees or under employed in R&D activities. The percentage for this category fell for the manufacturing industry, but remained stable for the automotive sector.

Finally, Tables Table 179 and Table 180 show the main source of cooperation in the innovative activities broken down by agents and nationality. In 2005, for the automakers, suppliers were singled out as the most relevant partners, followed by clients and companies from the same corporation. It is interesting to note, as will be seen in the next section, that the INGINEUS survey data corroborates the larger survey date. However, taken together, universities, research institution, technical training centers and technical support, would be second to clients in the rank. The least quoted partner was competing companies. Another key information from the tables is the importance of cooperating with foreign institutions. More than 80% of the companies declared to have links with foreign partners.

For the automotive sector in particular, the main partners identified in 2008 were costumers, suppliers, other firms from the same group (mostly foreign), and universities and research institutions. It is also important to register that the number of collaborations with universities rose significantly from 2005 to 2008, and that the number of collaborations with foreign universities rose from none to four cases.

Table 177 | Number of employees in R&D in Brazilian companies by education level, 2005

Selected activities	2005									
	Employees in R&D in the companies that innovated, by education level									
	General total	College					High school	Percentage	Others	Percentage
		Total	post graduate	percentage	graduate	percentage				
Manufactured Products	47360	27425	4280	9,04	23145	48,87	14730	31,1	5205	10,99
29 Motor Vehicles, trailers and semi-trailers	6530	4258	387	5,93	3871	59,28	1552	23,76	720	11,03
29.1 Motor Vehicles	4466	3158	264	5,91	2894	64,8	777	17,4	531	11,89
29.2 Bodies (coachwork)	331	181	23	7,06	158	47,73	98	29,51	52	15,69
29.3 Parts and accessories for motor vehicles	1733	919	100	5,75	819	47,28	677	39,07	137	7,9
10 Food Products	2694	1729	243	9,03	1485	55,13	685	25,43	280	10,4
11 Beverages	211	123	14	6,53	109	51,54	79	37,48	9	4,45
30 Other transport equipment	3770	2312	290	7,68	2023	53,66	597	15,85	860	22,81
20. Chemical and chemical products	6199	4129	850	13,71	3279	52,9	1545	24,93	525	8,46
24. Basic metals	1600	924	177	11,04	747	46,68	573	35,84	103	6,43

Table 178 | Number of employees in P&D in Brazilian companies by education level, 2008

Selected activities from Industry, according to CPA 2008 - Statistical Classification of Products by Activity	2008									
	Employees in R&D in the companies that innovated, by education level									
	General total	College					High school	Percentage	Others	Percentage
		Total	post graduate	percentage	graduate	percentage				
Manufactured Products	47236	29058	4340	9,19	24719	52,33	12987	27,49	5191	10,99
29 Motor Vehicles, trailers and semi-trailers	8817	5614	381	4,32	5233	59,35	2013	22,83	1190	13,5
29.1 Motor Vehicles	4899	3521	220	4,49	3301	67,39	784	16,01	594	12,12
29.2 Bodies (coachwork)	611	268	25	4,06	243	39,79	147	23,99	197	32,17
29.3 Parts and accessories for motor vehicles	3307	1824	136	4,11	1689	51,06	1082	32,73	400	12,1
10 Food Products	2195	1366	259	11,78	1107	50,43	573	26,09	257	11,7
11 Beverage	227	123	17	7,44	106	46,73	76	33,36	28	12,46
30 Other transport equipment	4663	3967	370	7,94	3597	77,14	682	14,62	14	0,3
20. Chemical and chemical products	3940	2755	455	11,56	2299	58,36	1001	25,42	184	4,66
24. Basic metals	1560	893	212	13,56	681	43,67	550	35,28	117	7,49

Table 179 | Innovative Companies, by cooperation group, 2005

Selected activities	Innovative Companies					
	Total			Costumers		
		Total	(%)	Brazil	foreign	
Manufactured Products	29951	2139	7	1245	90	
29 Motor Vehicles, trailers and semi-trailers	819	101	12	48	11	
29.1 Motor Vehicles	28	20	72	7	5	
29.2 Bodies (coachwork)	241	11	5	8	1	
29.3 Parts and accessories for motor vehicles	550	69	13	33	5	
20 Chemicals and chemical products	1574	254	16	185	12	
24 Basic metals	676	39	6	25	1	
10 Food Products	3451	206	6	114	6	
11 Beverage	320	43	13	31	-	
30 Other transport equipment	205	43	21	32	5	
	Innovative Companies					
	Suppliers		Competitors		Other firm in the same group	
	Brazil	foreign	Brazil	foreign	Brazil	foreign
Manufactured Products	1231	153	348	43	115	257
29 Motor Vehicles, trailers and semi-trailers	71	11	10	5	12	30
29.1 Motor Vehicles	14	4	6	2	2	12
29.2 Bodies (coachwork)	7	1	3	1	2	-
29.3 Parts and accessories for motor vehicles	50	6	1	2	8	17
20 Chemicals and chemical products	154	21	91	5	9	47
24 Basic metals	20	6	2	1	6	9
10 Food Products	116	12	23	3	13	25
11 Beverage	37	3	5	-	5	3
30 Other transport equipment	6	6	4	2	5	3
	Innovative Companies					
	Consulting Firm		Universities and Research Institutes		Professional training and technical assistance centers	
	Brazil	foreign	Brazil	foreign	Brazil	foreign
Manufactured Products	571	40	812	43	579	6
29 Motor Vehicles, trailers and semi-trailers	26	-	34	-	30	-
29.1 Motor Vehicles	8	-	8	-	6	-
29.2 Bodies (coachwork)	1	-	3	-	6	-
29.3 Parts and accessories for motor vehicles	18	-	23	-	18	-
20 Chemicals and chemical products	77	6	102	1	53	-
24 Basic metals	5	5	22	-	6	-
10 Food Products	51	3	94	1	65	4
11 Beverage	2	1	5	-	6	-
30 Other transport equipment	3	-	5	-	3	-

Table 180 | Innovative Companies, by cooperation group, 2008

Selected activities	Innovative Companies						
		Total	(%)	Costumers		Suppliers	
				Brazil	foreign	Brazil	foreign
Manufactured Products	37808	3796	10	1839	61	2288	392
29 Motor Vehicles, trailers and semi-trailers	1190	158	13	110	7	97	21
29.1 Motor Vehicles	30	11	37	7	1	10	-
29.2 Bodies (coachwork)	451	33	7	25	-	14	-
29.3 Parts and accessories for motor vehicles	708	115	16	78	6	74	21
20 Chemicals and chemical products	1782	182	10	160	4	182	21
24 Basic metals	661	57	9	35	6	27	8
10 Food Products	4484	473	11	154	4	343	15
11 Beverage	308	64	21	41	-	59	1
30 Other transport equipment	181	32	18	20	1	11	7

	Innovative Companies					
	Competitors		Other firm in the same group		Consulting Firm	
	Brazil	foreign	Brazil	foreign	Brazil	foreign
Manufactured Products	708	69	275	278	1257	35
29 Motor Vehicles, trailers and semi-trailers	8	3	13	37	38	4
29.1 Motor Vehicles	2	-	1	7	3	1
29.2 Bodies (coachwork)	1	-	4	1	4	-
29.3 Parts and accessories for motor vehicles	5	3	8	29	31	3
20 Chemicals and chemical products	14	2	16	53	54	3
24 Basic metals	4	4	16	10	14	7
10 Food Products	163	31	58	20	86	1
11 Beverage	35	-	6	3	40	-
30 Other transport equipment	3	-	3	6	7	1

	Innovative Companies					
	Universities and Research Institutes		Professional training and technical assistance centers		Labs for Tests and certification	
	Brazil	foreign	Brazil	foreign	Brazil	foreign
Manufactured Products	1296	20	1135	5	94	16
29 Motor Vehicles, trailers and semi-trailers	45	3	36	-	8	1
29.1 Motor Vehicles	7	-	4	-	2	-
29.2 Bodies (coachwork) for Motor Vehicles, Trailers and Semi-Trailers and Semi-Trailers	3	-	5	-	1	-
29.3 Parts and accessories for motor vehicles	35	3	27	-	5	1
20 Chemicals and chemical products	160	1	33	1	11	-
24 Basic metals	23	5	14	2	3	2
10 Food Products	124	2	126	1	6	2
11 Beverage	37	1	38	-	-	-

30 Other transport equipment	7	-	8	-	2	-

10.5 INGINEUS survey results

This section presents an overview of the INGINEUS survey data for the automotive sector in the State of Minas Gerais, Brazil.

10.5.1 The present nature of sector activities in your country

The automotive sector is composed of MNC's subsidiaries and autonomous productive units. In Brazil, the auto-parts and components companies dominate the market as standalone companies. The subsidiaries are, mostly, automakers and first tier suppliers. The later are very well structured companies which have their own chain of suppliers and systems that ultimately supply the automakers.

This general structure of the sector in the country is also reflected in the survey's composition in the State of Minas Gerais, as can be seen in Table 181. There are only two HQ from MNC's. The rest of the companies are split between standalone autonomous companies and subsidiaries.

Table 181 | Organizational characteristics (Q2)

	(%)	N
Standalone company	52,3%	23
Subsidiary of an MNC	43,2%	19
Headquarter of an MNC	4,5%	2
Answered question		44
Did not respond		25
Source: INGINEUS survey 2010 (N=69).		

The sample also shows that over 50% of the companies can be classified as middle to large sized, according to Table 182. None of the companies considered themselves as small. This result was expected, given that the survey was only sent to companies which declared to have more than 30 employees in 2008.

Table 182 | (Q3.1) How many full-time equivalent (FTE) employees does your enterprise have?

	(%)	N
Fewer than 10 FTE employees	0,0%	0
10 to 49 employees	15,6%	7
50 to 249 employees	33,3%	15
250 to 999 employees	26,7%	12
1000 or more employees	24,4%	11
answered question		45
skipped question		24

Source: INGINEUS survey 2010 (N=69).

The characteristics expressed in the previous tables show the expected structure of the automotive 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). Table 183 below reinforces this notion. Only one company identified the export market as its largest one, whereas 46% have the local regional market as the most important. For the exporting company, North America was identified as the main destination of its goods.

Table 183 | (Q4.1) Location of largest market

	(%)	N
Internal to your enterprise	0,0%	0
A regional market (local region in your country)	47,6%	20

Domestic market (rest of the country)	50,0%	21
An export market	2,4%	1
answered question		42
skipped question		27
Source: INGINEUS survey 2010 (N=69).		

The orientation towards the local market does not mean that companies only sell locally. As Table 184 shows, 15% of the respondents declared to have a significant share of their revenue from external markets. For these companies, the share of the revenue from exports to total revenue was between 10 and 30%.

Table 184 | (Q3.2) Does your enterprise have a significant share of sales activity abroad? / (Q 3.2.1) If you answered 'Yes''* to the question above then please provide the percentage (%) of total sales derived from export

(Q3.2)	(%)	N	(Q3.2.1)	(%)	N
Yes	15,9%	7	less than 10%	28,6%	2
No	84,1%	37	Between 11% and 30%	42,9%	3
			Between 31% and 50%	0,0%	0
answered question		44	Between 51% and 75%	0,0%	0
skipped question		25	more than 75%	0,0%	0
			answered question		5
			skipped question		2
Source: INGINEUS survey 2010 (N=69).					

A more even situation arises when R&D is considered. Over 40% of the respondents declared to keep significant activities with their plants. This is a high share for the survey sample. However, a closer inspection reveals that the number of employees dedicated to R&D is still relative low for the vast majority of the companies. Only six companies declared to keep over 25 employees permanently dedicated to R&D. It is also important no note that amongst companies that stated to have significant R&D activities there are cases in which the R&D structure is seasonal, i.e., employees are assigned to R&D activities depending on the internal demand for such services.[60]

Table 185 | (3.3) Do you have significant R&D activity? / (3.3.1) If you answered 'Yes' to the above then please estimate the number of full time equivalents employed in R&D.

(Q3.3)	(%)	N	(Q3.3.1)	(%)	N
Yes	42,5%	17	less then 5	43,8%	7
No	57,5%	23	Between 5 and 10	18,8%	3
answered question		40	Between 10 and 25	0,0%	0
skipped question		29	Between 26 and 40	12,5%	2
			More than 40	25,0%	4
			answered question		16
			skipped question		1

Source: INGINEUS survey 2010 (N=69).

The survey also found evidence of an association between firm size and importance of R&D capabilities. A large number of companies declared to keep R&D activities, but most of the respondents tend to keep less than 10 workers dedicate to such activities.

[60] This characteristic was confirmed by case studies.

The next Table brings data on the sources of technology. This information is key to shed light on the type patterns of GIN formation in the automotive sector. As can be seen in the table, over two thirds of the technological inputs are either obtained in-house or from a MNC, be it a branch from the same group or another unaffiliated MNC. Only 33% of the inputs are obtained from local firms. These characteristics point indicate a level of immaturity of the local GIN. At the one hand, only about a fifth of the technological inputs are produced in-house. On another hand, 45% of inputs come from multinational companies.

Another key aspect of the date comes from the absence of technology purchases from public sector organizations, universities and other research institutions. The lack of connections between URIs and the productive sector is an important characteristic of the Brazilian National Innovation System, which is reproduced in a regional scale.

Table 186 | (Q5) The most important sources of technology

	(%)	N
We produce most technological inputs in-house	22,5%	9
We buy most of our inputs from other branches of our own MNC	15,0%	6
We buy most of our inputs from firms which are not MNCs	32,5%	13
We buy most of our inputs from MNCs with which we are not formally affiliated	30,0%	12
We buy most of our inputs from public-sector organisations, e.g. research institutes, universities, etc	0,0%	0
answered question		40
skipped question		29

Source: INGINEUS survey 2010 (N=69).

10.5.2 The nature of innovation in the sector

A second set of questions from the survey allow us to dig deeper into the nature of innovation in the automotive sector. Table 187 below brings date on offshoring of R&D activities. Over 40% of the respondents declare to have offshored R&D activities in the past.

Table 187 | (Q9.1) R&D offshoring

	(%)	N
Has offshored R&D	41,4%	12
Has not offshored R&D	58,6%	17
answered question		29
skipped question		40
Source: INGINEUS survey 2010 (N=69).		

Table 188 offers more detailed information on the determinants of the R&D and production offshoring. The table can also be interpret as an indication of limits of the local GIN and, ultimately, of the local innovation system. Around two thirds of the respondents indicated the availability of specializes knowledge in the region as the main reason for offshoring activities. This factor is followed closely the availability of specialized labour in the region. Another important reason for 50% of the respondents is general infrastructure and market access.

When the offshoring of innovation is isolated, the lack of local infrastructure rises to the top of the list. The local availability of technological resources also appears as an important centrifugal force in terms of innovation, given that the availability of human capital and cheaper resources rank high in the list.

Table 188 | (Q9.1). Location factors for offshoring of production & innovation

	Overall Importance	Relative importance of the factor		
	Share stating importance of factor	Offshoring of production	Offshoring of innovation	N
Availability of specialized knowledge in region	66,7%	37,5%	62,5%	8
Availability of qualified human capital in region	58,3%	57,1%	42,9%	7
Access to knowledge infrastructure and services	41,7%	20,0%	80,0%	5
Access to other infrastructure, cheaper resources	50,0%	33,3%	66,7%	6
Market access	50,0%	66,7%	33,3%	6
Incentives for the location of activities	41,7%	60,0%	40,0%	5
Efficient financial markets	25,0%	33,3%	66,7%	3
The level of ethical standards and trust	16,7%	50,0%	50,0%	2
The enforcement of intellectual property rights	0,0%	0,0%	0,0%	0
Following clients who are outsourcing	0,0%	0,0%	0,0%	0
Other	8,3%	100,0%	0,0%	1
Answered		20	23	
Skipped		49	46	

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 impart the relative importance of the factor for offshoring of production and innovation, respective. The table must therefore be read from left to right!

Source: INGINEUS survey 2010 (N=69).

Table 189 | (Q6). Please indicate if your enterprise experienced innovation in the past 3 years (2006-2008) in any of the following

Share of innovation type		Degree of novelty					
		New to the world	New to the industry	New to the firm	None	Response count	Not needed
New products	21,4%	10,1%	29,0%	44,9%	2,9%	60	26
New services	21,0%	2,9%	18,8%	29,0%	21,7%	50	26
New production processes	19,4%	4,3%	27,5%	43,5%	5,8%	56	26
New logistics, distribution etc	18,3%	1,4%	11,6%	29,0%	21,7%	44	28

New supporting activities	19,3%	2,9%	15,9%	43,5%	10,1%	50	25

Source: INGINEUS survey 2010 (N=69).

Table 190 | (Q13) Considering your future innovation activities, please assess the need for improving the following factors

Overall Importance			Relative importance of the factor				
	Moderately or very high	Very high	Moderately high	Moderately low	Very low	Not needed	N
Practical support from centres for the internationalisation of innovation and technology transfer	65,4%	26,9%	38,5%	19,2%	15,4%	0,0%	26
More public incentives and economic support	88,5%	34,6%	53,8%	7,7%	0,0%	0,0%	26
Better access to international research networks	65,4%	30,8%	34,6%	23,1%	11,5%	0,0%	26
Higher skills in the labor force	82,1%	50,0%	32,1%	10,7%	7,1%	0,0%	28
More stringent IPR regulations/enforcement	69,2%	26,9%	42,3%	26,9%	0,0%	0,0%	26
Better and cleares rules regarding FDI and trade	80,0%	28,0%	52,0%	12,0%	4,0%	0,0%	25
More open and flexible migration policy for employing experts from abroad	63,6%	22,7%	40,9%	27,3%	9,1%	0,0%	22
Greater availability of risk capital for innovation activities with an international dimension	72,0%	28,0%	44,0%	24,0%	4,0%	0,0%	25

Source: INGINEUS survey 2010 (N=69).

Table 189 to Table 190 bring information regarding innovation activities specifically. As Table 189 shows, the majority of product innovations carried out by the survey respondents were either new to the firm or new to the industry.

The table also highlights another key aspect of the sector dynamics. The predominating trend to the companies seems to be one of internal reorganization. Within this process, innovative activities are gaining relevance and becoming more and more frequent. This notion is reinforced by the fact that for over 43% of the respondents new product process and new supporting activities to the firm were amongst the main types of innovation. This perception was later confirmed by case studies (see WP5 and WP6 reports for detailed information).

The observed trend also supports the working hypothesis that within the automotive sector automakers are ahead in terms of innovation. Those are the companies who declare to have introduced innovations that are new to the world. The rest of the companies, mostly systems and parts suppliers, have been trying to catch up by absorbing new product and process innovation which are new to the firm.

Table 191 | (Q14) How have you reacted or planning to react to the current global economic crisis?

	(%)	N
Few or no changes	37,1%	13
Increasing effort at innovation on our part	42,9%	15
A serious reduction of innovative activities	11,4%	4
Relocation abroad of innovative activities	0,0%	0
Relocation of innovative activities to you from abroad	8,6%	3
Answered		35
Skipped		69

Source: INGINEUS survey 2010 (N=69).

In the course of this process companies have encountered a series of shortcomings. Table 190 brings information on the main facilitating factors for future innovation. For those whose overall relevance was considered moderately high or very high, more public support and economic incentives as well as a more qualified labor force are the most important factors quoted.

Another important aspect mentioned was the availability of risk capital for innovation. Together with the necessity of more public incentives, one possible interpretation of the data is that external funding is considered as key to future innovations.

Finally, Table 191 brings some information on the expected impact of the financial crisis on innovation. As can be seen, the vast majority of the companies did not expect any change or an increase of their innovative effort.

10.5.3 Collaborating to innovate

The surveying of agents involved with innovation activities in companies is an important indicator to the identification of the GIN patterns. These agents include several types of institutions and relationships with innovative companies. The data shown in Table 192 below reveals that a little over a half of the respondents rely on external partners to develop their main innovation projects. It is also noteworthy that all the companies that declared to have any form of collaboration with external agents also cited the collaboration with their clients. This seems to be a general trend for the automotive sector when the data for other countries is taken into consideration.

Another important factor is the presence of international links in all categories, albeit in varying levels of importance. This information is crucial to draw a clearer picture of the local GIN. In particular, the survey supports the notion that the innovation network is highly dependent of the productive chain of MNCs and on their relationship with clients. The main regions of this international network are North and South Americas and Western Europe.

The reported share of collaboration with consultancy companies is also relatively high. The presence of public institutions in the innovation projects within auto companies is very peculiar. Governments´ participation in projects was declared by almost 30% of the companies, which is a relatively high share. Given the nature of the local NIS, this type of collaboration is largely dominated by funding mechanisms.

Finally, another fundamental piece of the puzzle is found when the partnership with URIs is taken under consideration. The share for this type of relationship is relatively for both local and foreign universities. In addition, the connections seem to be concentrated in the core region of surveyed companies. This fact suggests a weak connection between universities and firms in the automotive sector in the region, a finding which as later confirmed by the cases studies carried out for WP5 and WP6.

Table 192 | Collaborating agents in the company´s most important innovation, by geographical location

	% Partner used	Your region	Your country	North America	South America	Western Europe	Europe other	Africa	Japan and Australasia	Asia	N
Clients	100,0	55,3	60,5	26,3	21,1	23,7	2,6	0,0	2,6	2,6	38
Suppliers	89,5	52,6	65,8	15,8	10,5	10,5	5,3	0,0	0,0	5,3	34
Competitors	36,8	15,8	26,3	2,6	0,0	2,6	0,0	0,0	0,0	0,0	14
Consultancy companies	47,4	23,7	31,6	2,6	2,6	2,6	0,0	0,0	0,0	2,6	18
Government	28,9	15,8	21,1	2,6	2,6	2,6	0,0	0,0	0,0	2,6	11
Local universities and I´s	18,4	15,8	5,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	7
Foreign universities and RI´s	13,2	0,0	7,9	5,3	5,3	5,3	0,0	0,0	0,0	2,6	5
Other	7,9	5,3	2,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3
Answered	38										38
Skipped	31										31

Source: INGINEUS survey 2010 (N=69).

Following the same pattern from the previous question, it is also important to define if existing collaborations are formal or informal. This differentiation is important to establish the level of maturity of the GIN. The data in Table 193 shows that many of the companies could not answer whether they had formal or informal linkages with external agents (rate of skipped answers is 45%). Still, valid answers are more frequent regarding linkages with clients and suppliers. The incidence of formal linkages with foreign universities and RI labs (23.7%) is also noteworthy.

Many of the valid answers also declared to have no linkages with such agents (average of 57.5%). This finding lends support for the notion that companies from the automotive sector still have, currently, few firm and permanent connections with other external agents. However, where these linkages do take place, the incidence of formal connections is greater than that of informal ones.

Table 193 | Formal and informal linkages with selected institutions

	Yes Formal (%)	Yes Informal (%)	No (%)	N
Clients	45,9	10,8	45,9	38
Suppliers	37,8	13,5	48,6	37
Competitors	5,4	10,8	73,0	33
Consultancy companies	10,8	8,1	67,6	32
Government	8,1	2,7	70,3	30
Foreign universities/RI´s/Labs	24,3	5,4	56,8	32
Other	2,7	5,4	51,4	22
Answered				37
Skipped				32

Source: INGINEUS survey 2010 (N=69).

10.5.4 Challenges and Barriers to innovation

This question is directed to companies that declared to have collaboration with foreign institutions. It is possible to notice that most of the surveyed companies do not have any collaboration with foreign institutions (53.3%). Still, considering the 46.3% that do, the evidence shows that co-development projects are difficult in general. In fact, none of the aspects presented in the question indicate less than 50% of the share of moderate or higher barrier. The most critical features are costs associated with location changes of the development activities (75% of the companies declared to be moderate to higher barrier) and conflicts of organization and management practices between the host and affiliate companies (almost 70% of the companies declared to be moderate to higher barrier).

Table 194 | Barriers to collaboration for innovation with foreign institutions

	Moderate or higher	Extreme barrier	Serious barrier	Moderate barrier	Small barrier	Not a barrier	N

Finding relevant new knowledge	53,1	3,1	15,6	34,4	18,8	25,0	31
Overcoming organizational barriers and gaining management acceptancy	68,8	9,4	37,5	21,9	18,8	9,4	31
Changing the current location and associated cost thereof	75,0	18,8	31,3	25,0	12,5	9,4	31
Managing globally dispersed projects and cultural differences	65,6	9,4	25,0	31,3	21,9	6,3	30
Harmonizing tools, structures and processes	53,1	3,1	18,8	31,3	28,1	12,5	30
Answered							32
Skipped							37

Source: INGINEUS survey 2010 (N=69).

The survey data is consistent with the information obtained from case studies. In local MNCs, local R&D is subject to an inflexible hierarchy and mandates tend to be coordinated by the HQ. Homegrown projects are few and far apart and tend to depend to a large degree on the leadership of individuals rather than on the companies' culture.

10.6 GIN Formation and Dynamics in Brazil

The combination of ICS data with case studies and the INGINEUS survey allowed us to identify the inner workings of a GIN in the automotive sector in Brazil. The GIN is centered one of the local market leaders (top five in Europe). The company coordinates innovative projects across both across its own productive chain and with outside partners such as universities and research institutes.

The case study provided evidence of increasing levels of independence of the MNC in relation to its headquarters in the last decade. From pure product adaptation mandates the company's capabilities have been progressively upgraded towards new product development. This process includes the constitution of independent R&D department in one of the group's companies as well as the appointment of a director of innovation to each internal department,

However, R&D is still restricted to product development under strict oversight of the HQ. Basic research is still virtually absent from the network for a variety of reasons, chief amongst them are the dynamics of innovation in the sector (kept closely to the HQ) as well as depth of the local market which only allows for incremental innovations stemming from the more usual processes of product adaptation. Hence, it can be said that the formation of a GIN does not present a significant challenge to the hierarchical structure of the sector.

Within this broader landscape, new initiatives that divert from the sector's norm could be observed. The case studies have revealed a couple of successful projects which have originated locally and, when the financial viability was verified by the HQ, sprung out to involve different parts of the corporation as well as outside partners to bring the project to fruition.

During theses projects, the types of innovations and connections between several distinct partners, which involved the movement of local engineers to the company's HQ, can be said to fit the "true" configuration of a GIN as described by the literature. However, such projects are still not the norm in the industry and are commonly associated with the personal effort of some professionals which have moved faster than the institution itself in terms of the pursuit of innovations.

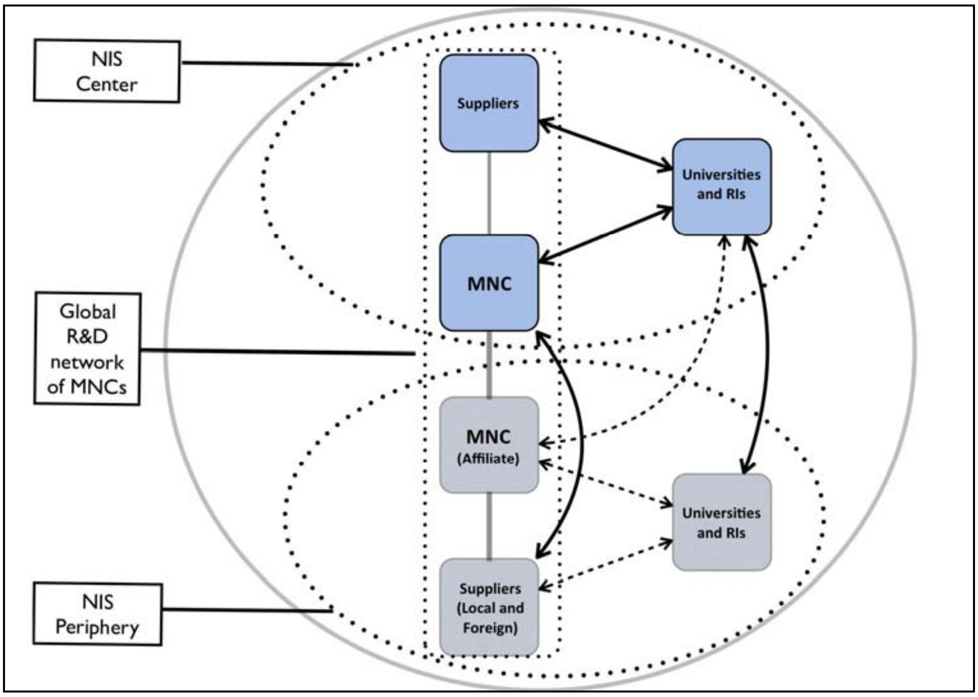
Based on all available data, we argue that that a GIN could be clearly identified in the auto sector. However, contrary to what has been described in the literature, the local GIN's structure is, at one time, incomplete (immature) and intermittent.

The GIN is incomplete for three main reasons. First and foremost, the vast majority of innovation projects are of product development usually to adapt new products to the local market. Secondly, the connections between companies that are part of the proactive chain such as universities and other RIs is still in its infancy. There are only but a handful of on-going formal collaboration projects involving URIs. However, the case studies have shown that the companies are actively searching new forms of collaborations and partnerships. Finally, the companies interviewed are still in the process of institutionalizing innovation management routines.

The intermittent character of the GIN comes from the close relationship found between the degrees of freedom to innovate and economic performance of the local branches. Economic success is still not seen as emanating from the local innovative effort. However, this scenario tends to change in the short run given the rates of growth of the local market observed in the past few years which has led to increasing competitive pressure within the sector.

Figure 1.1 below illustrates one of the key reasons why Brazilian GINs can be classified as immature. One of the key aspects of GIN formation (see WP7 report for a detailed analysis) is the strength of the interaction and collaboration between companies (both MNCs and local standalone) and universities and research institutions (URIs). Data from the survey indicates that only a small share of the respondents declared to have formal collaborations with URIs and none declared do acquire technological inputs from these institutions.

Figure 1.1: GIN Dynamics in Brazil



Source: Cedeplar/UFMG

10.7 INGINEUS SURVEY ANALYSIS

The perceptions described above are grounded in the analysis of the INGINEUS survey data. The survey data for the state of Minas Gerais reveal some interesting facts. The composition of the survey in the state of Minas Gerais reflects the sector's profile nationally. Medium and large sized companies are the most relevant players in terms of innovative effort. Small suppliers are known for following the pace imposed by larger companies and are absent from the survey.

The vast majority of respondents identified their own region as their most important market, followed closely by the rest of the country. This finding is consistent with the literature, has shown the local market as the most important factor behind automotive MNCs decision to start operation in the country. In addition, the importance of the local region is consistent with the sector structure, which shows the usual pattern of large automakers surrounded by their most important suppliers.

The survey also reveals another well-known fact concerning innovation in Brazil. Innovation is restricted to a small percentage of companies within anyone sector. Only about a quarter of the respondents declared to have significant R&D activities. Out of those, only six companies have over 26 employees working full time on R&D activities.

The majority of technological inputs are acquired from companies, both local and MNCs, with which there is no formal affiliation. This source is followed by inputs produced in-house or from other companies from the same group. In addition, according to the survey no company acquired technological inputs from local universities, research institutes or the government.

The companies have reported that their efforts have resulted in innovations that are mostly new to the firm or new to the industry. Only a very small percentage was considered new to the world. This pattern is consistent across innovation types.

The survey reveals an immature Global Innovation Network. The network is largely dependent on a multinational corporation and its connections, both formal and informal. Most companies in the sector have been dedicating considerable resources to innovative efforts, but the results in terms of outputs are still rather modest and constitute mostly of product adaptation and development.

Clients and suppliers are the most likely partners for innovation. Local universities and research institutions come in a far sixth place, after competitors, consultancies and government (mostly for funding), and followed by foreign universities. Apart from the sources of collaboration, survey also reveals the true global nature of the network. The cooperation with clients is present with the Americas (both North and South) Europe (mostly Western), and to a lesser extent with Japan, Asia and Australasia. The same pattern arises for collaboration with suppliers. There is a small percentage of collaboration with competitors and consultancies abroad.

As for the linkages that would not normally be found in a simple production network, a few companies declared to have cooperated with universities in North America, South America and Western Europe. The relatively less important linkages with universities and RIs reveal one side of the immaturity of the GIN (under 50% of the companies have collaborations with institutions abroad). However, for those who do collaborate, formal linkages are more frequent than informal ones.

As for the difficulties encountered with the process of co-development of R&D, companies declared that organizational barrier and management acceptance is the most important factor after cost considerations.

This finding is consistent with those obtained from the case studies. The process of implementation of formal methods of innovation management is still in its early stages even for the largest automakers.

The finding is also consistent with the recent history of the sector in the country. Only recently MNCs branches located in Brazil have obtained a higher degree of freedom to run start projects of product development independently from their headquarters. It is only a consequence to find out that other smaller companies identify management (institutional) acceptance as a barrier.