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A.1. Introduction and description of the case study area

Toscana is the sixth region in Italy, both in absolute and relative terms, as far as the share of local units and employment in high-tech industries is concerned. Toscana has the core of manufacturing and services activities linked to traditional sectors like textile, leather productions, and mechanics and is not specialized in high-tech industries neither in terms of number of local units nor in terms of employment (Unioncamere Toscana, 2011).

The region is largely composed of micro and small enterprises (as to the high-tech segment, 73% of local units have up to 10 employees and 20% ranges from 11 to 50 employees); however, medium-large size firms contribute more to local employment (35% in medium and 26% in large enterprises). The firm size distribution can partly explain the minority share of private research investments (around 30% of the regional total R&D spending).

The provinces of Pisa and Florence however show quite a distinctive pattern. In fact, their contribution to the region's employment is far larger (more than 55% of employment in Toscana in high-tech sectors), their specialization indexes in high tech industries higher (and greater than the Italian average), the presence of medium and large size enterprises wider than in the other Tuscan provinces. Additionally, these two provinces are urban areas of relatively large demographic size and more importantly are university centers with a long standing academic reputation and host several public research organizations; according to Unioncamere Toscana (2011), both factors are generally associated to a greater presence and importance of high-tech industries in the local economy. Accordingly, in this research the analysis focuses on these two provinces only.

The combination of a relatively higher contribution to regional employment, specialization in high-tech industries, concentration of larger size companies, location in urban settings, being centers of research organizations, universities, higher education institutions qualifies these two provinces as cases of best practices in knowledge creation in advanced sectors.

Understanding and identifying the key distinctive elements enabling superior performances in advanced sectors is even more attractive in these cases because of the stronger vocation and specialization in more traditional sectors of the Toscana region.

The identification of the interviewed firms is mainly based on information available from the Observatory of Toscana high-tech firms database, created and maintained by MAIN Lab of Sant'Anna School of Advanced Studies jointly with Unioncamere Toscana, the regional union of Chambers of Commerce.

This is a key source of information on the regional high-tech industries. Among the most important tasks, the Observatory is involved in the identification of high-tech industries in Toscana and in the monitoring of firms growth paths to assess, in a cross province perspective, their competitiveness and possible contribution for the further development of the region.

The Observatory applies different criteria to identify high-tech firms, based on both qualitative and quantitative information. A firm is identified as high-tech if it meets at least one of the following qualitative criteria and one of the following quantitative criteria.

As to **qualitative** criteria, the following aspects are considered:

- The firm conducts internal research activities aimed at new technologies or products development;
- The firm holds at least one patent application (in the last three years);
- The firm has participated at least to one EU project in quality of principal investigator or project partner (in the last three years);

[1] This case study report has been written by Camilla Lenzi, BEST – Politecnico di Milano.

- The firm is involved in research projects with a public research organization (PRO) at the time of the survey;
- The firm has launched actions to participate in national or regional public programs of innovative activities financing ;
- The firm is a PRO or university spin-off or is settled in a technological park.

As to **quantitative** criteria, the following aspects are considered:
- Share of R&D employment greater or equal to 10% (in the last 3 years);
- Share of R&D expenditures greater or equal to 10% (in the last 3 years);
- Share of S&T graduate employees greater or equal to 50% (in the last 3 years).

The Observatory database lists 776 high-tech firms meeting these criteria which are active in one or more of the following sectors: Life sciences, namely Biomedical (40), Biotechnology (8), Pharmaceuticals (9); Chemicals (45); Energy and environment (58); Electronics and optics (62); Innovation services (35); Aerospace, avionics and defense (11); Industrial automation (97); Instruments (32); Nautical (6); Informatics (328); Telecommunications (32).
In this study, firms active in the electronics and optics sector were selected which are involved in the design and manufacturing of electronic systems, chips, sensors, semiconductors, lasers. This sector is of relevance since it encompasses a rather large number of local units (more than 8% of total local units in high-tech) and its contribution to employment in the high-tech segment (11,5% of employment in high-tech, i.e. 1564 employees).
Ten firms were identified as possible target of our analysis after extensive interaction and consultation with key informants, namely researchers at the MAIN lab which possess a deep knowledge of all of firms in the database. I was able to reach and to interview five out of these ten firms.
Data were collected via semi-structured face-to-face interviews conducted at the firm premises lasting on average one hour. Information were integrated and supported by additional documentation collected through desk research, website search, company documents when available, and finally validated by respondents. Additionally, an interview with the past Head (until December 2010) of the Department of Industry, Innovation, Internationalization and Entrepreneurship of Toscana Region allowed to describe the broader economic context conditions and public initiatives undertaken to support knowledge creation in the region with particular reference to the sector under scrutiny.
Table A.1 and A.2 summarize key information about the interviewees and their relative organization.

Table A.1. Summary information on the interviewees

Organization	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
Organization A	Marketing and sales director	No	6	Yes
Organization B	President of scientific committee and founder	Yes	30	Yes
Organization C	Marketing and sales director and founder	Yes	18	Yes
Organization D	Director of product group	Yes	8	Yes
Organization E	Chief executive officer	Yes	25	No
Organization F	Past Head of the department of industry, innovation, internationalization and entrepreneurship of Toscana Region	Yes	10	Yes

Table A.2. Summary information on the interviewed firms

Organization	Year of Foundation	Part of a group	Listed on the stock market	Employees	Turnover	R&D% on turnover	Patents
Organization A	1979	No	No	11	1.5 mil €	n/a	In the past, not renewed
Organization B	1981	Yes	Yes	969	190 mil €	8-10%	>50
Organization C	1993	No	No	30	3 mil €	8-10%	In the past, not renewed
Organization D	2003	Yes	No	35	10 mil €	40%	> 150
Organization E	1980	Yes	No	100	12 mil €	n/a	In the past, not renewed

A.2. Firm profiles and innovative activity

The interviewed firms are interestingly highly heterogeneous in terms of size ranging from very small one (Organization A) to large groups with multiple locations worldwide (Organization B). Despite this heterogeneity, they all show a high and persistent innovative profile. This is confirmed by their capacity of constantly introducing new products and services on the market as well as to incrementally upgrade and improve the products and services currently offered. This is also confirmed by their engagement in research activities as attested by the share of intra-mural R&D expenditures on turnover (Table A2).

For example, Organization A, which is mainly active in the production of new industrial electronic applications and solutions, has recently introduced touch screen displays and bluetooth remote controller for industrial equipment, which are constantly upgraded, renewed and targeted to customers' needs.

On the other hand, Organization B is constantly engaged in the concept, design, development and manufacturing of new instruments and sub-systems of lasers with a large spectrum of applications, ranging from industrial ones (namely to cut materials) to medical-aesthetic ones and for cultural heritage restoration.

Organization C develops a wide range of standardized products and solutions that can be readily applied in industrial applications (e.g. the design and development of custom HW & SW solutions for automation and process control applications), advanced transportation (e.g. microprocessor vehicle logic, onboard automation systems and embedded control systems, diagnostic, monitoring and communication systems, data management and recording units, and integrated solutions for fire detection and fire fighting on board of railway and mass-transit vehicles), defence (e.g. design and manufacturing of microprocessor equipment for real-time data acquisition, storage, handling and processing, and for control of weapon systems and subsystem).

Organisation D is a semi-fabless semiconductor company developing and supplying high volume customer-oriented components based on fail-safe, wireless and MEMS technology for automotive, industrial and high-end consumer applications. Applications include electronic stabilization systems, rollover detection and navigation sets for 'dead reckoning' without GPS support.

Organization E has a long-lasting reputation in the nuclear physics research market. Since its establishment, it operates in a highly specialized international market: the design, the production and the supply of electronic instrumentation for radiation and low light sensors. The company operative field is focused on two main areas: nuclear physic research (both high and medium-low energies) and its fall-out applications, such as power supplies and measurement systems (beam position monitoring) for synchrotron light source laboratories and radio frequency electronics and related software.

Key findings:

- The high and persistent innovative profile of the area is attested by R&D spending, patents applications, number of innovations developed by local firms; this support the qualification of the area as a case of best practice in knowledge creation;
- Several firms are university or public research organizations' spin-off or located in a technological pole close to Pisa university; this points to the importance of basic and general knowledge.

A.3. Types of knowledge and expertise required for local innovation

All the interviewed firms are highly knowledge intensive and offer products and services with a massive knowledge content. The sources and types of knowledge used in their activities are diverse. Some firms reported of the importance of scientific knowledge available from scientific journals, from participation to scientific conferences and projects, as well as interactions with researchers at universities in terms of monitoring the scientific landscape and frontier, of updating current competencies available in-house and as source of inspiration in the daily research activities. Employees at the interviewed firms are in fact directly engaged in the publication of scientific papers. However, this never comes alone, rather it is frequently integrated with applied and technical knowledge sourced from technical and sectoral publications and journals as well as patent literature, and attendance to sectoral meeting and fairs. Interestingly, much of the inputs next integrated and developed in research projects and embedded in new products and services come from users and customers. The client-oriented nature of the business in fact requires large efforts in terms of targeting the original design and prototype to customers' needs and requirements. The frequent interactions, that such targeting process requires, enable a constant re-elaboration and refinement of the original project and can become a source of new ideas generation, a platform for knowledge exchange and the incubator of new and common projects and prototypes. Related to this, Organization A indicates that the customers portfolio is rather stable and some business relationships last since the very beginning of the firm's activities, so that they have become over time crucial actors in their internal development activities.

Key findings:

The knowledge being used is of different types:

- basic, general and pervasive knowledge developed internally to the firm and sourced from local, national as well as international research institutions
- applied knowledge from technical journals
- feedbacks and requirements from users and customers

A.4. Internal and local channels for knowledge and innovation creation[2]

The mechanisms of knowledge and innovation creation are largely firm-centred and carried out in-house. Each of the interviewed firms host an internal R&D unit although the organisation of the R&D activities is quite different across firms. As reported in Table A2, R&D activities cover a rather high share of turnover, and, importantly, interviewees report that human resources and working time dedicated to such activities certainly cover an even higher percentage of total employees and working hours. The internal R&D unit is also reported as one of most important sources of knowledge; internal brainstorming is a key practice to identify new research and business opportunities. Interestingly, Organisation D indicated that the internal R&D personnel is largely composed by PhD students from Pisa university. The company is used to sponsor PhD grants provided that the students develop their doctoral project at the firm premises. By doing so, the company is able to attract young and highly qualified researchers that participate in the company's current research projects and to keep open more uncertain

[2] In this report, internal stands for internal to the firm, local for internal to the region under investigation (i.e. the provinces of Firenze and Pisa) and external for external to the region of investigation.

and, at least in the short run, less profitable from a business perspective, research directions. This is also the firm's primary recruitment channel; in fact, 12 out of 18 PhD students awarded the company's doctoral grant are now full time employees.
More in general, both the universities of Pisa and Florence are reported as important knowledge sources and partners in research activities, underlying the importance of local pre-conditions for knowledge and innovation such as higher education and research institutions. Firstly, they provide a highly qualified workforce with competencies that closely match the professional profiles required by the firms. Second, they are important research partners and sometimes allow the utilisation of laboratories infrastructures, as reported by Organization B. However, the cross-mobility from university to industry (and the other way round) is limited, secondment stays scarce, and most of the moves refer to students entering into the labour market or PhD visits. Interestingly, Organisation E reports that visiting periods and secondment stays involve more frequently foreign academic institutions and research centres. The marked scientific profile of the organisation and the international spread of scientific communities can perhaps explain this finding. The recruitment strategy at the time of the launching of Organisation D included also the attraction of local expatriate researchers. Notwithstanding, mobility of research staff is overall low and this is definitively not one of major driver of knowledge acquisition. Some specific local research organisations are indicated as very import sources of knowledge such as the Electronic Systems & Microelectronics Division of the Consorzio Pisa Ricerche which also provides business and innovation services. This is also an important source of complementary competencies and research consultancies.
Most of the firms performs externally funded research (by regional, national and EU authorities) which always require the gathering of a research consortium. The geographical dispersion of research partners is most of the times determined by the sponsor of the project. Regionally promoted and funded projects require the participation of Tuscan firms and universities only. EU funded projects, to which only three of the interviewed firms have experience of, generally allow a more geographically dispersed research consortium. Partnership in research projects is reported as one of the most important source of knowledge, new ideas and inputs for current and future research activities. Research networks play some role in the development of new and innovative products and services by enabling the exchange of different points of views, experiences, expertises, learning mechanisms and human resources. Also, projects participation provide the opportunity to reinforce successful partnership through follow-up or related projects. This finding points to the importance of local firms relational capacity and receptivity as elements enabling to source knowledge external to firm and probably to the area in which they are located, to absorb it and to use it for internal research projects. Those firms with multiple worldwide locations also benefit from their embeddedness in different economic environments and markets as well as from close relationships with foreign offices and affiliates. However, especially for smaller firms with a more limited international orientation and openness, most of these research and business relationships are occasional, mainly driven by the opportunity to access extra funds.
Customers are for most of the interviewed firms an important input for knowledge creation. Their requirements in terms of specific adjustments to initial designs and prototypes greatly contribute to the refinement of the final output. Participation in research networks, in fact, can be pursued to follow strategic actors, namely key customers that invite companies to join and contribute to the consortium by providing specific solutions to their requirements and needs. However, the geographical distribution of customers is rather widespread, mainly across Europe and also worldwide. However, smaller and less internationalised firms show a different pattern and report to benefit from the geographical proximity to their key customers. Differently, suppliers, such as knowledge-intensive business services are not reported as crucial in the knowledge creation process. Especially smaller firms may require to make use of these services, due to size constraint, but this is oftentimes occasional and mainly referred to software consultancies which are reported to be rather easy to be sourced thanks to the proximity to Pisa university. Other business services are instead reported as not relevant in the

knowledge creation process. Overall, customers seem to be more important than suppliers to activate new research projects.
Importantly, competitors look crucial to understand market trends and to identify market niches as well as areas for technological improvements and refinements in the current products and services portfolio supporting the importance of a certain degree of technological/cognitive proximity as enabler of knowledge exchange and diffusion. However, all the interviewed firms reported that they offer greatly targeted and specific products and mostly address niche markets in which the number of competitors is rather limited and their geographical distribution is worldwide spread. This also limits the opportunities of possible cooperation with competitors which are additionally limited because of general mistrust attitude perceived.
Lastly, sectoral and technical exhibitions and fairs are indicated as important not only in terms of promotional activities but also in terms of learning and update occasion to screen the competitors and possibly to launch new research and commercial partnership.

Key findings:

The main internal (to the firm) and local (internal to the region) channels for knowledge and innovation creation are:
- internal R&D unit and foreign affiliates for multiple location companies
- universities of Pisa and Florence and related research centres
- regionally funded research projects
- international research collaborations especially in larger and more internationalised firms

A.5. Territorial elements supporting knowledge and innovation creation

The universities of Florence and, especially, of Pisa (and their related research centres such as Scuola Normale and Consorzio Pisa Ricerche) play a pivotal role in the knowledge creation processes taking place at the local level. All firms report a very positive opinion about the qualification and background of degree students in science and technology field in the area. Also, the universities are considered to have contributed to the development of a common cultural mindset in the area open to research in physics and engineering studies in general, and in optics and microelectronics in particular. Additionally, the proximity to the university of Pisa is indicated as a major location advantage. However, some organisations report that the intensity of contacts and exchanges with universities have decreased over time mainly because of the extra bureaucracy and coordination costs linked to public administrations.
Overall, firms show a rather atomistic attitude. Cooperation with other firms is scarce and fragmented especially for smaller firms and mainly framed within specific project publicly financed. Voluntary participation in joint research project is limited and frequently pushed because of the prospects of external financial support. Interviewees reported that the small size of the firms, together with an inadequate investment propensity and weak scientific approach and research activities structure, on the one hand, and the lack of trust, on the other, are among the most important elements explaining such a finding. Also, the limited technological content of most of local firms and the mismatch between lines of business are mentioned among the most relevant impeding factors limiting research cooperation opportunities at the local level. In turn, different knowledge bases and competencies increase coordination costs, which are perceived as additional constraints. These findings are actually consistent with the figures reported in section 1, pointing to the limited specialization of Toscana in high-tech sectors. Rather, cooperation can more frequently take informal channels and is largely based on personal rather than business contacts. The role and effectiveness of business association in this respect are perceived as limited and mostly related to promotional activities rather than the pursue of new business opportunities and research directions. Only larger firms, with higher international reputation and markets, undertake more formal cooperative research projects, which are not always publicly supported. For example, Organization B reports the successful experience of a joint venture created and launched with a local firm

operating in a related market with the aim of pursing a specific research direction, i.e. the research of new methods and equipments to minimize the consequences of laser surgical interventions, with the financial support of regional and EU funds, as well as with other local research organizations (e.g. CNR). Organization D reports that their participation into research networks is linked to the scouting activities carried out at the headquarters or to proposal coming from partners such as the Fraunhofer Institute in Germany. Organization E, which shows a stronger orientation towards basic science, continuously cooperate with worldwide research institutions to perform large scale experiments whereas cooperation with local firms is more limited. Also, participation in research networks is primarily pushed by past partners' proposal and is actually undertaken only in case the project is synergic with current research activities and the firm participated only once as principal investigator. The electronics and optics sector, in fact, encompasses a large spectrum of market segments, applications and niches that are frequently occupied by a small number of players not only at the local but also at the global level.

Interestingly, all respondents indicate that the potentialities to activate more intense research partnerships in the area are large and could be better exploited, given the high level of competencies locally available. Initiatives are however partial, limited to specific interventions and the role of institutions could be more proactive and powerful in this regard.

Key findings:

The key territorial elements supporting knowledge and innovation creation at the local level are:

- a highly qualified workforce educated in local universities (e.g. PhD students)
- the presence of universities as research partners
- the development of a common cultural mindset open to research in optics and microelectronics

A.6. Local innovation policy assessment and governance

The opinion of interviewees on local innovation policy is mixed and largely dependent on the capacity of the organization to actually be capable to access regional funds. Differently from other sectors, such as life sciences or more traditional sectors such as ceramics, textile, leather productions, electronics and optics have not being directly target of regional policies in the last decade. However, given the horizontal and pervasive nature of their technologies several projects and initiatives taken at the regional level had the opportunity to (indirectly) benefit firms active in these sectors. Most of the firms but Organization A in fact reported to have participated or to be participating in research networks funded by the Toscana Region, mostly as co-financing to EU funds. This confirms the fact that Toscana Region has in fact gained over time some reputation in the administration and spending capacity of EU funds. For example, Organization B is currently involved in two of such research projects, Organization C in one as Organization E. Differently, Organization A never accessed such type of research networks while Organization D reported that in general they do not conduct externally financed research with other Italian partners or Italian government, and only in 2010 were able to access (minor) regional funds. These findings indicate that the region played a not negligible role in promoting and supporting the relational capacity of local firms and their networking attitude.

The amount of resources made available is overall perceived as limited and sometimes not worth the timing and coordination and bureaucracy costs it involves; also, there is the perception that the procedural aspects are judged and appreciated more than the technical contents. This observation comes even stronger especially with reference to regional projects co-financing EU funds. Discussion with Toscana region representative partly confirmed this point and stressed that these elements are even more compelling for micro firms, the largest majority of Tuscan firms. However, it is important to highlight that regional financial support always comes in the form of co-financing of national or EU

funds and that it has been able to reach only a small portion of potential beneficiaries (around 4000 local units in the whole region across all sectors). Further initiatives would be appreciated not simply in terms of financial aids to investments but also to building a network to acquire and to jointly use equipments and share their cost so to internalize some stages of the production process. Also, further efforts to make the role of technological poles such the one in Navacchio going beyond the mere provision of logistic and organizational services to include the launching of initiatives aimed at competencies, expertise and experiences exchanges, and more in general to create synergies, would be welcome. Regional authorities are actually trying to work in this direction by providing not only buildings, facilities and services useful to launch a new business and to support the start-up phase, but also to sustain already started businesses and to support the continuity of their innovation activities and to translate the initial and more frequent investments in incremental and process innovation into future product technologies. In fact, much attention has been put over time on the progressive rationalization of the activities of the technological poles initiated in Toscana (among which the one of Navacchio, mostly dedicated to electronics), through an increasing process of sectoral specialization mixed to the hosting of different and complementary disciplines and competencies to promote a cross-fertilization culture and practice.

Another field in which the interviewees report that additional efforts could be placed is on improvement of the infrastructure and channels conceived and implemented for technology transfer. The difficulties in technology transfer activities and cooperation between academic and public research institutions and private firms have also been acknowledged by the representative of the Toscana Region and indicated as one the area in which regional policies should make a progress. Given their rather strong in-house research capacity, all respondents indicated that this is not a major hampering factor for their knowledge and innovation creation processes. However, they all believe that could benefit from an easier and faster access to knowledge and technologies and from a more homogenous approach and effectiveness of technology transfer activities across different disciplines and research institutions. The heterogeneity and fragmented approach and view on the relationship between science and technology across academic and public research institution generate in fact an uneven picture largely dependent on the capacity and engagement of single institutions (and sometimes also individuals) in technology transfer activities. In fact, limited mechanisms are available to access and to diffuse the results of research projects besides those already envisaged by the projects themselves or independently initiated, activated and organised by each single organisation and individuals. Respondents suggest that the limited effectiveness of the initiatives pursued is to a large extent linked to the small number and untargeted occasions created to communicate and make different actors meeting and exchanging competencies, practices and experiences. Creation of new channels, better synergies among channels and more systematic and institutionalised mechanisms would be welcome and is highly recommended. As an example, it has been suggested that the organization of visiting periods of students and employees at (other) companies premises and their involvement in the host company research activities could become a more common and formalized practice. However, it is also difficult for regional authorities to take initiatives that can influence the graduate and post-graduate education (which is of national competency), whereas there is a slightly larger room to adapt technical and professional educational profiles to local businesses needs and to better integrate production and education policies.

Lastly, as to national (sectoral) innovation policies, all respondents complain about the absence of a broader and long term vision about the role of innovation policies at the national level. Importantly, all respondents perceive that the length of time elapsing from the project call, the publication of the results of the competition, the kick-off of project activities, and the timing of financing. All these steps take a time that is not compatible with the speed of the markets in which the interviewed firms operate. On the other hand, the experience with EU authorities is limited, and sometimes in partnership with the region, frequently related to a negative opinion of the bureaucracy and coordination costs

linked to project management, and the perception that the procedural aspects are judged and appreciated more than the technical contents.

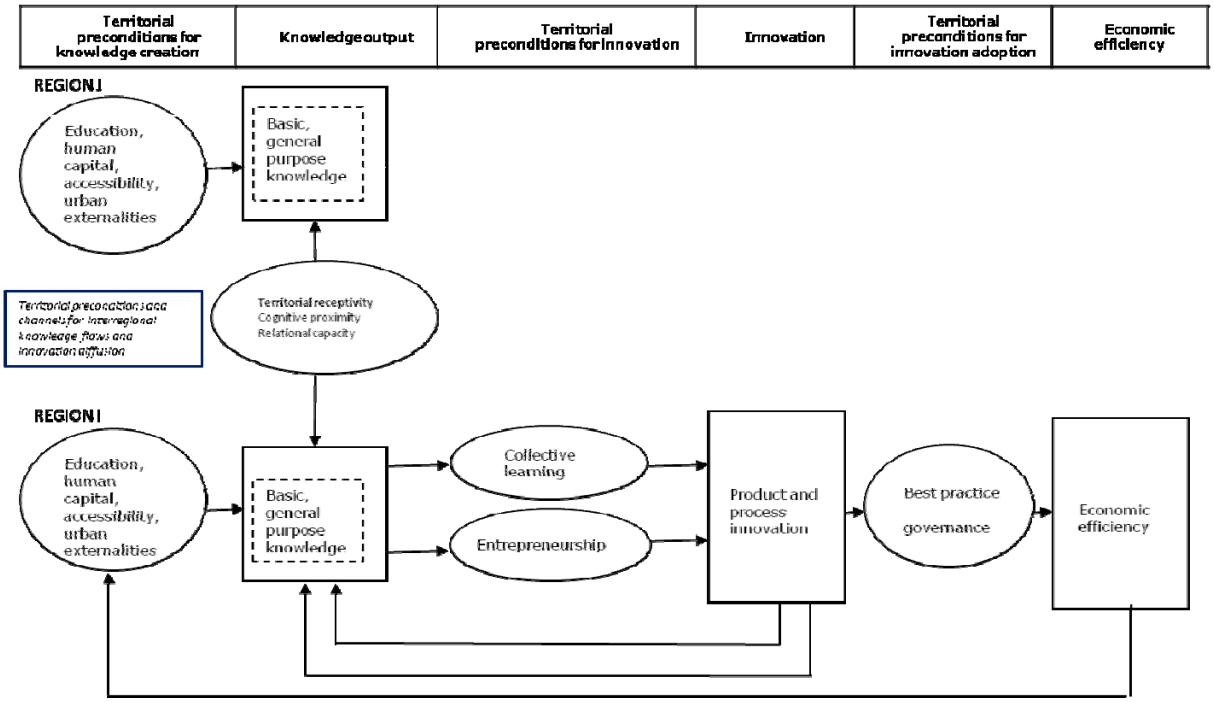
Key findings:

Local innovation policies:
- have not directly targeted this specific sector and benefited a small number of beneficiaries
- have enabled the identification of local partners for research purposes
- have received an overall positive assessment of the initiatives undertaken.

A.7. Conclusions

This document has summarised the findings of the qualitative analysis carried out in the electronics and optics sector in Toscana in the provinces of Florence and Pisa.
All in all, these findings suggest that this case could be associated to an endogenous pattern of knowledge and innovation creation, i.e. pattern 1 conceptually and empirically identified in Chapter 2, Volume 1 of the Scientific report and reported in Figure A.1.

Figure A.1. An endogenous innovation pattern



Source: KIT final report

Knowledge in fact is primarily developed internally to the firm and within the regional boundaries, by private firms and research organizations and integrated and expanded with knowledge sourced externally thanks to the networking attitude and receptivity of local actors. This knowledge is next exploited in the development and introduction of new products and processes that can lead to higher economic performance, in terms of increased GDP growth or higher employment rates. Whereas the first two stages were actually detected in this study, the last one has been not clearly identified. Probably, assessing the impact of this knowledge and innovation creation process on GDP growth and employment is far from straightforward because of the limited size of sector at the regional level (as described in section 6) and because regional innovation sectoral policies have not primarily addressed this sector (as described in section 1).
Despite Toscana not being specialised in high tech sectors, the firms interviewed show a high and persistent innovative profile nurtured by autonomous and continuous investments in knowledge creation. The sources of knowledge are heterogeneous,

according to the different specificities of the markets and customers each firm addresses. Knowledge sources are primarily internal to the firm and local, i.e. linked to relationship with the universities of Pisa and Florence (and the related research institutions) which represent a key distinctive trait of knowledge and innovation creation process in the area and stress the importance of the presence of local pre-conditions for knowledge creation such as research and higher education institutions. Links to other regional, national and foreign research partners are largely dependent on the capacity to access to external funds which, in turn, is tightly linked to the size and internationalization profile of the firm, being larger firm overall more internationalised and more open to joint research projects (probably because less frightened by the risk of knowledge leakages and key assets sharing with competitors). This points to a not negligible level of networking (for research and knowledge exchange purposes), relational capacity and receptivity of local firms. Interestingly, participation in knowledge networks is associated to the need of following strategic actors, namely key customers that invite companies to join and contribute to the consortium by providing specific solutions to their requirements and needs, thus underlying the importance of a certain degree of technological/cognitive proximity. Additionally, despite being primarily built to access external fund, networks of research are considered an important channel to acquire knowledge and competencies from other partners. However, the collaborative attitude, especially at the local level, of the interviewed firms is mitigated by the general perception of an atomistic behavior and the individualistic culture that mostly inspire the local business model and can make the governance and the coordination costs of research projects even higher. Importantly, the possibility to be granted regional funds have been an important step to identify key local research partners and to create synergies locally. The regional governance therefore played a not minor role in promoting and supporting relational capacity of local firms and their networking attitude. However, it is worth pointing out that regional government efforts have been primarily directed to promote research and knowledge networks at the local scale while the national and international reach of such networks has been less supported. Differently, this could be an interesting policy direction to be pursued to enrich and to enlarge the local knowledge base through externally sourced knowledge.
Lastly, regional authorities have been reported to be active in the support to knowledge and innovation in the sector although indirectly, because this has not been an explicit target of regional innovation policies. Arenas for possible future and welcome policy actions have been also identified, especially in the mission and activities of technological poles and technology transfer services.

Key findings
- Receptivity and networking look as enablers of superior knowledge and innovation performances
- Cognitive proximity is a primary conduit to direct and to shape knowledge and research networks
- Local pre-conditions for knowledge generation are crucial to sustain high innovation rate.

A.8. References

Unioncamere Toscana (2011), L'alta tecnologia in Toscana. Imprese e territori, 2° Rapporto Annuale, available at http://www.osservatorio.sssup.it/documenti/pubblicazioni/Unioncamere2011.pdf, last visited 11/07/2011.

B. The automotive sector in Piedmont[3]

B.1. Introduction and description of the case study area

Piedmont is a technologically-advanced region, participating in Italy's first wave of industrialization of the Country, and contributing to a large share of its manufacturing employment ever since.

The region is strongly specialized in traditional (albeit technologically-advanced) manufacturing and quality primary sectors. It hosts less than 8% of total Country population, while producing 8% of its GDP. Its productivity levels cannot compete with similarly large and technologically-advanced regions in the core of the EU27;[4] however, a relatively slow growth of salaries[5] and a renewed success of companies belonging to the FIAT group (see Sections below) granted a slow but steady increase in productivity statistics. In recent years, therefore, Piedmont narrowed the gap with the average productivity level recorded in the EU27.

Piedmont has traditionally been specialized in the automotive manufacturing industry. Such sector is characterized by high relevance at the national level, while at the same time enjoying consistent growth rates at the international level (Figure B.1, left panel), its maturity notwithstanding. A slightly decreasing global market share characterizes the FIAT/Chrysler group (Figure B.1, right panel), at the heart of the automotive industry in Piedmont,[6]; this decline was however foreseen in the company plan for the current years and is matched by solid forecasts of sustained future growth.

Although this traditional manufacturing industry seems to have saturated western markets, a huge challenge faces European carmakers with the emergence of potentially enormous new markets in BRIC countries. Piedmont tackles this challenge with a consistent specialization in manufacturing activities,[7] and in particular in the automotive sub-industry.[8] While this specialization grants Piedmont the know-how to compete with international competitors, it also exposes local firms and institutions to potential pitfalls from an impending crisis of the head company of the FIAT-Chrysler group, or the industry as a whole.

[3] This case study report has been written by Andrea Caragliu, BEST –Politecnico di Milano.

[4] A measure of Total Factor Productivity is traditionally obtained as a residual to a standard Cobb-Douglas production function of the form $Y_t = A\left(K_t^{\alpha} L_t^{\beta}\right)$. For a review of the concept, see Syverson (2011). By doing so, Piedmont usually scores in the top 35th percentile.

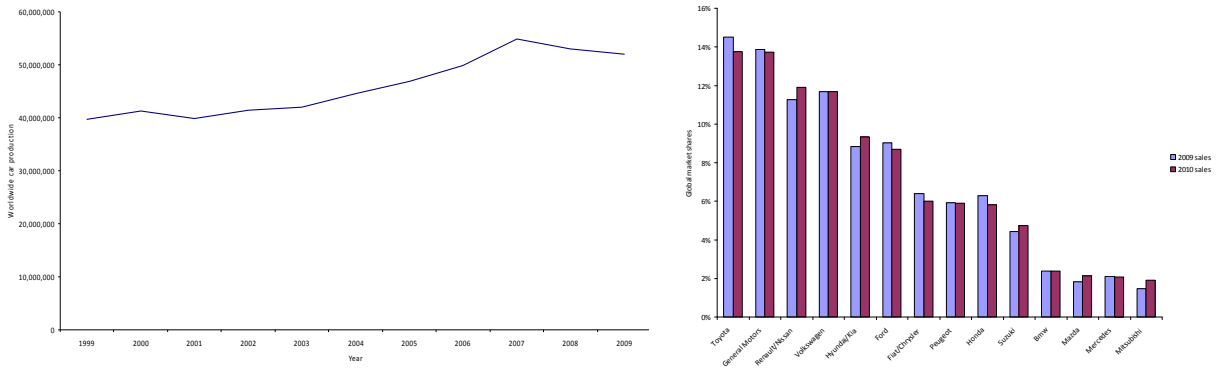
[5] Between 1996 and 2001, average compensations per employee grew in Piedmont 14% less than the Italian average and 43% less than in the EU27; a reversed gap characterized the period 2001-2006, with the salaries growing in the region 32% less than the Italian and 9% less than the EU27 average. Data from Cambridge Econometrics, 2008 edition; author's elaborations.

[6] Yet the market share of the group oscillates around 6% of total world car sales.

[7] The location quotient of the manufacturing sector calculated on the basis of employment data, and with respect to the EU27 average, is equal to 1.49 for 2009. Although this figure has been steadily declining over the years 1980-2009, this still points towards a remarkable specialization of the region, which still employs roughly 25% of its workforce in manufacturing.

[8] In this case, the location quotient calculated on employment in the DM industry ("Transport equipment") is equal to 2.24 in 2009; while this figure has also been steadily declining for the 1980-2009 period, it still remains strikingly impressive in absolute figure, with more than 3% of the total workforce employed in the automotive.

Figure B.1. Total world car sales 1999-2000 (left panel) and world car market shares by carmaker 2008-2009 (right panel)



In Piedmont the whole productive filière of the automotive industry is represented, from suppliers to a whole range of cars and commercial vehicles, to providers of after-market services. Hence, organizations interviewed for the present case study cover the whole range of production, including:

1. Suppliers;
2. The mother company;
3. luxury brands;
4. commercial vehicles.

Table B1 and B2 show some relevant information on these organizations.

Not only does the FIAT group, along with its suppliers and induced-industries, represent a stronghold of the Piedmont economy. It also represents a major contributor to the generation of (world-wide) relevant innovation. Measuring the total number of patents within the US Patent and Trademark Office (henceforth, USPTO) owned by the FIAT-Chrysler group since 1976, for instance, it turns out that the group obtained 6.12% of total patents granted to the carmaker groups listed in Figure B.1. This makes the group the 6th largest generator of technical and scientific knowledge related to car production world-wide.[9]

Table B.1. Summary information on the interviewees

Organization	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
Organization A	CFO	BSc	From inception	-
Organization B	Sales manager-Africa Middle East	BSc, Master's	~5	Similar roles in other companies not specialized in the automotive industry
Organization C	Plant Human resources Manager	BSc, MA	~ 15	Similar roles in another MNC
Organization D	Marketing strategist	BSc	~7	Not available
Organization E	Project manager	BSc	~10	In the firm from the beginning

[9] These figures are obtained with a search on the USPTO Patent Full-Text and Image Database, carried out on Sep. 8, 2011.

Table B.2. Summary information on the interviewed firms

Organization	Year of foundation	Part of a group	Listed on the stock market	Number of employees	Turnover	R&D% on turnover	Patents
Organization A	2005	No	No	12	1 mil €	n/a	In the past, not renewed
Organization B	1975	Yes	Yes	26,000	10 bill. €	3-5%	83
Organization C	1883	Yes	Yes	1,400 (ITA) 38,000 (world)	500 mil. (ITA) 13,423 mil. (world)	3%	12,114
Organization D	1899	Yes	Yes	40,000	35,880 mil. €	3%	9,624
Organization E	1914	Yes	Yes	695	694 mil. €	5%	41

Source: author's interviews, USPTO, and company profiles.

The nature of the car-making industry points towards a rather unique, and somewhat traditional, model of knowledge generation. R&D labs, unlike for instance in such case studies within the KIT project as the ICTs in Bratislava and Lombardy, and the wine industry in the Arezzo province, are still alive and well. Indeed, the ultimate aim of carmakers is still to obtain monopoly profits from specific new technologies granting some technological advantage over competitors. The fallout of this industry on local areas is therefore quite extensive, and is maximized when, as is the case of Piedmont (see Sections 2 through 6 for further details), the whole logical chain depicted in the theoretical scheme of the KIT project is well developed.[10] In particular, such endogenous innovation pattern encompasses a wealth of human capital uphill the knowledge production process; a relevant stock of General Purpose Technologies (henceforth, GPTs); a high entrepreneurial and creative capability in translating basic and scientific knowledge into applied innovation. The simultaneous presence of all these elements, therefore, maximizes the *retombé* on the region.

Specialization in manufacturing, and in particular automotive, along with a relevant knowledge generation capability, strongly supports our choice of a case study on Piedmont, and in particular of its automotive industry, as a potential best practice region in knowledge creation.

This report is structured as follows. In Section 2, the innovative portrait of the interviewed organizations is described. In Section 3 the reader can find an analysis of the type of knowledge and expertise needed by local firms in order to innovate. Section 4 presents a deeper analysis of the local and external channels for knowledge and innovation creation. Section 5 focuses on the territorial elements supporting knowledge and innovation creation. Section 6 summarizes this case study's findings on innovation policy assessment. Finally, Section 7 concludes.

B.2. Firm profiles and innovative activity

The variety of size and characteristics of the firm interviewed is equally matched by a wide range of innovative profiles among the organizations. In fact, interviewees include firms from small medium size to large MNCs; this is reflected in a markedly different mode of knowledge generation, according to the goal of the firm.

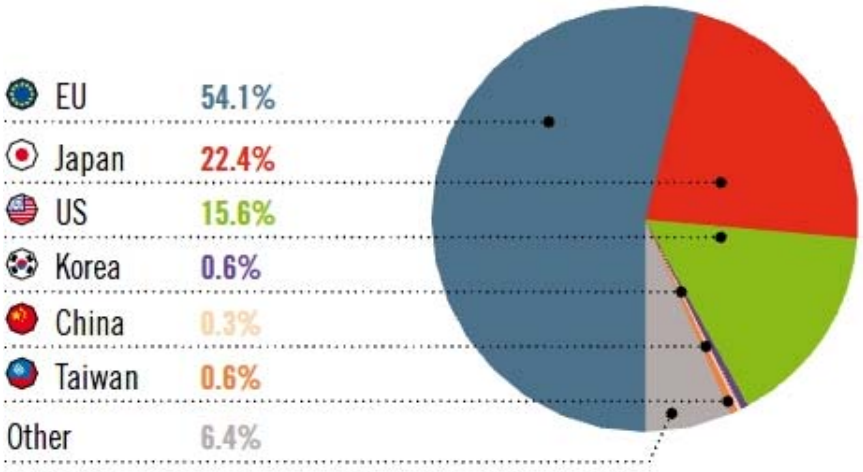
Small-Medium enterprises in this region/industry innovate on single stages of production, in an incremental fashion. This involves a process of active search for practical solutions to applied problems, without resorting on formal intellectual protection of the findings achieved, nor to a structured system of capital-intensive R&D functions. Innovation takes instead place by applying practical, bench-level skills to (sometimes very small) imperfections of the production chain.

The MNCs interviewed, instead, focus on in-house R&D in order to foster innovativeness and competitiveness, while at the same time preventing outward Knowledge Spillovers.

[10] See Capello and Lenzi (2011) for more details.

Indeed, European carmakers show on average a rather relevant share of the world knowledge production. In fact, data from the EPO on the patent applications intensity in the automotive industry[11] show that European carmakers alone cover more than half of total patent applications to the EPO in the automotive industry (Figure B.2):

Figure B.2. Patent applications filed by the auto motive sector, 2008 data



Source: EPO and ACEA.

The enormous relevance of the internal R&D labs for this specific region-industry is very interesting for the KIT project as a whole. Some regions exhibit an innovation pattern (pattern "2" in the KIT theoretical framework) based on knowledge acquisition. The scientific base needed to generate innovative products and processes is channeled in those regions via entrepreneurial creativity (such regions, therefore, attract external knowledge, understand it, decode it and ultimately exploit it, in combination with entrepreneurial skills, to innovate), and the final products bring applied innovations to the market. The case of the Piedmont industry-region is rather different; in fact, in this case uphill the innovation capability described for the knowledge acquisition innovation pattern, a wealth of human capital coupled with the local availability of GPTs enhances the chances of local firms to maximize the local returns to R&D activity. This represents the core of an endogenous innovation pattern. Interviewees state that in the short run companies in this industry-region seek the exploitation of monopoly profits over their innovations; however, according to most surveyed organizations, in the long run a greater openness to external sources of knowledge may probably be beneficial. This renewed importance of external knowledge for innovation may in fact turn out to be a crucial asset in the near future.

An interesting exception to this structured approach to R&D and knowledge creation among Piedmont MNCs of the automotive industry is the case of the commercial vehicles producer. One of their biggest innovations in the last years has been the creation of a contact centre located in Turin and connected via the mobile network to the control units installed on the vehicles and trucks sold worldwide. This allows the company to identify most of the crashes to the electronic component of their trucks 24/7, with no spatial friction and at a very small cost. This specific innovation required creativity in recombining pre-existing technologies, and therefore points more towards a creative acquisition of externally-produced scientific knowledge, aiming at producing an innovative service for the company's customers.

All in all, however, background information matches replies from interviewees and clearly identifies an endogenous approach to knowledge generation, with a remarkable relevance of the internal R&D department of all companies belonging to the group and in the general of the organizations located in this particular industry-region.

[11] Source: European Automobiles Manufacturers' Association-ACEA, and EPO: http://www.acea.be/news/news_detail/automotive_sector_tops_rd_investment_scoreboard/)

Key findings:

- The automotive industry in Piedmont is mainly made up of:
  - Large MNCs, innovating mostly with traditional R&D departments, and
  - SMEs, offering incremental innovation at different stages of production;
- Presently, the internal/endogenous production of knowledge is sufficient for the region-industry's pattern of innovation;
- However, future challenges to the endogenous pattern of innovation are faced by local carmakers, stemming in particular from more open modes of innovation.

B.3. Types of knowledge and expertise required for local innovation

The automotive industry is both a traditional sector, while at the same time presenting a consistent technological content (Jaklic et al., 2005; Sturgeon et al., 2009). Organizations belonging to this *filière* need therefore an all-round knowledge, mostly scientific and technical, but also bench-level. Investments in R&D need to present a stable flow of money employed in an endless search for a technological edge on competitors and incumbents.

The scientific part of such knowledge is usually covered by intellectual property. Actually, data from the European Patent Office (henceforth, EPO) show that European carmakers are at the forefront of scientific research in this industry.[12] The FIAT group introduced in the last 30 years a set of innovative technologies marking significant technological shifts for the whole industry. To name a few:

1. The Variable Camshaft Timing (VCT), first introduced by Alfa Romeo in its "Duetto" Cabriolet in 1980, on the 1750 cc. engine to be exported to the US market. This device, currently adopted, among others, by BMW, Honda, and Ford vehicles, allows the reduction of gas emissions.
2. The direct Diesel injection engine, first available on the Fiat Croma in 1987. This type of engine was electronically-controlled; although the injection pressure was still only around 300 bar, the injection timing, the quantity of fuel injected, and the turbo boost (all electronically controlled) allowed a more precise control of the engine's sub-components and a lowering of the Diesel engine emissions.
3. The common rail system. This is a device designed to directly pump Diesel gas via a high pressure pump; on current Common Rail engines, equipping most Diesel Turbo engines worldwide, it works at around 2,000 bars. This system, which allows to overcome most of the shortcomings of Diesel engines in terms of explosive power, had been conceived at the Zurich Polytechnic in the 1960s, but never applied to commercial road vehicles. In the 1990s, research on an electronic version of this idea has been jointly carried out by the *Centro Ricerche Fiat*, *Magneti Marelli*, and *Elasis*.[13] In 1994, because of the financial distress FIAT group was then experiencing, this technology was licensed to Bosch GmbH. In 1997, the first car ever using the common rail system was the Alfa Romeo 156 2.4 JTD (Riegler, 2009).

All these innovations needed a whole set of preconditions to be obtained. Uphill this R&D process, a wealth of scientific knowledge, embedded in previously obtained stocks of patents, technologies, know-how must be available to the region-industry. GPTs are crucial in this respect. It is by no chance that the Centro Ricerche FIAT is organized in three branches - Powertrain Technologies, Vehicles, and Innovative Technologies-, the last of which carried out research on those technologies (viz. Electronics, Micro and Nano Technologies, and Business Information Technology) being identified as GPT in previous analysis within the KIT project.

Collective learning and entrepreneurial skills of local actors, then, "ground-discharge" new knowledge to real products, generating innovations increasing the final products' competitiveness on world markets. This has in particular been found relevant for the suppliers of the main group interviewed, which deal with industrial paintings, plastics, coatings, and glasses; and who, in close collaboration with the FIAT group, but also

[12] See Section 2 above.
[13] All companies are currently part of FIAT group.

independently, creatively add sub-components, devices, techniques that maximize the economic value of the scientific and technical knowledge previously contributed by FIAT group's research centers.
The qualitative evidence emerging from the present case study clearly points towards the relevance of the synergies among the two types of local actors (i.e. MNCs and independent SMEs) in shaping a competitive innovation pattern. Given the intrinsically rival nature of knowledge in this oligopolistic sector, and more generally, the far-from-complete diffusion of the open innovation approach, for an endogenous pattern of innovation to emerge both scientific knowledge, as well as innovative capabilities, are needed.

Key findings:

- The high complexity of the automotive industry requires an all-round knowledge, covering both scientific and technical, as well as bench-level, knowledge;
- Collective learning and entrepreneurial skills of local actors "ground-discharge" new knowledge to real products, generating innovations increasing the final products' competitiveness on world markets;
- Both SMEs as well as MNCs of this industry-region enjoy a rich set of scientific and technical skills, and entrepreneurial capabilities, that allow them to make a creative use of external knowledge turning it into radical innovation,
- Thanks to their innovative skills, they will maintain a competitive edge on several competitors for some time;
- However, challenges will have to be faced because of a relatively weaker exchange of knowledge from outside the industry-region.

B4. Internal and local channels for knowledge and innovation creation

According to the conceptual framework developed within the KIT project, channels for knowledge acquisition have been classified as follows:

1. Internal channels: channels of knowledge acquisition internal to the firm/company/organization;
2. Local channels: channels of knowledge acquisition external to the firm/company/organization, but internal to the region being analyzed;
3. External channels: channels of knowledge acquisition external to the firm/company/organization, and external to the region being analyzed.

The following paragraphs are organized accordingly.

B.4.1. Internal channels

Internal channels are the main source of knowledge creation in the present case study. Although some of interviewed companies are MNCs, the aim of all companies in this region-industry is to retain internally most of the positive fallouts of their research activity. In such a competitive environment, firms try to capture monopolistic profits by intellectually protecting their results.[14]
The multi-national nature of some of these firms, however, allows exchanges of ideas within the head company's boundaries. This has in particular been found true in two cases:

1. *The commercial vehicles brand*, which – as above mentioned – first developed the online assistance service which has been later on introduced, by will of the head company's decision-makers, to the other brands of the group. This is a success story of an innovative service developed in a branch of the group brought forward from within the group itself, being distributed all over the group's companies.
2. *The Piedmont branch of the industrial paintings' MNC*: in this case, while proper R&D activities are mainly carried out in the head company's US location, incremental and

[14] Companies directly selling in the automotive industry claim that the competitive advantage lies mainly in producing goods with a superior technological content. Besides, competition is also organized along product design and marketing, after market services, absolute cost efficiency; all interviewees, however, agree on the crucial role of obtaining a technological competitive advantage.

applied innovations are obtained, oftentimes in response to local customers' needs, also in the Piedmont branches. Such positive findings and inventions are then circulated across different branches belonging to the same group, which prompts the emergence of a rather original way of knowledge diffusion, one that partially eludes the definitions herewith given. In fact, in this model of knowledge diffusion what's *internal* (to the firm) is not necessarily a *local* channel.

B.4.2. Local channels

The relations of both the companies within the FIAT group as well as the independent ones, working partially or totally in connection with FIAT group, are rooted in the territory in several different ways.

In Turin, the company enjoys very strong connections with the city's technical university (the Politecnico di Torino). Most of its recruits comes from that university's freshmen, and several joint research projects have been carried out. This is definitely connected with the strong identification of the territory with the automotive industry, which in turn is partially due to the strong sectoral specialization registered in Piedmont (see Section 1 above). This strong identification motivates the Turin Polytechnic to create ad-hoc courses suited for the automotive industry's needs.

At the same time, an ever-increasing level of complexity and competition typical of this industry produced new branches of this collaboration, in two main directions.

One the one hand, the smallest interviewee of this case study, Organization A, which does not reach alone the sheer size needed for specific quality and resilience trials on some of the paintings, coatings, and materials needed for its production, has a joint agreement with the Politecnico for using its facilities to run such tests. Organization A has been lately trying to diversify its network of buyers towards other, mostly foreign, carmakers, and rather successfully so. First, sales to German carmakers have begun. A large recent order, however, came from a large US carmaker, extending its range of operation across the Atlantic.

On the other hand, since the breaking up of the FIAT-General Motors (henceforth, GM) joint venture (and underlying put option) back in 2005, GM decided to launch a new research centre, PowerTrain Europe, and a new research institute, the *GM-Politecnico Institute of Automotive Research and Education*, which, along with the Shanghai Jiao Tong University and Michigan University peers, aims at identifying future trends in the automotive industry (Ferrando, 2009). In a Jacobian manner,[15] technological progress and cross-fertilization across companies and industries identify a story of urban innovation, whereas the wealth of knowledge produced from cooperative behaviors of the local academia and firms spills over to other companies, and generates further knowledge production.

Finally, a further channel of knowledge creation emerges from the continuous pattern of knowledge exchange through informal channels between pairs of SMEs for solving specific problems. In the KIT theoretical framework, this covers the second set of local characteristics, viz. those leading to the preconditions for innovation, and the innovation process itself. In this case, informal channels (in some cases, through personal friendship or acquaintance; in other cases, via more formal professional meetings) lead SMEs to exchange ideas on problem solving. An interesting example pertains Organization A, which rapidly moved from a craft-made painting process to a fully-automated process. Given the high complexity and the tailor-made nature of the robotized processes needed, this company could not simply buy standardized production lines on the market. Instead, jointly with a second entrepreneur operating on markets outside the automotive industry, but needing similar technologies, he went on a short tour of Italian and German industrial robots producers, to ultimately bring in the knowledge needed to specify the exact characteristics of the production line needed. The final result was an order placed to an automation company in Brescia, Lombardy, from which the production line currently being used came.

[15] See Jacobs (1969).

Key findings:

- Internal channels of knowledge creation are the most relevant ones, although the multinational nature of these firms implies internal knowledge exchange may well cross regional and national borders;
- Other car manufacturers are locating R&D centers reaping the benefits of the local know-how, or buying semi-finished products from local SMEs, in a classical mechanism of collective learning;
- A further channel of knowledge creation emerges from the continuous pattern of knowledge exchange through informal channels between pairs of SMEs for solving specific problems. Such collaborations are based more on a common identity, a sense of belonging rather than on classical trust-oriented relations à la Putnam.

B.5. Territorial elements supporting knowledge and innovation creation

The Piedmont automotive cluster is subject to a huge competitive pressure from traditional (German, French, and Japanese) and new (Korean, Indian, and Chinese) competitors. Recent rumors suggest that a technical discussion on the likely future location of the control functions of the FIAT-Chrysler group (i.e. whether they should be centered in Turin, Italy, or Detroit, US) have been going on for months now.[16] Transportation costs of semi-finished products in this industry have been declining in this recent years, reducing the scope for strongly concentrated production lines.

One reason for the automotive industry to remain a Piedmont issue all interviewees agree on is the extremely good quality of the workforce, with a (quality-adjusted) low cost. Although most organizations complained about a general gap in applied skills being registered in new recruits (which is probably due to the country educational system's weakness, rather than being area-specific[17]), the average level of human capital is quite satisfactory.

However, the present case study clearly identifies the rich set of skillful and (quality-adjusted) low-cost suppliers as the one reason for automotive companies to remain anchored to the Piedmont region. The high quality of Piedmont's suppliers is also testified by the large share of semi-finished products being sold from Piedmont companies world-wide. However, this local competitive advantage currently seems to be barely enough for allowing Piedmont to maintain the control powers of a large MNC of the automotive industry.

The combination of a highly skilled human capital, the presence of a sound scientific base, the collective learning and entrepreneurial proclivity leading to an efficient ground-discharge of new knowledge, and finally the creativity of SMEs entrepreneurs in looking for general purpose technologies needed to innovate, allow the identification of an endogenous pattern of innovation creation (pattern "1" in the KIT theoretical framework).

Key findings

- Local firms, including MNCs, are linked to the territory mostly:
  - For a very good fabric of high quality suppliers;
  - Because of a technically skilled, and know-how rich, labor force;
  - Via a network of relations based on common sense of identity and belonging, fostered both by industrial/technological as well as cultural proximity.
- The choice to retain control functions in Piedmont may be supported by a higher attention to innovation policies.

[16] For a detailed discussion of this topic, see Associated Press (2011).

[17] See also the case study on ICTs in Lombardy, where similar complaints about the educational system have been made.

B.6. Local innovation policy assessment and governance

This Section marks a significant detour from similar best practice in knowledge creation case studies in other regions. In fact, the absolute dimensions of the companies belonging to the head company allow (or at least they did in the past) the company efficient lobbying capability both at the national, as well at the supra-national level. Even recently, the Italian government set up schemes financing the substitution of old cars with new ones, under the condition the new products respected European environmental criteria.

However, recently the financial crisis and the increase in competition in the automotive industry, with a constant corrosion of technological margins and potential new competitors threatening to erode traditional market shares, posed new challenges. Increased competition is exerted by carmakers being relatively newcomers (Korean) and incumbents (Chinese and Indian). Besides, shrinking financial availability for national and supra-national entities makes policies financially supporting or targeting specific industries increasingly unsustainable.

The diminishing transport cost associated to semi-finished products, and a general negative influence of the country's overall economic situation, may actually suggest companies directly belonging to, or indirectly depending on, the FIAT group to move the control functions to Detroit, home to Chrysler. Industrial and innovation policies both at the national, as well at the supra-national, level should therefore enhance the likelihood of FIAT group's companies to remain in Piedmont. The likely impact of a departure of the group's control functions would in fact be a loss of human capital-intensive jobs, and a weakening of the input-output linkages connecting the different stages of innovation production in the region-industry.[18]

Interviewees also lamented an insufficient attention of trade unions to such themes. Old-style union policies, in fact, offer resistance to the speed of technological change, both in terms of new products and processes introduced, as well as in terms of new modes of production. Indeed, one of the main reasons for FIAT group to withdraw control functions from Italian branches would be the search for a more flexible system of work relations; however, recent steps in the direction of easing such relations is the extension of a pilot contract first signed at the Turin *Mirafiori* plant to other Italian branches of the company.

Besides, there is still room for expanding collaborations between university and industry; in fact, interviewees agree on stating that the whole industry-region may benefit from a more applied and concrete approach to education on the side of universities (apparently, recruits in the automotive industry need on average a lengthy period of apprenticeship to be actively involved in the production process). This last statement, however, should be best understood in the sense of a closer relation between scientific and applied research, rather than on the pure shift of apprenticeship costs from private to public finances. Along with closer research collaborations, specific post-graduate courses aiming at forming skillful applied technicians for the automotive industry may also increase the attractiveness of the local university for the automotive companies, thereby making the whole regional system a better production and design location.

Crucial challenges face therefore local and supra-national policymakers if the aim is to retain such a fundamental and technology-intensive industry in the region.

[18] Accurate estimates suggest that 100€-worth value added recorded in FIAT group's internal balance sheets in Piedmont would induce around 250€-worth value added in connected businesses in the region, with a clear leverage (multiplier effect) of any (positive or negative) trend in the company's performance. Source: Bricco (2011).

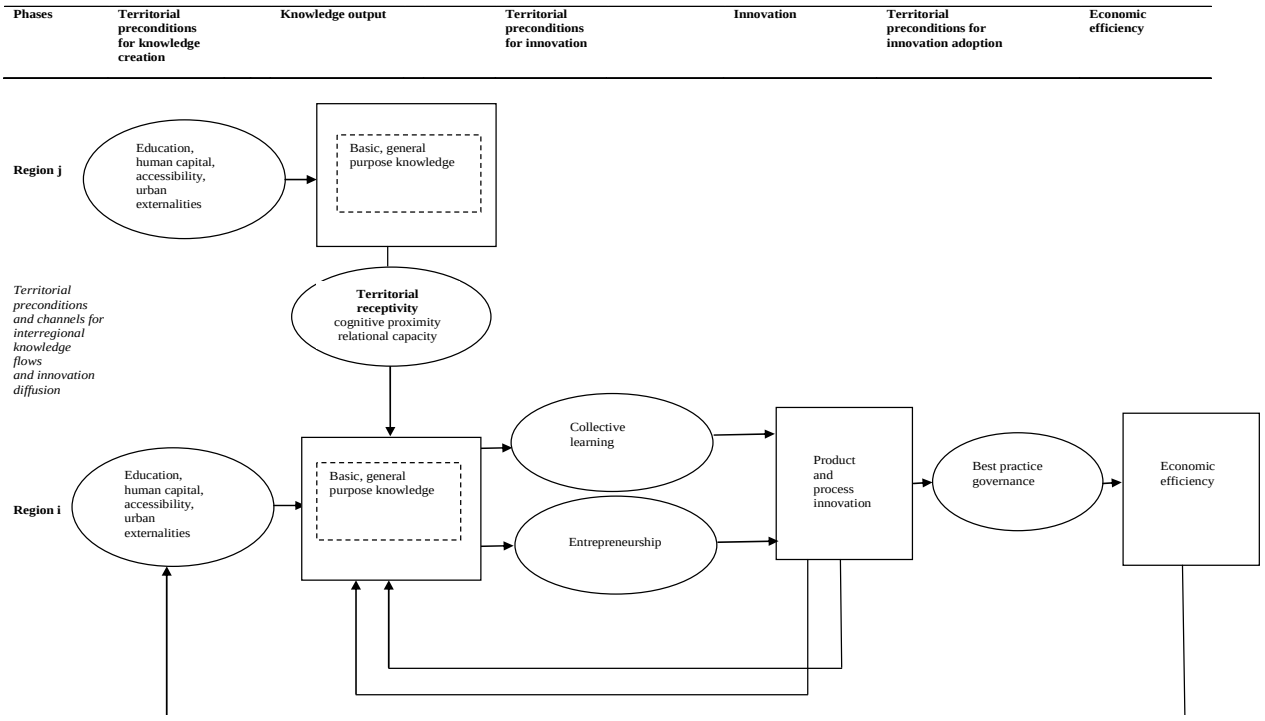
Key findings:

- In the past, lobbying capability at all governmental levels allowed the automotive industry to obtain competitive advantages;
- Increased competition from Asian and German carmakers, and the worsening of the EU's financial availability, may hamper this lobbying capacity;
- Policies should foster the collaborations between university and industry: a more applied and concrete approach to education on the side of universities is welcome by local firms, to be understood in the sense of a closer relation between scientific and applied research, rather than on the pure shift of apprenticeship costs from private to public finances.

B.7. Conclusions

The simultaneous presence of a wealth of human capital, with good quality schools at all educational levels, a base of general purpose technologies, entrepreneurial capabilities of local SMEs, and a creative attitude towards product and process innovation, depict for Piedmont a case for an endogenous pattern of innovation (pattern "1" as described in Chapter 2, Volume 1 of the Scientific report and reported in Figure B.3). With the presence of human capital as a major precondition for knowledge creation, firms (mostly large and MNCs) of this region-industry produce new knowledge, which is oftentimes protected by patents and trademarks; local SMEs in the industry, then, add product and process innovations in a never-ending loop closely resembling traditional R&D-based innovation modes.

Figure B.3. An endogenous innovation pattern



Source: KIT final report

A major departure from a textbook-best practice case of an endogenous pattern of innovation lies in the present case study in a relative weak network of connections with outside regions. In Figure B.3 above, this would correspond to a relatively weak connection with the scientific base of other regions. In fact, the very competitive, and rival and exclusive, nature of knowledge identifies a case where endogeneity of the innovation production is weakly matched by flows of knowledge generated outside the region. For the companies belonging to FIAT group, the main source of innovations is the

internal R&D department. This relative weakness may represent a major flaw in the attempt to retain control functions in Piedmont; because of an increased competition in this industry, in fact, openness to external sources of knowledge may be the only way to keep ahead of competitors in technological, as well as in managerial terms.
In two respects, this statement is partially attenuated. On the one hand, the technological standard of the main FIAT group competitors is continually pushed forward by the overall shift of the technological frontier; as such, innovations obtained by the company's rivals are necessarily introduced in FIAT companies' vehicles, in order to match the quality of the competitors' products. On the other hand, SMEs not directly owned by the head company form a fabric of process innovators, operating a never-ending practice of technical, rather than technological, advancements, leading to substantial improvements of the semi-finished products being assembled.
A potential weakness of the local innovation system is linked to the frailty of the local rooting of the companies, exposed to international cost competition and tending to re-locate abroad. In this respect, policies aiming at directly stimulating innovation, as well as targeting the intensity of human capital, the quality of the transport and communication infrastructure, and the overall level of service offered by the Public Administration at the local, national, and supra-national levels will be fundamental in the following years in order to strengthen the link between automotive companies and the Piedmont region.

Key findings:

- The simultaneous presence of a wealth of human capital, with good quality schools at all educational levels, a base of general purpose technologies, entrepreneurial capabilities of local SMEs, and a creative attitude towards product and process innovation, identify a best practice region in knowledge creation;
- A relative weak network of connections with outside regions may in the long run weaken the effectiveness of this best practice in knowledge creation;
- Future challenges for local firms may be tackled with sound policies aiming at improving the innovation potential of the local industrial fabric, and the quality of the services offered by local and national political centers.

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C. ICT sector in the Bratislava region[19]

C.1. Introduction and description of the case study area

The Bratislava region (NUTS 2) as the most efficient region in the Slovak economy takes part in creation of GDP in the Slovak Republic (SR) with 26.7 % (2007). The region belongs to the economically most developed regions in the EU. Regional GDP reaches 160 % of the EU27 average (2007) and GDP per capita is 26,996 euro (2007). The above-average level of GDP relates closely to the restructuring of regional economy, localisation of activities with the higher value added, concentration of private sector entities and central authorities of public sector.

Higher concentration of sections, which are demanding qualified labour force particularly concerning PC activities (ICT as well) is recorded. The amount of firms in the sector ICT has progressively grown and the employment in this sector has increased (Table C.1). This growth leads to additional localization of new innovative firms that absorb new human resources. Consequently, these firms can directly or indirectly (through tacit or codified knowledge) raise their qualification and value simultaneously.

Table C.1. Profile of the Bratislava region

Population	606,753
GDP per capita (EUR/per capita)	26,996
Employment in technology and knowledge-intensive sectors (%)	6.92
Employment in IT in 2008 Employment in IT in 1997	8,075 1,563
Number of ICT companies in 2010 Number of ICT companies in 1997	4,961 2,481
GERD / GDP (%)	0.23
BERD / GDP (%)	0.14
Researchers (% of total population)	2.47
Business researchers	579

Source: Eurostat, 2008, Infostat, 2010, Statistical Office of the SR, 2011.

Research, developing and technical-innovation potential in the region tends to reach high performance results and contribute in such way to the development of the region. Innovation infrastructure in the Bratislava region is insufficiently developed. Therefore, the progressive development of advisory innovation infrastructure is important. The establishment and development of technological centres and parks, which directly support arising innovation firms, is desirable. Referring to the area of non-material infrastructure, development of consulting services in the area of intellectual property, patent consulting, including consulting in the area of patent protection financing and consulting services in the area of innovation activities is needed.[20]

Distinctive differences in innovation efficiency as well as computerisation exist at the regional level, i.e. only between the Bratislava region and other regions. These differences are consequence of the geographical position and character of Bratislava, which is economical, administration and culture centre of the SR. The Bratislava region, which is ranked at 27 out of 208 regions of the EU25 according to the evaluation of innovation efficiency, represents the centre for innovations of European importance. The Bratislava region together with Vienna (ranked 24) and Budapest (ranked 34) create one of the most significant innovation regions of Central and Eastern Europe (CEE).[21]

Innovation infrastructure in the Bratislava region is developed relatively lightly in comparison with highly-developed regions of the EU. Therefore, the progressive development of the material as well as non-material thus advisory innovation infrastructure is important. In the area of material innovation infrastructure, the

[19] This case study report has been written by Rudolf Pástor, University of Economics in Bratislava.
[20] Program of the Economic and Social Development of the Bratislava Region 2007-2013.
[21] Operational Program of the Bratislava Region, NSRF 2007-2013.

establishment and development of incubators (for example the university technological incubator of the Slovak University of Technology -STU), technological centres and technological parks is important. According to the research performed in project RIS[22], the Bratislava region has the preconditions for the formation of "innovation clusters" of the firms, which operate in the area of the ICT, new materials and nanotechnologies.

C.2. The ICT sector in the Bratislava region

The ICT sector is growing very fast but is changing even faster. The first private ICT companies in Central Europe started to be established at the beginning of 1990´s after the dissolution of the Communistic Bloc and the opening of this area for global economical processes. The Central-European area was soon fully open to foreign companies that would bring mainly their goods and services here. These companies were above all the American and German technological companies, which were coming to the Central-European market with their up-to-date technologies. This sector has been, therefore, developed very dynamically. Several ICT companies that passed through secular, successful development and represented a real concentration of technological know-how were established here. Due to this know-how, they may be asserted not only in the domestic but also in foreign markets. The success of these firms (e.g. Eset), which were weak referring to capital at the beginning, was often based on the recognition of the free market segment, which, although, maintained the perspective of fast and long-term growth (Sobotka, 2002).

The section of computer activities has the highest concentration rate in the Bratislava region in comparison to other sections. The value of the Gini coefficient in the section rose from 25.29 on 46.38, which represents a significant concentration rate. Although this section generated only a few, new, work positions (8,130), their creation had been very non-uniform. Up to 76.5 % of the generated positions arose in the Bratislava region. The Hoover– Balaasa coefficient rose considerably from 2.08 on 3.00 in 2008. In 2008, up to 62 % of employees in the section of computer activities worked in the Bratislava region, whereas in 1997, it was only 35 %.

From the aspect of the section structure, the Bratislava region mainly dominates in the area of software consulting services, when up to 45.11 % of firms in the SR in this section were localized in the Bratislava region. It is similar in case of data processing (39.79 %) and telecommunications (31.54 %). The software consulting services and activities with databases also recorded the highest dynamics of growth firms´ registration; when their number increased by more than triple. The Bratislava region reaches relatively high figures in every area in comparison with other regions in the SR. The exception is the area defined as *other activities with computers*, in which the lowest number of ICT firms is situated just in the Bratislava region.[23]

The fact that ICT firms in the Bratislava region are mainly aimed at software consulting services, the data processing and telecommunication services (Table C.2), represents a significant shift from production or hardware trading (beginning of 1990´s) towards software products and ICT services with higher added value, which currently prevail.

[22] Regional Innovation Strategy of the Bratislava Region.
[23] University of Economics in Bratislava (2010): Regional Dimensions of Knowledge Economy.

Table C.2. Employment in the ICT sector in the Bratislava region in 1997 - 2008

Sector (code)	Production of office machines, computers 30	Production of electric machines, appliances 31	Prod. of radio, TV, comm. devices and applian. 32	Communications 64	Computer Activities 72	Total
1997	233	2,745	313	9,719	1,563	14,573
1998	276	2,495	170	10,002	2,397	15,34
1999	402	2,051	370	10,015	2,193	15,031
2000	379	1,923	398	9,905	2,505	15,11
2001	356	2,046	335	9,445	2,87	15,052
2002	354	1,555	301	8,986	3,068	14,264
2003	374	1,446	176	8,716	2,843	13,555
2004	397	1,573	153	9,144	3,637	14,904
2005	481	1,786	188	8,797	5,246	16,498
2006	476	1,413	194	8,61	5,933	16,626
2007	463	1,415	214	9,089	7,545	18,726
2008	361	1,246	307	9,191	8,075	19,18

Source: Statistical Office of the SR.

The ICT sector is, at present, one of the most dynamically developing sectors in the economy of the Bratislava region. The concentration growth of ICT companies of world-wide and national importance proves this fact.[24]

Overall, the development of the ICT sector in the Bratislava region is characterized by two synchronic trends. The first trend is a development of the local firms and their establishment in new markets (e.g. segment of Information Security). However, firms often run a business only in local and national markets and gain advantages from a better understanding of the markets. Competitive pressures of large foreign firms are expressed to an even lesser extent that of the acquisitions and mergers of the smaller local firms. More distinctive success and establishment in foreign markets can be observed by firms which invented a very specific product or service. This group of firms is expected to be more intensively interconnected with the local and university sector. The second trend is represented by the entrance and development of the large IT centres of global firms (e.g. HP, IBM, Dell, AT&T), which employ a large part of the labour force. The knowledge transfer of these firms is often very strictly internal (within the firm) with a very limited interaction with the local knowledge base at universities.

ICT sector development, after 1989, in the Bratislava region, has its own specific features. ICT firms that were established by local businessmen, employees of research institutes or Informatics students, were founded here. Among the most significant ICT firms in Bratislava (Table C.3), firms founded in the first wave after 1989, e.g. **Asseco** (founded in 1990), **Datalan** (1990), **PosAm** (1990), **Siemens** (1991, **Siemens IT Solutions and Services)**, **Tronet** (1991, predecessor of the company **Soitron**), **Gratex** (1991), **Eset** (1992), **Anasoft** (1992), **DITEC** (1993) etc. can be also mentioned.
The period at the beginning of the 1990´s was mild, referring to the growth of ICT firms. In the 1990´s, the first mobile operators were founded - **EuroTel** (1990, predecessor of the **T-Mobile**), **Globtel** (1997, predecessor of the **Orange**) and later in 2002, **Telefónica Slovakia**. Later, in the second wave, in the second half of the 1990´s, some innovative firms were founded, which were aimed at Information Security, e.g. **Gordias** (1997). Other firms from the area of Information Security were founded in the third

[24] Operational Program of the Bratislava Region, NSRF 2007-2013.

wave, after 2004, e.g. **Innovatrics** (2004), **Ardaco** (2006), or firms concerning new technologies e.g. Mobile Navigations - **Sygic** (2004), mobile marketing - **mSolutions** (2006), etc.

Table C.3. Timeline of the establishment of ICT firms in the Bratislava region

Firm	Year of foundation
Asseco	1990
Datalan	1990
PosAm	1990
T-Mobile (before EuroTel)	1990
Siemens	1991
Soitron (before Tronet)	1991
Gratex	1991
Eset	1992
Anasoft	1992
Ditec	1993
Orange (before Globtel)	1997
Gordias	1997
InterWay	1997
Lomtec	1999
Accenture	2000
IBM	2000
Dell	2002
Telefónica Slovakia	2002
Hewlett-Packard	2003
Innovatrics	2004
Sygic	2004
Lenovo	2005
Ardaco	2006
Erni	2008

Source: own elaboration.

ICT firms in the Bratislava region were progressively established by employees from computing centres of former state businesses, which already existed before 1989 (e.g. Computing Enterprise - PVT, Slovnaft, etc.), by Informatics students or former employees of research institutes for Informatics (e.g. Research Institute for Medicine Informatics in Bratislava). Initially fans of computing machinery gradually developed into global ICT companies (e.g. *Eset*) during 1990´s.

In regards to the development of the absolute number of the ICT firms in the Bratislava region, it had the tendency to rise, increasing from 2,481 in 1997 to 4,961 in 2010 (Table C.4). This growth of ICT firms in the region was connected with the growth of employment in the ICT section, from 14,573 in 1997 to 19,180 in 2010 (Table C.2). Mainly foreign investors in the ICT sector of the region participated in this growth (IT service centres).

Table C.4. Number of ICT companies in the Bratislava region in 1997 - 2010

Year	Bratislava	**Total in Slovakia**
1997	2,481	**6,501**
1998	2,672	**7,078**
1999	2,604	**7,083**
2000	2,758	**7,532**
2001	2,986	**8,482**
2002	2,969	**8,843**
2003	3,12	**9,497**
2004	3,465	**10,656**
2005	3,595	**11,142**
2006	3,772	**11,587**
2007	3,972	**12,115**
2008	4,439	**13,159**
2009	4,799	**14,101**
2010	4,961	**14,457**

Source: Infostat.

Regarding the entrance of foreign technological companies into Central-European region, many significant foreign firms started to come to Bratislava after 1990. They established their own subsidiaries in the SR, which prepared all know-how for the firms. Patent rights also remain in these companies. The decisive volume of workload is performed by domestic professionals. These companies are rarely interested in the cooperation in marketing and the sale of products of domestic IT producers. The profit from the sale of their products is executed abroad (Sobotka, 2002).

The Bratislava region represents an interesting investment locality for multinational ICT companies in reference to the geographical location in the SR. The prevalent majority of the most significant investors in the ICT sector reside just in Bratislava. Progressively, these investors founded here their service centres (Table C.5).

Table C.5. Foreign investors in the ICT sector in the Bratislava region

Firm	**Came to SVK**	**Number of employees**
Soitron	1991	750
Accenture	2000	600
IBM	2000	200
Dell	2002	1,500
Hewlett-Packard	2003	350
Lenovo	2005	561

Source: www.sario.sk, 8.1.2010.

Just in 2006, the firms Accenture, Dell, HP, IBM, Lenovo created more than 1,000 work positions in the service centres. IT companies such as Dell, IBM, Ness, etc. represent an example for export of IT services. The Bratislava region became one of the most demanding localities for outsourcing and offshore services in the area of information technologies.

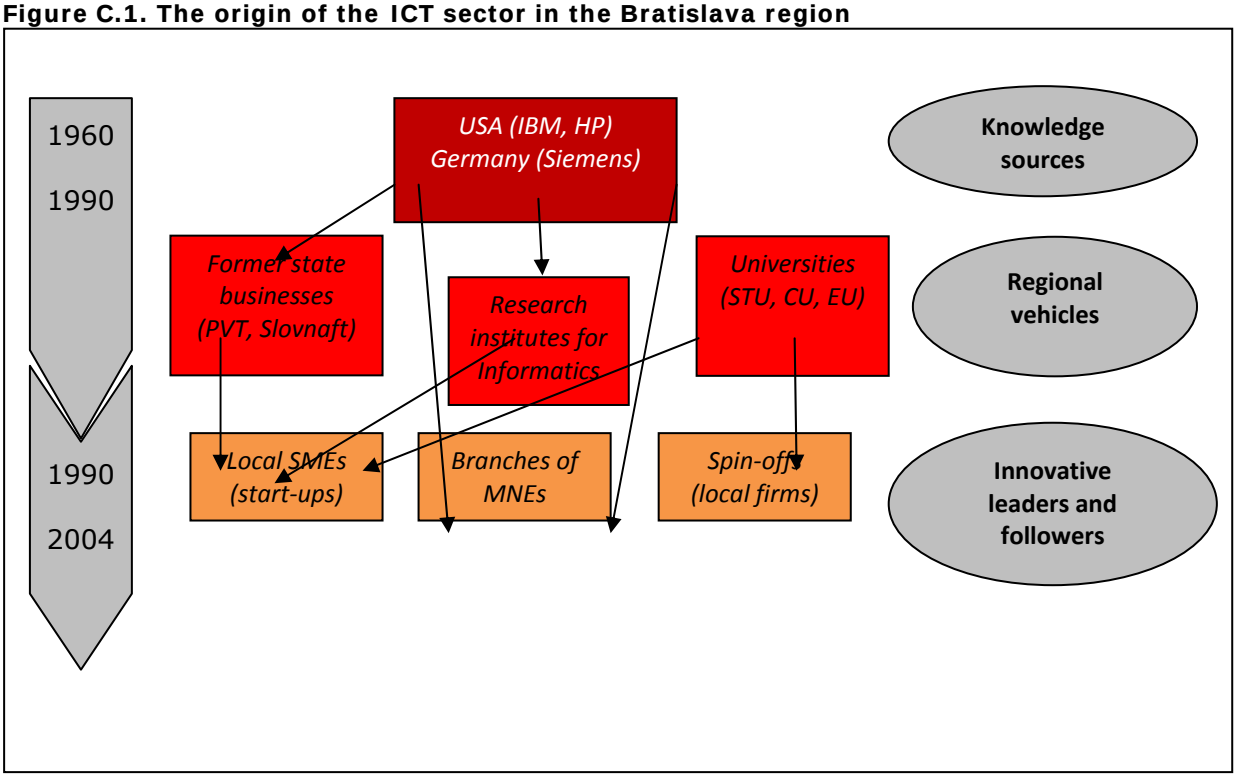
Representatives of the ICT firms point to advantages of Bratislava; the availability of qualified employees, telecommunication infrastructure of good quality, presence of universities and easy transport access from neighbouring Vienna (Airport in Schwechat).

Referring to the origin of the ICT sector in the Bratislava region, (Figure C.1), some significant multinational IT companies were present here already in the 1960´sThese companies had their subsidiaries in closely located Vienna (for example, the company HP has been in operation in the SR since 1967; during this time, its representative was located in Vienna). In 1979 was established sale subsidiary of HP in former Czechoslovakia. The knowledge from abroad was coming in to the region mostly through the existing computing centre. Existence of these computing centres in former state businesses and research institutes in the Informatics area in Bratislava played an important role. Successful leaders from those businesses and institutions were those who

later founded their own private ICT firms aimed at hardware sale, IT services and later at Information Security services. ICT companies connected to the academic sector were also established. Former students of Informatics at universities (STU, CU, EU) in Bratislava were also establishing ICT companies.

Universities played an important role in development of the ICT sector in the Bratislava region. In 1974, the Department of Theoretical Cybernetics in the Faculty of Natural Sciences of the Comenius University (CU) in Bratislava was founded. This department was the first workplace in former Czechoslovakia that provided an autonomous area of study enabling the gain of a complex education in Informatics. Since 1980, it has been operating as the Department of Informatics in the Faculty of Mathematics, Physics and Informatics (FMFI) of CU. In 1973, the Department of Computers and Department of Cybernetics were simultaneously established in the Faculty of Electrical Engineering (today Faculty of Electro Engineering and Information Technology – FEI) at the Slovak University of Technology in Bratislava by division of the Department of Mathematical Machines. The first content rebuilding of studies, due to which the areas of study at the Faculties of Electro Engineering within the whole CSSR were united, is established in the academic year 1977-78. From the Department of Computing, the Computing centre was detached which became the Centre for Computing Technology of STU. The year 1990 may be considered as a significant milestone in the development of the department and area of study. Transformation of studies began in the Faculty. In 1991, the area of study, Informatics with a specialization of Software Engineering and Computing Technology, as well as Telecommunications was established. The Department of Telecommunications started to partake in management of the area of study.

Figure C.1. The origin of the ICT sector in the Bratislava region



Source: own elaboration.

This report is structured as follows:

- In section C.2, we draw profiles and explain the innovation activities of the interviewed organizations.
- In section C.3, the type of knowledge and expertise required of the firms to innovate is described.

- Section C.4 analyses the channels used by the reviewed organizations for knowledge and innovation creation.
- In section C.5, a description of territorial elements in support of knowledge and innovation creation is presented.
- Section C.6 offers an overview of local innovation policy assessment and governance from the perspective of the interviewed firms and policy makers.
- Section C.7 consists of our conclusions.

C.3. Firm profiles and innovative activity

The ICT sector represents an important source of innovations in the Bratislava region. The case study of the Bratislava region presents selected innovative ICT firms that were personally interviewed (Tables C.6 and C.7). Our selection is represented by large multinational firms, medium sized firms, as well as small firms. This selection of firms provides us with a sufficient overview of a current state in the ICT sector in the Bratislava region.

Table C.6. Summary information on the interviewees

Organization	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
Company A	Marketing & Communications Leader	MA	12	no
Company B	Business Unit Leader	MA	3	yes
Company C	General Director	MA	14	yes
Company D	General Director	MA	7	no
Company E	General Director	MA	6	yes
Company F	Executive Director	MA	21	yes
Company G	CEO	MA	8	no
Company I	Sales Director	MA	1	yes

Source: own elaboration.

Table C.7. Summary information on the interviewed firms

Organization	Year of Foundation	Part of a group	Turnover in €	R&D spending in % of turnover	Export in % of turnover	Nr. of employees
Company A	1992	Yes	N/A	-	5 %	500
Company B	2007	Yes	1.6 m	90 %	100 %	35
Company C	1997	No	-	-	-	5
Company D	2004	No	N/A	40 %	80 %	15
Company E	2001	Yes	35 m	10 %	25 %	400
Company F	1991	No	55 m	2.5 %	0 %	700
Company G	2004	No	6.1 m	24.5	100 %	80
Company I	1991	No	N/A	N/A	1 %	30

Source: own elaboration.

Company A has been operating in the SR since 1992. In 2002, it started to run a technology centre for the development and maintenance of business applications in IT, which was established in Bratislava (Bratislava Delivery Center – BDC). At present, the firm employs 500 employees in the area of IT (2011). This firm deals with the Consulting and Technology Solutions divisions, which are represented in the form of the technological centre (BDC). Employees in the BDC are concerned with applications´ unification, migration of complex databases, system and software development and technical support.

Company B is a subsidiary company of a prominent Swiss company dealing with IT consulting. The firm is aimed at process and technology innovations. The company has

its subsidiaries in Switzerland, Germany and in Slovakia. The subsidiary of the Swiss firm in Bratislava was founded in 2007. Recently, the company in Bratislava has 35 employees (2011) and here, the *Shared Service Centre* is run. The activities of this centre are particularly aimed at exporting abroad, in which the firm performs up to 100 % of the company's turnover.

Company C was established in Bratislava in 1997. It is aimed at undertaking in the area of protection of information systems. This small company recently employs 5 employees (2011) and provides its services within the SR (the biggest portion of services performs within the Bratislava region). The services are exported abroad very rarely. Development of the firm is financed solely by its own sources. It also uses knowledge from other sectors for its activities. The firm works on implementation of the formal system of knowledge management but currently this is only in its preparation phase. In regards to the segment of Information Security, the firm significantly participates in many knowledge networks.

Company D is a small start-up company with 15 employees. It was founded in 2004 by two students (from the SR who studied IT and telecommunication in Paris) together with a professor of a French college. The company owns an algorithm for the identification of fingerprints. The company's products are offered to various consulting firms worldwide. Currently, the firm has its subsidiaries in France, the Slovak Republic and the Czech Republic. The firm has clients in French speaking countries in Africa (Chad, Gabon, Guinea, Nigeria and Morocco). The main products and services provided by the company are the searching databases of fingerprints (AFIS) and the licensing of technology for existing players in Biometrics. Its first mass product is an attendance system for firms on the basis of fingerprints. The acceptance into the Incubator Telecom Paris was a very significant step for the firm's establishment. Its first client (the Canadian firm, Bioscrypt, which is the leader in the market in the area of door-opening on the basis of fingerprints) presented a significant milestone for the firm in 2004. The subject of the order was the licensing of the source code for the algorithm and single-providing of consulting services. Cooperation with this firm was started due to a contest in biometrical algorithms, which had been announced by Bioscrypt. The firm was ranked among the first in the contest. The first product of firm D was an algorithm that could compare fingerprints on the principle of the so called "one to one". Later, in 2006, the firm came up with a new algorithm that was able to search and find fingerprints in large database and work on the basis of the so called "one to many". The Identification of fingerprints by use of this algorithm is in comparison to the previous one, much faster. Just after its founding, in 2007, a new product, "ExpressID", was created. Presently, the firm develops its products towards the widening of their usability. New programme languages are added, which then enable a broader application of their products.

Company E was founded in Bratislava in 2001. It is a subsidiary company of an Israeli technology company and belongs to the most prominent companies in the Slovak IT market. Its specialty is providing complex IT solutions and services to prominent local companies from the energy utilities, state administration, financial services, telecommunications, industry and services. In 2005, the subsidiary company operated its first European software Development centre in Košice, which is aimed at the development and testing of software, as well as specialised services, for clients from Western Europe and overseas.

Company F is among the innovative leaders of large ICT companies in the Bratislava region. The predecessor of this firm resulted from the fusion of business activities of two IT companies in 1991. The firm´ s platform consists of its previous IT company's long-time experience in the Slovak ICT market and the know-how gained from the two-year cooperation with the Spanish expert company on selective outsourcing. The firm was founded in 2004, in Bratislava. Its subsidiaries are located in Košice, Banská Bystrica, Žilina and in Prague. In 2005, the Slovak company took over the shares of the Spanish

firm and became a prominent provider of IT services. Business activities have been integrated into one company the result of which was the first IT delivery centre in the SR. The firm is today one of the biggest info-communication integrators and providers of IT services, with 700 employees (2011) and a consolidated turnover of 55 million euro.[25] Concerning the organisational structure of the firm, the main scope of integration part of the firm is projects or project integration. The second division is outsourcing, in which approximately 500 employees work. The firm's major client was HP. The main products of the company are network technologies and technologies concerning infrastructure, as well as infrastructure integration. Some other products are application of data infrastructure – data centres, data centres administration, computer networks in general, content management centres – projects as IP telephony, unified messaging, etc. The company provides services in following branches: analyses and consultations, layout of solution architecture, implementation services, management services, outsourcing, vocational trainings and project management. The company was presented the IT Firm of the Year Award in 2010 for several unique products, for example, the application of Unified Communications, re-design of WAN network, implementation of the IP telephony, multimedia content management centres for the operator of outsourcing of call-centre services, supply of HD video transfer of the NATO representatives meeting, multimedia content management centres, etc. Major firm's clients are the state administration, the bank sector, the retail business, power engineering, telecommunication companies, transport, hospitals, and hotels. The firm has gradually expanded its global status by means of acquisitions, which represent a natural consequence of development in the ICT sector.

Company G is a new innovative and fastest growing ICT firm in the SR. Company was founded in Bratislava in 2004. The subject of business is Mobile Navigations. The founder of the company built his career while studying at the University of Economics in Bratislava, Faculty of Economic Informatics. The aim of the firm was the creation of a new operational platform for mobile devices. This was not too attractive to large firms at that time. In 2006, the firm launched a tight collaboration with a supplier of maps, the firm TeleAtlas. According to one of the heads of the company, "the firm had already been able to present navigation solution for mobile telephones in a "ripe" stage, while other companies had only been starting". The Slovak market is not important to the firm in regards to current profit. Today, the firm dominates the market in India, Brazil, Colombia, Argentina, Uruguay, Spain, Australia, south-eastern Asia, Italy, etc.[26]

In 2008, the firm has started the vision with orientation on mobile phones. In 2009, the firm provided a new navigation system for Apple iPhone and new Nokia Maemo devices. Today, the firm is one of the four strongest companies in the world in the area of navigations, which is represented by the companies TomTom, Garmin, Navigon.[27]
The firm currently has 80 employees (2011). Even now, space for the firm's expansion exists, namely in the LBS (location based services) market. According to the founder of the firm, the firm has good diversified business portfolio, e.g. one sixth makes navigation for iPhone. It is important where to be successful and not where to expand. Today's market is very young and risky, markets responded very shortly.[28]

Company I was founded in Bratislava in 1991. It is a small ICT company with 30 employees (2011). The firm is aimed at the complex needs in the area of web solutions, advanced e-commerce applications and made-to-measure software development. The company cooperates with prominent domestic and international companies and organizations (e.g. UNDP). The firm has approximately 70 clients (institutions of public administration, banks, insurance companies, the commercial sector, etc.).

[25] Interview, Bratislava.
[26] HN, 24.8.2011.
[27] HN, 3.6.2010.
[28] Interview, Bratislava.

Key findings:

- The ICT sector in the Bratislava region has been developed in a natural way, while the shift from the hardware sale to the production of its own innovative products can be observed;
- The source of innovation of new products is local and stems from foreign multinational ICT companies;
- Innovative ICT firms are established without venture capital in comparison to the U.S. and Western Europe; e.g. in case of Information Security firms;
- New knowledge from local sources comes within the firm's boundaries, mainly through the innovations of innovative leaders in Information Security and Mobile Navigations;
- The ICT system in the Bratislava region does not constitute a real functioning system, since the linkages between ICT firms, local universities and local public institutions are based on formal associations, e.g. IT Association Slovakia (ITAS), Slovak Association for Information Security (SASIB), etc.

C.4. Types of knowledge and expertise required for local innovation

ICT firms in the Bratislava region need various types of knowledge such as scientific knowledge from scientific journals, technical knowledge from sector-specific journals, bench level knowledge based on-the-job trainings and experience, as well as customer knowledge based on interactions between the user and producer.

Firms gain technical knowledge from specific sector magazines, namely from the area of Information Security (Virus Bulletin)[29], in which the experts that are centred on this area have the opportunity to comment on specific problems in online discussion forums, social networks, etc. A new algorithm of a firm from the area of Information Security was founded on basis of knowledge gained from study of scientific articles on methods of algorithms creation, as well as by the creative thinking of its founder. A new product of a firm was created on basis of the firm's internal knowledge, without the cooperation of any external firm. Concerning the product development, the firm also used the framework knowledge of the biometrical market from a marketing study focused on Biometrics. Firms from the area of Information Security also use other knowledge from other sections (e.g. from information technologies, marketing, etc.) concerning their activity, which is represented by the mentioned area of Biometrics. The firms have a formal system of knowledge, "WIKI" (a function from the Google). Through this, they share internal information, offers on their products, price lists, telephone numbers, etc.

ICT firms use also other kind of information, e.g. social and demographic information, by predicting market development, etc.

ICT firms often use knowledge based on trainings, mainly by elevating ICT skills, etc. Despite the progress concerning information technologies and communication, personal contacts still play a significant role. Customer knowledge is based on the relationship between users with producers. These personal relations are also important when detecting the needs of clients and made-to-measure solutions adapted for a client. Personal relations in the sections with fast technological changes, such as in the ICT sector are essential when solving problems relating to offered IT products or services.

[29] http://www.virusbtn.com.

Key findings:

- ICT firms gain knowledge from parent companies or partner firms from abroad, which represent key know-how, mainly at the beginning after establishment of the firms´;
- Technical knowledge is used mainly by firms in the area of Information Security, which at the moment represent a very innovative segment in the ICT sector in the Bratislava region;
- Customer knowledge is recently preferred and used mainly in ICT firms, e.g. in Mobile Navigation which thoroughly need to know the needs of their clients to be able to adjust their product solutions.

C.5. Internal and local channels for knowledge and innovation creation

The Slovak Republic has a small and open economy without a strong internal market. Stimuli of the growth and decrease of economic activity come here mainly from abroad. According to IUS[30], Slovakia belongs to the group of medium innovators with below average efficiency. Relatively strong aspect is human resources and production. The Bratislava region show an innovation level at the EU average, but is located in catching up countries whose overall innovation performance is well below average.

At the beginning of the 1990s large first IT investors in the Bratislava region were using knowledge developed in their parent companies and did not contribute to the regional knowledge creation.

The system of knowledge and innovation creation in ICT firms in the Bratislava region is different in the subsidiary companies of multinational ICT firms, in comparison to the smaller Slovak ICT firms. A large ICT firm, for example, acquires knowledge through internet platforms (leveraging leading edge platform) for knowledge exchange (based on functional, technical or sectional filters), through Knowledge Exchange Portal, through Internal Research Department. Product or process innovations arise in technological laboratories, innovation centres, etc. Another subsidiary ICT company may gain technical and methodical knowledge from a parent company. The parent company gains projects, which are further shifted to a subsidiary in Bratislava or other branches in Europe. Yet, another big ICT company has a so called innovation channel, in which some people endeavour to capture stimuli and ideas. This results in the creation of product drafts, which then leads to the investment council. This process is also set within subsidiaries in the Czech Republic and Romania. The source for subsidiary companies of multinational firms in the SR are intra-corporate partner firms, in which the internal Exchange of information, experience, rotation of employees working on various IT projects, etc., take place.

In case of smaller innovative ICT firms in the Bratislava region, development takes place internally. Stimuli and target determination are important. Stimuli for the improvement of products and services provided come from clients. The internal R&D department is a very important source of knowledge for the firm from the area of Mobile Navigations.

Referring to the firms from the area of Information Security, approximately 8-10 persons are employed in the domestic R&D department in Bratislava. The firms from the area of Information Security consider the feedback from its clients as important by the development of its products. The feedback is mostly obtained by e-mail or telephone in the form of comments on product functioning and new requirements for the supply of systems and technologies. Some products are generated through a direct collaboration with the order's buyer (for example, a project for the Ghanaian government, where a firm tightly cooperates with a local system integrator). Currently, the firm creates strategic partnerships with other complementary firms that run a business in the field of production of fingerprints scanners. It tightly cooperates with six suppliers of scanners

[30] Regional Innovation Scoreboard 2010.

(DigitalPersona, Upek, Cross matsch, SecuGen, Futronic and Lumidigm). Collaboration with partner firms is established through various means, such as actively searching for partners, but the firm also receives various offers for cooperation. The barriers of the cooperation for the firm are e.g. various reasons of confidentiality (this phenomenon is relatively frequent in the segment of Information Security), or coordination expenses.

With reference to the evaluation of the quality of available labour force in the Bratislava region, the representatives of ICT firms evaluate the availability of human resources very positively. Despite this, adjusting to current needs of ICT firms is important. The aim of universities or faculties with specialisation on Informatics should be the sufficient preparation of graduates for the labour market. Graduates command theoretical knowledge, but lack practical experience needed for work in specific IT projects. Although, this cannot be considered a problem in the Bratislava region, the problem of quality of preparation is current. If a firm hires a graduate, it needs the time for training in order for the graduate to be useful. Because of this, the endeavour of universities to adjust curricula to the needs of ICT firms was declared. Until now, however, other specific steps are absent. Innovative ICT firms face a problem when employees must work on higher positions. The firm must constantly educate them and it also needs to innovate faster.

The firm from the area of Mobile Navigations search for collaboration activities on projects with other companies in the region such as start-up firms which think in the same intentions. The firm provides them with start-up capital. The cooperation of the firm from the area of Information Security with a Canadian firm brought the contribution, which lies in acquiring of new technical knowledge and knowledge from the area of licensed contracts.

Key findings:

- The system of knowledge and innovation creation is different in subsidiaries of large ICT firms in comparison to smaller Slovak ICT firms;
- Concerning new innovative ICT firms from the area of Information Security and Mobile Navigations, the development of new innovative products is performed internally;
- Important stimuli for innovative ICT firms are external ideas, reactions from clients, market reactions, etc.

C.6. Territorial elements supporting knowledge and innovation creation

In regards to the territorial aspects of knowledge and innovation creation in the Bratislava region, the localisation of ICT firms in Bratislava is given by historical aspect, mainly due to the presence of government institutions, firms and universities with faculties centred on Informatics. This is also due to quality information, as well as transport infrastructure (primarily because of the proximity of the airports in Bratislava and Vienna). Concerning localisation, innovative activities of competitive firms do not play a very important role, although ICT firms observe what the competition does. ICT firms evaluate the innovative activities of public institutions negatively. Mutual cooperation with competitive firms exists, for example in the area of Information Security during the exchange of information on virus infiltrations. If the partner is ahead in the development of a product, there is no sense to develop the same product for other ICT firm. The firm form the area of Information Security cooperates, for instance with suppliers, which help in the production of a product, etc. ICT firms have shifted more towards clients. Concerning access to employees, other ICT firms in the region present a competition for innovative firm from the area of Mobile Navigations. Finding a qualified, quality employee is yet more difficult. The firm must usually educate and train them and cooperates mainly by means of informal agreements.

The localisation in the capital, Bratislava, was a decisive criterion for small ICT firms from the viewpoint of time and efficiency. Due to competition from other ICT firms, clients and institutions are present there. The presence of other ICT firms is important. It influences innovative activities, mainly as the source of new ideas and facilitates a possibility of cooperation with partners. Firms cooperate by means of informal agreements, for example, during the exchange of information and experience, etc. Partner firms positively influence the firm's efficiency. The presence of other ICT firms in the region is unimportant for a large ICT company. The local market is important, but not from the viewpoint of products development. The competition does not play an important role.

The local KIBS perform a critical activity for a large ICT firm from the aspect of contribution and firm's position. It is mostly based on business and technology consulting because the majority of projects start with this phase.

ICT firms that are members of associations, chambers of commerce, alliances of entrepreneurs, profit mainly from socialising and information exchange with other interconnected ICT firms.

Key findings:

- An important territorial element for the localization of ICT firms in the Bratislava region, which is given historically, is mainly a critical mass of government institutions, universities, as well as other ICT firms or clients;
- Innovative activities of competitive ICT firms do not play an important role in localization;
- The local market is important. Competition does not play too important role. Competition is presented by global ICT firms; firms from the area of Information Security and Mobile Navigations;
- ICT firms cooperate with suppliers, for example in the production of a product, etc. ICT firms have been shifted more towards clients.

C.7. Local innovation policy assessment and governance

Despite the importance of the ICT sector for the economy of the SR (in regards to employment, added value creation, productivity growth, etc.), it can be mentioned that state support for development of the ICT sector is low. The integral government strategy for ICT is absent.

The majority of ICT firms in the Bratislava region are members of supporting associations and institutions, e.g. ITAS, SASIB, The American Chamber of Commerce in the Slovak Republic (AmCham), The Business Alliance of Slovakia (PAS), etc. Except for enabling the exchange of information among members, these institutions function as mediators between ICT firms and government, for example the creation of legislation in the area of Information Security, etc. The involvement of ICT firms in politics is connected, mainly, to activities of the ITAS, which, basically, represents a mediator between government and firms when creating legislation in the area of ICT. The platform of the ITAS is also used by ICT firms for annotations of legislation in specific areas (e.g. Information Security). An example of this active involvement of firms in politics is the company from the area of Information Security. This company cooperated on an expert basis with various state committees that were involved in the formation of Information Security legislation in the SR (e.g. law on electronic signature, law on confidentiality, etc.).

Among other supporting institutions on a national level there is the Slovak Research and Development Agency (SRDA), National Agency for Development of Small and Medium

Enterprises (NADSME), Slovak Investment and Trade Development Agency (SARIO) [31], etc. Also, on a regional level there are innovation centres - BIC Bratislava (Business and Innovation Centre)[32]. According to a representative of an innovation agency, there are enough political tools. The problem lies in allocation and implementation. Cooperation between public institutions and ICT firms is good from the viewpoint of institutions. Cooperation between the academic sphere and firms is low. According to the opinion of a representative of a large ICT company, knowledge institutions (e.g. universities, research institutions) are strongly deviated from the market. Their mutual connection should be stronger. Slovak Innovation and Energy Agency (SIEA) partially help with "knowledge creation". Education policy towards ICT is improving, but it is insufficient. ICT firms are forced to train new employees.

Referring to the institutional support of innovations, SIEA[33] plays a very active role. The agency deals with legislation and implementation. Since 2007, preparation and coordination of innovation development support in the SR has been among its tasks. Despite this, the agency develops the analyses for the Ministry of Economy of the SR, as well as performs the information campaign on clusters and the advantages of clustering. It also organises *"The Innovative Deed of the Year"* contest, in order to encourage domestic firms and natural persons to participate in innovative business activities. Simultaneously, within the operational programme, Competitiveness and Economical Growth, it also administrates the calls for submission of application for the non-refundable financial contribution from structural funds of the EU to the sub-measures, which are connected to the support of innovation activities in businesses. This aid is intended for entrepreneurs that submit the projects aimed at the purchase of innovative technologies. With exception of this, the agency procures the implementation of government strategic documents in the area of innovations.[34]

BIC Bratislava has been actively working in the area of development support of Information and Communication Technologies (ICT) since 1996. It creates the conditions for the technological and commercial collaboration of Slovak and foreign firms; as well as helps with the exchange of experience and creation of new knowledge on particular progressive technologies, and technological transfer and know-how among firms within the SR, EU and associated countries. It also facilitates access to European sources for the development and application of new technologies for Slovak clients. At present, the centre gives attention, mainly, on the area of international technological cooperation among firms from the SR, EU and associated countries. In frame of the Regional Innovation Strategy of the Bratislava region, there is intention to create the innovative ICT cluster.[35]

According to the opinion of representatives of the interviewed ICT firms in the Bratislava region, corruption is a very serious problem. Several publicly questioned managers of ICT firms, mainly, blame the non-transparent public procurement. Such malpractices deform the competitive environment. The other reason for the lack of interest of some ICT firms in supporting schemes also is an administration complexity. ICT firms are interested, principally, in the area of support of further education and training of their employees. Therefore, a stronger interconnection of universities with the private sector is needed.

[31] SARIO has launched a project called "Start up Development Program" to help Slovak companies to succeed in IT technologies. The main objective of this project is to create a mechanism for the promotion and development of Slovak companies based on innovation and technology to their future entry into the global market. The aim is also to transfer know-how, technology and capital by attracting high-tech investments to Slovakia. The sum of 40,000 Euros has been allocated for the program to be used by the end of the year 2011 including the opening of the incubator in Silicon Valley called STIC – Slovak Training Innovation Centre.
[32] http://www.bic.sk.
[33] http://www.siea.sk.
[34] http://www.siea.sk/inovacie.
[35] http://www.bic.sk.

Supporting measures in the SR are mainly focused on the area of the use of ICT. According to the opinion of several representatives of ICT firms, the firms, first of all, need educational support, the support of the knowledge economy, the support of the business environment and the support of formation of information infrastructure. Firms are mostly influenced by the national level of policy. Supporting tools, such as tax reductions are used, e.g. in case of incoming IT centres – Accenture, Dell, AT&T. The regulatory policy in this way has a negative influence, which deforms natural development in the ICT sector.

Lots of work positions opened in the ICT sector, in the Bratislava region, without the need of state aid. Some ICT "share" centres that were built here, were established without any state subsidies, e.g. HP. On the other hand, firms that were granted a state subsidy were established, too. We can see that a state subsidy is not a critical factor in whether such centres are established here or not. State investment help for the ICT sector in the SR reached 29.5 million euro in 2002-2010, what represents 2.6 % of the total amount provided.[36]

Project Minerva 2.0., which is in preparation, could improve the competitiveness of the Slovak economy, as well as support the formation of the knowledge economy. This interdisciplinary project presents the package of measures aimed at the change of the Slovak economy to the economy based on knowledge and innovations. Prepared reforms should enable the coming of foreign direct investments from high-tech sections, as well as create the space for the establishment and development of domestic technological firms. The realisation of measures defined in the project Minerva 2.0 should help to coordinate existing economical growth and to invest into modern innovative environment. Measures are concentrated on three major areas: education, science and research, and innovative entrepreneurship.[37]

Key findings:

- Institutionalisation of ICT firms in associations is important from the viewpoint of access to information, knowledge exchange and experience exchange in the ICT sector;
- State supporting policy does not play a critical role in the development of the ICT sector in the Bratislava region. State support in the form of subventions and subsidies is perceived rather negatively and affects the distortion of the ICT sector;
- Support of start-up ICT firms is an issue of individual access;
- Support of education, support of knowledge economy, support of entrepreneur environment and support of formation of information infrastructure is requested.

C.8. Conclusions

When we assume the results of interviewing different types of actors, ICT firms and public institutions, belonging to the ICT system in the Bratislava region, it allows for the identification of a typology of "an endogenous territorial innovation pattern" (as described in Chapter 2, Volume 1 of the Scientific report and reported in Figure C.2). The process of innovation and knowledge creation was different at the beginning of 1990´s in comparison to the recent situation. While innovations coming from abroad to Bratislava region, e.g. to IT centres of MNEs, are mainly process innovations. Product innovations are in specific ICT product development, e.g. Information Security (antivirus software development) and Mobile Navigations (navigation applications for mobile devices). Companies are actively looking for new sources of knowledge to innovate their ICT

[36] ITAS, 2011.
[37] http://www.economy.gov.sk.

products and processes, especially in the recently fast changing ICT business environment.

ICT firms in the Bratislava region progressively changed the structure of creation of added value in fundamental way. While in the beginning, the ICT firms created a larger part of the added value from the sale of purchased technologies and products, at present, a larger part of the added value is created from the sale of their own goods and ICT services. This characterises a progressive development of the ICT market, opening of Slovak economy to the world and this trend corresponds with the very development of the ICT sector. The Slovak ICT market is similar to developed economies in many aspects. Firms with qualified personnel are successful.[38]

We observe the continuation of the global trend of the integration of ICT firms in the SR into strong multinational groups. Local ICT firms in the Bratislava region that are not able to finance the international expansion are very often a part of acquisitions. It represents new opportunities for Slovak ICT firms and for their further development (e.g. PosAm). An opportunity is presented, to be connected to the international division of labour, i.e. to gain the access to references that are in a multinational group at the world level, to gain access to experts, which the firm in the SR presently does not have. Though, these opportunities exist in neighbouring countries. On the other hand, there is a possibility to propose local employees for intra-corporate subsidiaries, in those areas that multinational firms, for instance, do not have. This is the key motivation, which is the reason for the acquisitions of ICT firms in the SR. On the other hand, some innovative Slovak ICT firms, naturally, continue expanding abroad. They usually look for firms with similar sight and then, destroy the competition by acquisitions. (e.g. Eset in Czech Republic, Asseco Central Europe in Poland, Soitron in Romania, etc.).

Despite this globalisation in the ICT sector, there still exists a space for smaller local ICT firms, e.g. entrepreneurship in mobile communication, through internet, etc. These sections represent the future in the ICT sector. Concurrently, the demand in the ICT sector in Slovakia will be very soon influenced by computerisation of public administration – formation of eGoverment.

ICT is an industry that has already endured the period of high margins and volumes. The only way is through innovations. The market will be even more about the competition.[39]

ICT and innovations start to be inseparable. A new line of sector studies confirmed the decisive role of ICT when implementing new work processes, such as organisational and process innovations in firms. The borders between implementation of new systems on the ICT base and implementation of process innovations are becoming smaller. Because products and services are combined by new methods, the difference between "product" and "process" innovation disappears.[40]

Innovation leaders in the area of Information Security (development of anti-virus software, biometrical products) and Mobile Navigations dominate the innovations in the ICT sector in the Bratislava region. Product and process innovations are concerned. These firms managed to be well-established in the global market by the development of specific product (software), which today reaches top parameters due to innovations over the years. Despite the hard competition, these companies have been establishing themselves in the world market on the long-term basis, what is demonstrated by the growth of their revenues, as well as the growing amount of new clients. The researched area of Information Security and Mobile Navigations still has big perspective, concerning further development in the future.

[39] IT Summit, Bratislava, 28.9. 2006.
[40] Trends in the ICT area, e-Business Watch.

Concerning the financing of businesses in the SR, in comparison to USA or Western Europe, bank sources represent a totally dominant form of business financing. Especially, the funds of development and risk capital (private equity) can be the alternative.

Key findings:

- Large part of innovative fast growing ICT SMEs in the Bratislava region are either new start-ups or spin-offs from university or academy of science. The success of these global active ICT firms (e.g. Eset, Inovatrics, Sygic,) is based on human resources and innovations;
- Among the group of ICT innovative leader´s in the region, there is still a group of the ICT firms that are technology (or knowledge) followers with only minor individual R&D activities;
- Important role in the knowledge creation is played by parent MNEs, knowledge creation of such a firms is often strictly internal (intra-company) with very limited interaction with local knowledge base, innovative decisions are made also inside the subsidiaries of MNEs located in Bratislava;
- ICT policy attempts tend to the support of education activities, as the lack of qualified human resources in the ICT industry already emerged in the Bratislava region; leadership in the field of ICT is mostly performed on national level; it is determined, to great extent, by participation in EU initiatives.

Figure C.2. An endogenous innovation pattern

Source: KIT final report

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D. The ICTs Sector in the Košice Region[41]

D.1. Introduction and description of the case study area

The Košice region (NUTS 3) in Eastern Slovakia is the second most significant region in Slovakia in terms of export capacity and GDP per capita (Table D.1). The region is industrial and agricultural with tradition in metallurgy and engineering. Electronic and technical and food industry are important. The economic activity rate reached 55.3%. Mainly services were represented in the economy (65.5% of the total employed in the region), 30.1% of employed worked in industry and construction.[42]

Employment in the manufacturing trade remains important, however, a range of heavy to light manufacturing industries have a presence. There is some evidence of new industries making their way into the region. T-Systems, part of Deutsche Telecom, have opened a 'client service centre' in Košice in 2006, in addition to Ness, located in Košice Development Centre (KDC). As far as employment in the ICT sector is concerned, Košice region is second to the Bratislava region.

The most perspective industries are IT, bio- and nano-technologies industry, life-science sector, sector of renewable resources, recycling sector and service sector.[43]

Table D.1. Profile of the Košice region

Population	775,509
GDP per capita (EUR/per capita)	10 193
Employment in technology and knowledge-intensive sectors (%)	4.05
Employment in ICT in 2010	7598
Number of ICT companies in 2010	1288
GERD / GDP (%)	0.27
BERD / GDP (%)	0.11
Researchers (% of total population)	0.5
Business researchers	395

Source: Eurostat, 2008, Statistical office of the Slovak Republic, 2010

The regional centre of the region, Košice, is the second largest city in Slovakia and serves as a key economic agglomeration in Eastern Slovakia. About 50% of all industrial companies, which have created 70% of the turnover in the region, are concentrated here.

According to research[44] between companies in selected industries, in relation to the access to product, technology and process innovations, the most need for innovation in the Košice region was identified in the industry of electrical and optical devices. The least amount of need for innovation was identified in the environmental industry. Companies have innovated their products on the basis of customers' requests. Already, 76% of companies have labelled it as the most moving power for the innovation of products. More than 60% of companies have innovated their products based on their own ideas. The small number of companies have innovated their products on the basis of information and stimuli from sector-specific journals, media and experts.

The most important need for innovation in companies of the Košice region is the development of technologies and products. Approximately 19.27% of companies are considering software development as source of competitiveness in innovation. In contrast, 7.48% of companies consider ICT of small importance. In the case of technology innovation in the Košice region, the highest need for the application of technological innovation was in the machinery industry, the lowest in material production. More than 40% of the improved products of companies in the Košice region have been innovated through the company's or companies' own power. A small

[41] This case study report has been written by Rudolf Pástor, University of Economics in Bratislava.
[42] Regions of Slovakia, 2009
[43] Regional Innnovation Strategy of the Košice Self-Governing region
[44] Research in 162 companies in the Košice region, Regional Innnovation Strategy of the Košice Self-Governing Region

percentage of the innovations are given to other companies or institutions. Only companies from the machinery industry, food industry and material production had applied for registered patents. It was recorded that the highest amount of registered patents (30) belonged to companies in material production.[3]

D.2. The ICT sector in the Košice region

The Košice region presents successful area in Slovakia in terms of localization of ICT companies. The ICT sector in the region is still under development. Before 2005, Košice was a mostly industrial region. The second wave of foreign investors has nature similar to a cluster, while the region contains a dominant ICT company in terms of employment (T-Systems). Localization of this dominant ICT company has launched a change in the nature of the whole ICT sector in the region. ICT company T-Systems with over 1 800 employees, has also initiated the development of education in the ICT profession and "dialogue" between ICT companies, Technical University and the Košice Self-Governing region. In the past, the ICT sector in the Košice region was dominated by close local ICT companies, but currently it is becoming a balanced group of foreign as well as domestic ICT companies.

Support organizations linked to the East Slovakian Steel (VSŽ), have also served in the Košice region, for example INORGA (Research Institute of Metallurgy and Heavy Engineering), who since the 1980s have dealt with graphic systems engineering and engineering systems made by linking the CAD graphic). After the closing of INORGA, several companies in the ICT field have been established, in order to continue INORGA contracts or have switched to other sectors. Other private ICT companies have been established since the abolition of the corporate data centres of other companies, for example Telegrafia was established after the layoffs of the Tesla company. Some ICT companies were established after the dissolution of the Regional Data Centre in Košice.

There is a group of successful and innovative companies representing the ICT sector in the Košice region, with various historical backgrounds:

- Domestic companies with an incoming knowledge base from big companies before 1989;
- Companies established in relation to the East Slovakian Steel (VSŽ), e.g. Procesná automatizácia, ICOS, Kybernetika;
- Companies established in relation to other big companies, e.g. Telegrafia in connection to the former Czechoslovak company Tesla Pardubice;
- Companies established after closing the research institute INORGA, e.g. Apex, Novitech, INCOS, Acase;
- Domestic companies established on the basis of the academic environments of Košice universities, e.g. Elfa, VSL Software, Intersoft;
- Domestic companies established on the green fields – innovative SMEs established without any relation to previous development, e.g. Lynx, Datacreo;
- Subsidiaries of international ICT companies, that have come to Košice after the entry of Slovakia into the EU in 2004, e.g. RWE IT Slovakia, Ness KDC, T-Systems, Ixonos Slovakia.

Looking at the chronology of ICT companies in the Košice region (Table D.2), we can distinguish some waves in the development of ICT sector:

- After 1989, ICT companies were commonly established by former students of the Technical University in Košice or by former workers from East Slovakian Steel (VSŽ). At the beginning of the 1990s, ICT companies have focused their business on hardware selling, as revenues from this market were still high at this time. Step by step, we have observed the gradual move to the development of their products and software development or ICT services.

- After 2004, with the accession of Slovakia by the EU, big international ICT companies have established their subsidiaries or development centres in Košice, e.g. RWE IT (2004), NESS KDC (2005), T-Systems (2006), AT&T (2006), Ixonos Slovakia (2007). Foreign international ICT companies have chosen Košice as an ICT location, especially because of its access to qualified labour forces (graduates from local universities), low cost of high qualified labour forces, language proficiency in English and German, cultural proximity, e.g. in comparison to India or China, close access to the airport, etc.

Table D.2. Timeline of the establishment of ICT companies in the Košice region

Company	Year of foundation
Novitech	1989
Telegrafia	1991
ICOS	1991
Lynx	1991
Procesná Automatizácia	1992
Apex	1993
VSL Software	1994
Siemens PSE	1995
InterSoft	2001
RWE IT Slovakia	2004
NESS KDC	2005
T-Systems	2006
AT&T	2006
Ixonos Slovakia	2007

Source: own elaboration

The total number of ICT companies in Košice region has increased from 709 in 1997 to 1288 in 2010 (Table D.3). Especially, foreign investors coming to the Košice region have the key influence on this massive development of the ICT industry (an estimated increase in the number of employees in the ICT sector in the Košice region of about 2 000 in 2006 to more than 7 000 presently).

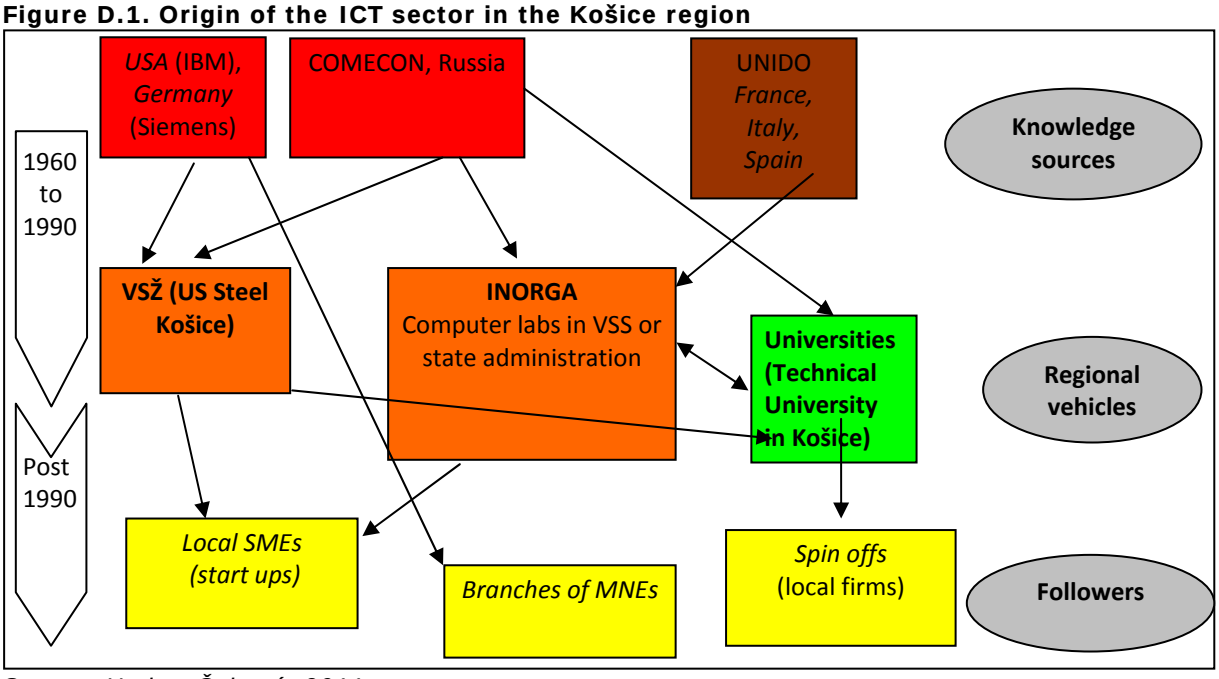
Table D.3. Number of ICT firms in the Košice region (1997 – 2010)

Year	Košice	Total in Slovakia
1997	709	6501
1998	767	7078
1999	734	7083
2000	793	7532
2001	938	8482
2002	989	8843
2003	1021	9497
2004	1110	10656
2005	1154	11142
2006	1190	11587
2007	1190	12115
2008	1252	13159
2009	1286	14101
2010	1288	14457

Source: Infostat

The development of the ICT sector in Košice region (Figure D.1) is interconnected with the establishment of VSŽ steel company in Košice in 1965, which has had crucial influence on the industrial structure of the region, as well as on the technology paradigm of the region. After 1990 and the atomization of the VSŽ company, some local ICT SMEs were established. Furthermore, companies interconnected to the academic sector have been founded. Then it was the coming of international ICT companies, for example ICT services providers (Siemens). Subsequently, after 1990, branches of MNEs came to the region.

Figure D.1. Origin of the ICT sector in the Košice region



Source: Hudec, Šebová, 2011

This report is structured as follows: In section D.3, we draw company profiles of the innovation activities of the interviewed organizations. In section D.4, the type of knowledge and expertise required to the firms to innovate is described. Section D.5 analyses channels used by the reviewed organizations for knowledge and innovation creation. In section D.6, a description of territorial elements supporting knowledge and innovation creation is presented. Section D.7 offers an overview of local innovation policy assessment and governance from the perspective of the interviewed firms and policy makers. Finally, section D.8 contains our conclusions.

D.3. Firm profiles and innovative activity

Generally, innovation activities in the ICT sector have different natures with respect to the innovations in manufacturing. The ICT innovation cycle is becoming shorter, since the beginning of the information revolution in the end of 1970s. This also means shorter time is needed from the inventing stage through the innovation stage to the final introducing the product to the market. The most innovative part of the ICT industry is software development, which is a particularly dynamic subsystem of the ICT sector's high innovative activity. The Košice region focuses on the development of medicine software (Siemens PSE)[45] and tailor-made software developed for the needs of the steel company (US Steel Košice).

In our case study of the Košice region, we present selected innovative ICT companies (Tables D.4 and D.5) with various backgrounds and history of foundation - big international ICT companies that have established in Košice their subsidiaries (e.g. RWE IT, Ness KDC, Ixonos Slovakia), innovative ICT companies with Slovak owners (e.g. Telegrafia, Novitech), as well as ICT companies (ICOS) that have based their business on previous connections to the US Steel Košice (before East Slovakian Steel-VSŽ). Selected companies have also offered various portfolios of business activities, e.g. software development, testing, software and solutions for connected devices and mobile services, near-shore services, information services, etc. Within this selection of ICT companies, we would like to present the picture of the recent situation of knowledge creation in the ICT sector in the Košice region.

[45] Siemens PSE is since 1.7.2011 Atos IT Solutions and Services, http://sk.atos.net/sk-sk

Table D.4. Summary information on the interviewees

Organization	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
Organization A	Chairman of the board	MA	6	yes
Organization B	Site Manager	MA	5	yes
Organization C	General Director	MA	5	yes
Organization D	President & chairman of the board	PhD	22	yes
Organization E	Managing Director	MA	4	yes
Organization F	General Director	MA	21	yes
Organization G	Strategy Director	MA	1	yes

Source: interviews

Table D.5. Summary information on the interviewed firms

Organization	Year of Foundation	Part of a group	Turnover in €	R&D spending in % of turnover	Export in % of turnover	Nr. of employees
Organization A	1991	No	2m	-	5%	50
Organization B	2007	Yes	3.85m	0%	100%	191
Organization C	2005	Yes	12m	10%	96%	290
Organization D	1989	No	7m	2%	20%	200
Organization E	2004	Yes	14m	5%	95%	230
Organization F	1991	No	10.5m	8-10%	15-30%	70
Organization G	1991	No	21m	2-2.5%	1%	102

Source: interviews

Company A was established in 1991 and currently has 50 employees. The company is known for its innovation and has received various awards for its own software solutions. One important product is the software solution package "Digitálne zastupiteľstvo", developed for the Košice Self-Governing Region. The company is a member of Košice IT Valley and the Israel Chamber of Commerce. As a member of the association, the company provides the opportunity for educational organizations to improve educational processes by means of providing resources and practical experiences using IT products in the area of ERP systems – Microsoft Dynamics NAV, Oracle E-Business Suite. The realized „Innovative Complex Original Solutions" in the field of design, development, implementation of IT and providing of support services enable customers to gain the competitive advantage.

Company B was established in 2007 and has over 190 employees. It is one of the strongest growing ICT companies around and also the only smartphone software developer in the whole of Slovakia. Its main customers are global companies as Intel, Nokia, Huawei. The company provides specific business and testing software for clients and will follow this trend in the future. Its main competitors are from China, India etc. The company currently services Finish clients, but gradually would like to extend themselves to Slovak clients. The company's endeavour is to innovate new, more effective service and solution models and operational processes that support international activities. The continuous improvement of these practices focuses both on the quality and productivity of internal production processes, as well as on the collaboration models used in customer operations. Innovation activities of the company are business development, solutions and process innovation (within the company).

Company C was established in 2005 as a development centre and a subsidiary of the ICT company located in Bratislava. The development of software solutions is located in Košice and all administration and management is located in Bratislava. The company, consisting of 290 employees (2011) belongs to the biggest ICT companies in Slovakia, specializing in software development and testing and related specialized services for customers from

Western Europe and overseas. Today, the company exports 95% of its own ICT services abroad to international companies and creates one-third of the mother company turnover in the field of development. The development centre for American NEVTEQ is situated in Košice. It develops software for the collection of digital map data navigations and other specialised services. For these projects, acquired professional know-how is exercised for example the preparation of basic elements of health informatics (eHealth). Sufficient amount of financial resources on implementation and successful finish of innovation solution belong to the main factors of innovation success. Also important is the selection of a right time and place for introducing innovation to the market. In the case of internal company innovation, flexibility and adaptability of employees is important, as well as the willingness of employees to further train and educate themselves.

Company D was established in 1989. The company's activities have expanded over time, giving a momentum for new subsidiaries created in Slovakia as well as abroad, which have started to live their own lives. Today, the company group consists of four daughter companies, four subsidiaries in Slovakia with independent legal personalities, one in Belgium and one in Luxembourg. The company, together with its affiliates, is a well-established systems integrator and software development group, present in the Slovak ICT market since 1990. Company growth in the region was accompanied by the rapid expansion of computer technology in the former Czechoslovakia. The installation and implementation of LAN and Novell based solutions was a remarkable success and within a short time, the company became one of the leading companies within the Slovak high-tech ICT sector. The company currently employs over 200 highly trained and qualified employees (140 full-time and about 60 part-time specialists), working in its specialised subsidiary companies and other subsidiaries not only in Slovakia, but also in Hungary and Belgium. The company covers the entire information system life-cycle from system design to implementation and maintenance services for medium and large enterprises. These solutions are routed to achieve new solutions for company clients. The company is developing permanent p-Business Ring technology within the framework of EU projects, Project Portal, e-learning applications for Slovak SMEs, European lobbying portal and Central European Business Community Portal Key technology partners.

Company E is a subsidiary company of German concern and was established in 2004. Currently, the company has 230 employees (2010). The reason for the company's location in Košice was the purchase of 49% of VSE (East Slovak Energy) by one of the biggest multi-utility companies in Europe in 2003. The company serves as the ICT near-shore centre for the mother group in Germany and the supported German home company, and provider of IT services. It is a dynamic company, active in the fields of development and implementation of large scale information systems and the provision of project management services. The company innovates activities in frame of concern projects (eMobility, SmartHome). The company's product or process innovation activities are mainly carried out from its own R&D departments.

Company F was established in 1991 and currently has 70 employees (2011). In 1990, the founder of the company started his own business and in 1991 he established the company in Košice which focused on radio communication, radio-metric systems, warning systems and evacuation systems. At the beginning, the company has also sold PCs. The company has also gone through various stages of development, as in the case of employment, turnover, as well as product orientation. At the beginning of 2006, the company has been transformed in order to join a stock company. The development of the company was marked by a gradual move from the classical sale of hardware during the 1990s to solutions and services with added higher value. In 2008, the division of sales was completely cancelled. The company is consistently innovating sirens and other elements of warning systems. The reason for selecting this company is its potential for innovations. The main competitive advantage of the company is its ability to secure the whole life-cycle of the warning system (development, production, installation and service).

Company G was established in 1991 and currently has 102 employees (2011). Firm provides various IT solutions mainly focused on information security and networking. It was established as independent start-up at the beginning of the 1990s in as it was usual back then. Firstly, its core business focused more on retail of PC and antivirus/spyware selling, but after the market transformation the current alignment to high-level sophisticated solutions became imminent. Together with another ICT company in the Košice region is company cooperating in frame of eHealth project.

Key findings:

- The source of innovation for new ICT products is mostly non-local. It mainly stems from foreign companies;
- New knowledge from local sources comes within the firm´s boundaries, mainly through the innovations of local innovative leaders in ICT sector;
- The ICT system in the Košice region does not constitute a real working system, since the linkages among ICT firms, local universities and local public institutions are based on the formal association Košice IT Valley.

D.4. Types of knowledge and expertise required for local innovation

In reference to the type of knowledge and expertise required of the firms, the fact that there is yet no technology gap in terms of technology availability between the EU's 15 countries and the EU´s 12 countries plays an important role. The new ICT technologies are available anywhere, at nearly similar prices. This fact has influenced the accessibility of knowledge, which is at one's disposal at anytime and anywhere, depending on the level and their use for new innovative ideas, products, innovative processes, etc. The possibilities and the level of the use of new knowledge and expertise in ICT firms, depends on the type of firm. The knowledge and expertise for innovating required by the ICT firms being interviewed in the Košice region is mostly technical, bench-level and very often customer knowledge.

The technical knowledge is especially used from specific sector journals (e.g. software development journals). The creative workforce in the ICT companies is taking part in special discussion forums, social networks, etc. They discuss via internet current issues in specific ICT area. Bench-level knowledge is also regularly used for innovating in ICT industries. ICT companies are providing on-the-job training, where ICT seniors give special thematic lectures to juniors in the forum. Despite the information and digital age, when we have instant access to knowledge, there is still a need to have personal contact with customers, because user-producer interactions are really important in ICT industry. ICT producers or ICT service providers have to know the needs of their customers. Present ICT development centres in the Košice region especially need customer knowledge based on user-producer interactions, e.g. in the case of product development (tailor-made software) or providing IT services. In addition, deep knowledge of sector specific processes plays such an important role, e.g. knowledge of energy processes, in the case of providing services for utility companies, etc.

Key findings:

- The knowledge and expertise for innovating required by the ICT firms in the region is technical, bench-level and especially customer; it really depends on the type of the ICT product development or ICT services;
- Technical knowledge is mostly used for innovating in a specific kind of ICT industry, e.g. in mobile software development;
- Customer knowledge is often based on personal contact of the leaders in ICT firms within the Košice region.

D.5. Internal and local channels for knowledge and innovation creation

According to the local channels for knowledge and innovation creation, the representatives of ICT firms are generally satisfied with the quality of the labour forces in the Košice region. There are enough graduates educated in areas of computing, telecommunication techniques and artificial intelligence. Some of the ICT firms already suffer from lack of availability of proved experienced experts, who tend to move extensively to Bratislava. Nevertheless the quality/price ratio of local workforce is good, however initial training is required most of the time (from 1 to 2 months), and it also takes up to two years to uncover the full potential of new prospective. Graduates have more theoretical knowledge, but they are often missing the practical knowledge (coming from work on a real project, etc.). To improve this situation, big ICT companies are organizing summer schools for students, among other things. Newly based foreign ICT companies are trying to find "ICT talents" in the region. Some ICT firms are already using headhunting to bring ICT professionals back to the region from abroad. In the case of local firms, the new workforce is coming to the firm through a "friend" contact or recommendation of firm workers.

In reference to local channels for knowledge creation, ICT firms have mostly received knowledge through personal contacts, as well as through internet, phone, and e-mail. Some of these innovative ICT firms have also received knowledge from sector specific publications. The internet has completely changed the nature of business services, e.g. concerning development centres that provide off-shore and near-shore services abroad. Some ICT firms still prefer traditional personal meetings with their customers. Also workshops with partner firms and clients and conferences play a vital role in information exchange (at least on macro-level). Various meetings with managers of other local firms, even competitive are second. Research and publications play no important role, they are only complementary type of resource.

ICT firms are looking for collaborative activities with other local ICT firms. There is a deep cooperation with local universities, especially the Technical University in Košice (Department of Cybernetics and Artificial Intelligence). Some of the ICT firms do not collaborate with other local ICT firms at all because of different knowledge bases, e.g. in mobile software development. Development ICT share centres localized in the region cooperate with local ICT firms on various projects. The electronic health services project (eHealth) is a good example of local cooperation between 2 firms. One of the firms is the system integrator on this project and covers application. Another firm is responsible for the security and infrastructure of the project. The project is realized through the use of technologies from other partners, e.g. Cisco, IBM, and Microsoft. Some of the ICT firms in the Košice region mostly collaborate with other ICT firms with complementary product portfolio regarding very complex projects. They combine solutions and different strengths to the mutual benefit and satisfaction of their customers.

A firms product or process innovation activities are mostly carried out by R&D departments in mother firms abroad, e.g. Finland, China. ICT share centres in the Košice region do not have their own R&D department. They usually help partners with product development. In case of other local ICT firm, each department of firm handles its own innovation process. The reasons for the location of innovation activity are, e.g. headquarters of company located in Košice, satisfactory workforce costs (principal cost of IT solutions innovation process).

Key findings:

- The quality/price ratio of local workforce is good, however initial training is required;
- The local sources of knowledge come from innovative leaders in specific ICT sub-sectors, e.g. radio communications, medicine software development;
- ICT firms in the Košice region receive and prefer knowledge mainly through personal contacts;
- Collaboration between local ICT firms is generally based on the complementary product portfolio, e.g. eHealth project.

D.6. Territorial elements supporting knowledge and innovation creation

According to the territorial aspects of knowledge creation, ICT firms have been located in the Košice region mostly because of access to labour forces (graduates from the Technical University in Košice). After entering of Slovakia to EU in 2004, ICT centres located their subsidiaries in Košice. Inside the ICT sector, companies located in the region have not influenced innovation activities at all, e.g. in the case of mobile software development, which does not have a long history in Slovakia. In this case, knowledge comes to the region from mother firms, e.g. from Finland (extensive know-how in mobile communication). In some cases, economic of scales is more important, living labour market, knowledge exchange, etc. Also, other ICT firms serve as sources of new labour forces for ICT centres in the Košice region. Usually, big ICT companies are much more interesting for graduates. Small ICT companies recruit new employees through personal contacts and due to the friendly atmosphere of the small companies.

Foreign investors in ICT sector have preferred the Košice region because of its good infrastructure, availability of cheap ICT labour forces, flat tax, cultural proximity (also an important factor for incoming ICT share centres). Furthermore, cheaper labour forces and lower costs on company functionality than in Bratislava are important location factors for ICT companies in Košice.
The investment decision of foreign investor for localization of IT development centre in the Košice region has relation to the need of development capacities near European customers, quality of graduates from local universities and cost-effectiveness. In respect to the present IT development centre, the investment in Košice region has already been evaluated as very successful after only a few years, because of its qualitative knowledge base. In addition, with the support of the Košice City Council, via the opening of the IT centre, the company has created labour places accessible to the labour forces who intend to work on challenging international IT projects. In case of other local ICT company, Košice region was chosen as the company location, because of the cost-effectiveness ratio of workforce and relative proximity to important business centres in the Middle Europe – Bratislava, Prague, Budapest, Vienna, Munich, etc. (mainly because of the airport).

The accession of Slovakia by the EU in 2004 has also positively stimulated ICT sector development since foreign investors have come to the Košice region, e.g. IT share centres. In addition, the Slovak government (remarkably) endeavours to support FDI inflow to Eastern Slovakia. From this point of view, strategic coming of IT centres represented very important employers in the ICT industry of the region, e.g. T-Systems, Ness KDC. Accession by the EU in 2004 has also influenced the mobility of labour forces in the ICT industry from abroad to Slovakia. There are some initiatives on the firm level that support this trend, e.g. the initiative of Siemens PSE focused on computer programmers working abroad.

The innovative activity of other ICT companies have played not so much important role in the Košice region for location decision, as for the social capital – the main source of it is located in Bratislava (reason why ICT company have established also an office there). Networking takes places almost entirely at various seminars, workshops and conferences.

There are some areas where some ICT company reasonably profit from local innovation, e.g. software engineering. Local universities put considerable effort into developing new general paradigm in this area, which creates an opportunity. Networking is almost entirely based on the perceived level of professional expertise – established expert is welcomed on both sides. However, personal transfers from academic area to business and vice versa are rare.

Key findings:

- The Košice region is important ICT location due advanced location with best supply capabilities and market conditions;
- In reference to the established ICT share centres, knowledge is created abroad by mother companies and is brought into the subsidiaries in the Košice region.
- The membership in local IT association (Košice IT Valley) and trade associations is regularly used by the ICT firms for networking and presentation opportunities.

D.7. Local innovation policy assessment and governance

From the perspective of local innovation policy assessment and governance in the Košice region, the level of perception of supporting policy between local ICT firms and satisfaction with policy measures to support innovation and learning activity in the region is very low. The support-institutions lack the dynamics, e.g. there is still not visible program regarding innovation in ICT area. There is also low number of start-ups in the region, inefficient requirements and resource allocation, lacks of proper link to markets, especially in such dynamic area as ICT represents.

The funding schemes are either not used, or if used, firms do not succeed in acquiring final approval of projects, because of the huge administrative difficulties, extensive bureaucracy, etc. Some big ICT firms in the Košice region have received state support for the creation of new labour positions, e.g. NESS KDC, T-Systems, or some support from the city of Košice, e.g. NESS KDC was granted a city building for a new development centre. According to the opinion of some representatives of ICT firms, direct state financial support is often perceived as "market deforming".

According to the major support schemes and activities, the main concept of Regional Innovation Strategy (RIS), is to be updated in 2012. The Project of Regional Innovation Centre had been prepared, but was never started. As far as regional support programs as the Operational Programme of Competitiveness and Economic Growth are concerned, the Košice Self-Governing Region has no sources, universities and companies that are eligible for support. According to other support institutions, Slovak Research and Development Agency (SRDA), Slovak Energy and Innovation Agency (SEIA), the scheme for the support of clusters is missing, as well as the support of the supply chain and value chain. There are no measures as for example innovation voucher. There is also no regional innovation fund or no qualitative strategic materials. About the strengths and weaknesses of the regional policy, we can mention the direct state support of some ICT firms (T-Systems and Ness Slovakia) and a prepared project between Technical University in Košice and T-Systems. There are no typical support measures for ICT, only through cluster policy, Regional Innovation Centres and areas of transfer of technology and innovation. Success achieved by agency concerning the support of innovation is e.g. Slovak Academic Information Agency (SAIA) – applications of ICT firms on increasing of IT skills.

In addition, association plays an important role in supporting the ICT firms in the Košice region. The association of legal persons of Košice IT Valley was established in 2007 as a common activity of university representatives (Technical University in Košice), public administration body (the Košice Self-Governing Region) and significant Slovak and foreign ICT companies that were interested in strengthening the field of information and communication technologies in the Košice region. The aim of the association is to bring

together firms focusing on ICT. IT Valley ('ITV') consists of over 24 different ICT firms operating in the Košice region. Košice IT Valley is trying to create a functional environment for IT business in the region.

Most ICT firms are members of Košice IT Valley and some of the Chamber of Commerce. They used this platform on the regularly basis for the meetings. They have particularly benefited from meetings with other representatives within professional bodies. These meetings consist of organizing training activities or seminars where they can exchange their own knowledge and experiences. Despite the existence of the association Košice IT Valley, some of the ICT firms don't really feel this institutional support at all.
Concerning the regional policy actors and support agencies, we have interviewed representatives of the Košice Self-Governing Region (Regional Development Department) and Association Košice IT Valley. Innovations are one of the objectives of the association, Košice IT Valley. At first, the focus was mostly on education, later the issue of innovations based on scientific-technology knowledge was added, as well as service for investors (about education structure etc.) and communication channels in frame of the Košice Self-Governing Region.

The major limits in supporting innovation activities are – the regions have to be the facilitators and creators of networks and the environment. The system is working in such a way, that universities and companies are recipients. "Triple helix" does not function. Public administration is not integrated into this concept. They have to be a part of scientific-technical parks. Universities have to educate, and conduct basic and applied research. For networking and facilitating, there are no human sources, which is the real barrier. As far as knowledge acquisition goes, public officials are not competent to make decisions, networks are not supported, and specialization of public officials is absent. As for diffusion, there are no programmes of mobility in public administration institutions.

Factors that are hampering the exchange and transfer of knowledge – the systems have to be based on the support value chain or clusters (firms, universities and public institutions). It is necessary to have a strategy, planning and communication. The second model, the concept of technology base, has to associate main "players"; has to be a source of expertise.

Level of satisfaction among firms in the ICT sector – motivation for secondary schools, system of special education, mutual cooperation of firms. In case of *cooperation among public institutions and firms in accessing support* – use of 7th FP, cross-border (project Knowbridge).[46] From side of structural funds, there is no method how to create cooperation – by buying expertise, it is necessary to have a method. *Organization is active in promoting industry-based associations of firms* – IT Valley, cluster for automatization and robotics, stimulation of clusters for creative industries. According to the *Education policy* – in the 2020 Agenda, at the national level, mechanisms were not created because they are not too effective. In real policy there is no space for it. *Regional policy support for knowledge creation* – for regional policy, all mentioned elements are important, including financing (venture capital). The financing of spin-offs plays an important role in commercialization.

The education policy and institutions in pre-university sectors are perceived as very important by the ICT firms, many perspective workers do have sufficient amount of capabilities even at the pre-university age. Moreover, ICT requires extensive practical honing of mathematical and logical skills. ICT firms would welcome improvement in this area.

[46] http://www.knowbridge.eu

Key findings:

- The ICT sector in the Košice region was developed naturally without any strong national or regional policy measures;
- The level of perception and satisfaction with existing supporting policy measures between ICT companies in the Košice region is very low;
- The direct state or city support for ICT firms, e.g. stimulus by the creation of new labour positions, is often perceived as "market deforming".
- The education policy is considered as crucial for further development of knowledge base of ICT sector in the Košice region.

D.8. Conclusions

When we assume the results of interviewing different types of actors (firms and institutions) belonging to the ICT system in the Košice region, it allows for the identification of a typology of "a creative application territorial innovation pattern" (as described in Chapter 2, Volume 1 of the Scientific report and reported in Figure D.2). The process of innovation and knowledge flows are bi-directional. While innovations coming from abroad, e.g. IT centres, are mainly process innovations. Product innovations are in specific ICT product development, e.g. medicine software or electronic sirens. Companies are actively looking for new knowledge to innovate their ICT products and processes.

Traditional economic structure of the Košice region (based on the steel industry), location of the region in Eastern Slovakia, capacity and focus of universities, culture in company relations (cooperation vs. rivalry), have the most important influence on recent form of ICT sector in the Košice region.

According to our interviews with representatives of ICT companies in the Košice region, we can summarize the following results:

The Košice region is represented by innovative ICT companies, with some relations to the previous state owned company, East Slovakian Steel (VSŽ), by subsidiaries of international ICT companies (NESS KDC, Siemens PSE, T-Systems), as well as by local innovative companies with global business operation (Telegrafia, Novitech).

The quality of available workforce is generally sufficient. Concerning innovative ICT companies, all kind of knowledge and expertise are presented (scientific, technical, bench level knowledge, customer knowledge). Bench-level knowledge is required especially in ICT centres, when providing on-the-job training, etc. Customer knowledge (e.g. user-producer interactions) plays regarding some companies a very important role, especially in case of product development for customers or deep knowledge of some sector specific processes (e.g. services for energy utilities etc.).

Inside the ICT sector, the same sector companies located in the Košice region have not influenced innovation activities at all, e.g. smartphone software development, which does not have a long history in Slovakia. In some cases economic of scales is more important, living labour market, knowledge exchange, etc. A territorial precondition to take knowledge from the outside is remarkable in the case of IT share centres (subsidiaries of multinational ICT companies). Human capital, accessibility and urban externalities are important territorial preconditions and channels for interregional knowledge flow and innovation diffusion. Product and innovation processes are coming into the region, mostly from foreign mother multinational companies. The level of entrepreneurship between the ICT companies is high.

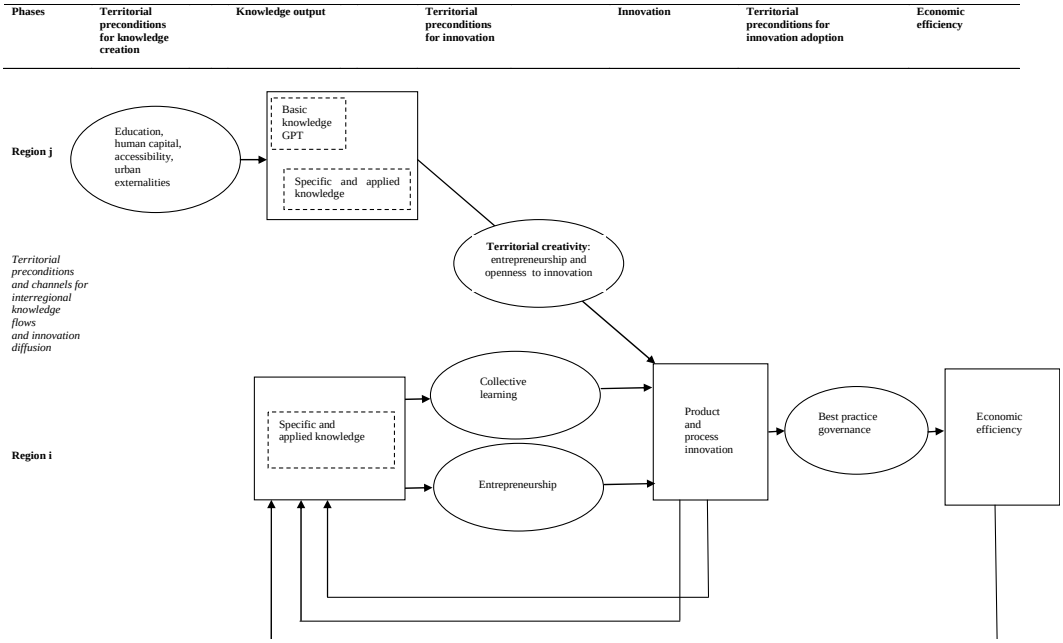
According to the factors that hamper the exchange of knowledge from public institutions, some representatives from ICT companies have mentioned fluctuations between employees of public institutions, as well as a weak level of human resources in these institutions. Innovation policy of companies is strongly directed by the policy of

multinational companies. That means that local subsidiaries have limited authority in selection and decision making processes of innovation support. The main sources for ICT companies are concerns´ "research laboratories", meaning software houses, which deal with development for the whole concern group, e.g. T-Systems in Germany. There is also a certain remarkable partial trend in the move of software development to subsidiaries located in Košice, e.g. NESS KDC, Ixonos Slovakia. The future of the Košice region lies especially with ICT, biomedicine and engineering mechatronics, e.g. in close industrial park Kechnec.

Key findings:

- The local industry basis of the Košice region has influenced the recent form of the ICT sector;
- A remarkable shift from hardware sales to own ICT product or service development has been observed;
- The Košice region represents a typical European nearshore locality exporting ICT services abroad;
- Knowledge creation is strongly influenced by the regional business environment;
- Knowledge linkages between ICT firms and universities are often unilateral;
- There are important knowledge exchanges through global linkages, especially from foreign multinational companies, particularly German companies, e.g. RWE, Siemens, T-Systems.

Figure D.2. A creative application pattern



Source: KIT final report

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E. ICT in Cambridge[47]

E.1. Introduction and description of the case study area

The Cambridge area has a reputation as a centre of knowledge production and innovative activity in a number of areas, and the city of Cambridge has developed as one of the UK's most dynamic and successful cities. It has a strong claim to being a leading centre for the development of the knowledge driven economy, based on scientific research and development. The high technology economy that has grown up in the area, particularly since the 1970s, has been labelled as the Cambridge Phenomenon (SQW, 1985), and this economy continues to develop and attract technologically advanced companies and research organisations.

The growth of the high-tech economy can be represented as four waves of development commencing in the early 1970's and focussed on different sectors (Simmie et al, 2006). While sectors did not succeed each other as such the first phase of development may be defined as having been centred on the IT sector; the second on the development of life-sciences; the third on IT applications and software; and the fourth and most recent has been on the strong growth of the biotechnology sector, and in the emergence of clean-tech approaches. Development has continued in all industrial sectors, and the ICT sector has been a central factor in this continued development both in its own right and in support of other activity. The case study, therefore, focuses on the ICT sector in Cambridge as an example of a high-tech industrial sector located in an industrially diversified region with claims to being a leading European region for knowledge generation, application and innovation.

The case study has been constructed on the basis of analysis of secondary sources including academic and consultancy reports, academic papers, and the websites and material provided by firms and other organisations in the Cambridge area. Interviews have also been conducted with firms in the ICT sector in Cambridge, and with policy makers active in the support of the continued economic development of the region.

E.1.1. Geographical Context

The British ICT sector[48] case study is focussed on Cambridge located in the East Anglia area (NUTS 2: UK H2) within the East of England (NUTS 1) region. The East Anglia area is divided into four NUTS 3 areas, namely Peterborough, Cambridgeshire, Norfolk and Suffolk. Within this area the city of Cambridge has a population of some 125,700[49] and other towns and cities within the East of England region include Peterborough (169,800); Norwich (132,000); Ipswich (125,400); and Luton (194,400). The northern and eastern parts of the region are largely rural, while the density of settlements is greater toward the south and towards the northern suburbs of Greater London. The region is connected to London by rail and motorway, while Standsted Airport, located within 100km of Cambridge, has become a de-facto third airport for London.

The case study deals with the ICT sector that has developed largely within and around the city of Cambridge, and which has been described consistently as one of the most important ICT clusters in the UK. The geographical context may, therefore, be limited to the city of Cambridge and a local functional economic region related to the city. However, specifying the extent of this economic area can be somewhat problematic since the influence of the city of Cambridge and its economic base extends beyond the limits of the city. In the first instance it might be considered to cover what is defined as the Travel to Work Area (TTWA), which is roughly the same as for the Cambridgeshire county area. Recent policy literature, while including the TTWA, also refers to the area of influence of

[47] This case study report has been written by Selyf Morgan, Cardiff University.
[48] ICT is designated by the NACE Rev2 coding system as a High-technology manufacturing industries sector covering the manufacture of computer, electronic and optical products
[49] Office of National Statistics (ONS) Mid-year estimate, 2010

a 'Greater Cambridge' since the area surrounding Cambridge includes a number of settlements, which are related to Cambridge in labour, housing and land markets as well as in infrastructure, business and social networks (GCP, 2009; Simmie et al, 2006). Greater Cambridge is defined as being roughly within a 25 mile radius of the city centre, covering a number of smaller towns and villages.

E.1.2. Local Economic Sectors

Notwithstanding the difficulty of drawing firm boundaries to Greater Cambridge, a report that reflected on a thirty year period of development (SQW, 2011), deemed the relevant economic region that included Cambridge to have a population of 265,000 people, supporting some 153,000 employee jobs, and being home to over 10,000 businesses. Around nine hundred of these businesses may be defined as 'high-tech', and some 37,000 people are employed by them. The value of its GVA approaches £7.5bn, with GVA per job of some £40k in the city of Cambridge and £45k in South Cambridgeshire (c.f. UK average of £37k).

In addition to the high-tech sector Cambridge City centre economy has developed more recently into a regional retail, services and business centre. The city has also become a regional hub for the public sector, and has attracted a number of government and public sector institutions, particularly in the education and health sectors. Cambridge is home to a second University, namely the Anglia Ruskin University and to the Addenbrookes university hospital, both of which support innovative activity. Tourism has also continued to grow in prominence, and strengths in sectors such as the food industry still exist. Table E.1 provides an overview of the distribution of employment by industrial sector in Cambridgeshire, indicating the higher than national proportion of education and public administration jobs in the area.

Table E.1. Employee jobs by industry (2008)

Sector	Cambridgeshire		East of England	Great Britain
	No. employee jobs	%	%	%
Manufacturing	33,100	12.0	10.3	10.2
Construction	11,400	4.2	5.4	4.8
Distribution, hotels & restaurants	59,400	21.6	25.0	23.4
Transport & communications	11,100	4.0	6.0	5.8
Finance, IT, other business activities	62,500	22.8	21.4	22.0
Public admin, education & health	84,200	30.7	25.3	27.0
Other services	10,700	3.9	4.8	5.3

Source: ONS annual business inquiry employee analysis

% is a proportion of total employee jobs; Employee jobs excludes self-employed, government-supported trainees and military

Modern Cambridge has developed from a market town that was dependent largely on local agriculture and on the existence of Cambridge University, one of the oldest and most renowned of the UK's universities. The university now acts as one of the most important drivers of local economic activity, underpinning the development of the area as a leading high-tech region (SQW, 1985). Within the last couple of decades, however, the central role of the university, together with other public research institutes has moderated as a diverse population of high-tech firms became established.

The high-tech sector in the Cambridge area is dynamic, as firms are created, move, are acquired, merge, and cease trading[50]. It is also highly diversified and includes drug discovery, bioinformatics, software, computer hardware, electronics, printing, computer games, clean-tech production and web-based new media. A report for the Greater Cambridge Partnership in 2008 defined high-tech companies as those in which 'products and processes are the commercial result of investment in the research and development

[50] During the writing of this case study Hewlett Packard was bidding to buy Autonomy, one of the largest software companies headquartered in Cambridge in a £7.1bn deal [see The Daily Telegraph, 19th August, 2011 http://www.telegraph.co.uk/finance/newsbysector/industry/8709821/Autonomy-board-backs-7bn-Hewlett-Packard-offer.html]

of new scientific and technology applications' (CIR, 2008). The report also differentiated companies and other organisations that operate in the high-tech sector into three tiers, namely those that fit the preceding definition and may be considered as constituting the core of the sector (Tier 1); those that have expertise in a technology but act in support of Tier 1 companies (Tier 2); and those that support Tier 1 companies but do not have expertise in the technology field (Tier 3). Tier 2 organisations may have patents but conduct research for other companies and include, for example, technology consultants such as Cambridge Consultants Ltd or University research centres such as Cambridge University's Institute for Manufacturing. Tier 3 firms include knowledge intensive business service companies such as patent attorneys, or manufacturers of simple components that feed into high tech products. Table E.2 shows the distribution of firms and other organisations among these three tiers.

Table E.2. The distribution of firms and organizations across high-tech sub-sector in the Cambridge area (2008)[51]

High tech sector	Tier 1 Companies	Tier 2 organisations	Tier 3 organisations
Biotechnology	208	52	70
Software	140	37	181
Instruments and Engineering	122	38	93
Electronics	87	25	37
ICT (non-software)	61	16	60
Sound and Imaging Systems	51	8	17
Materials	22	4	10
Printing and Packaging	18	1	5
Energy and Environment (EGS)	16	4	14
Total	725	185	487

Source: Adapted from CIR, 2008

The high-tech sector in the region may, therefore, be considered in terms of a number of different actors. Many technology businesses have been underpinned by the presence of Cambridge University, which has enhanced its role as a world leading research university by substantial investment in university facilities. Some of this investment has been manifest in the establishment of a number of science and business parks[52], which are designed to enable the development of spin-offs, start ups and growing companies, and to facilitate further interaction between university research centres and industrial companies (Simmie et al, 2006). Two hundred and five companies had been spun out directly from the university by 2005, with 45 currently active (Library House, 2006; and Library House, 2008).

The university has also been active in developing institutional support for commercialising its scientific output, including Cambridge Enterprises, which was established to help university inventors, innovators and entrepreneurs to commercialise their ideas, and acts to some extent as a university-based technology consultant, and Cambridge Networks, which facilitates interaction between business and academic researchers within the high-tech community.

Commercial technology consultants (Tier 2 companies in the CIR designation above) have also proved to be a significant element in the establishment of new high-tech businesses in Cambridge. The largest of these consultancies are global companies (Table E.3), and share a common way of employing a range of technical disciplines in making knowledge available to companies world-wide and to address customer-oriented problems and opportunities. Between them four consultancies that have their roots in

[51] It is difficult to differentiate companies in Tier 3 among the sub-sectors, and this differentiation is made on the basis of most activity relevant to the subsector in which they have been placed. Another 95 companies may be added to Tier 3 for which it was not possible to decide even on this basis, and may be termed generalist support companies.

[52] Cambridge Enterprises list 14 of these parks

Cambridge employ some 900 people in the Cambridge area, with another 250 worldwide, whilst the combined annual sales of the four companies in 2008-9 was in the region of £140m, 70% of which was derived from export (Marsh, 2009).

Table E.3. Global Technology Consultants active in Cambridge

Organisation	Headquartered	Activity
Cambridge Consultants	Part of Altran (France)	Innovative Product development
PA Technology	London (UK)	Industrial and Business consulting
TTP	Cambridge (UK)	Technology development
Sangentia	Cambridge (UK)	Technology and Product Development
Arthur D. Little	USA/ Global; UK offices in Cambridge and London	Management Consultancy

Source: Author from company websites (accessed July 2011)

E.2. The ICT Sector: Firm profiles and innovative activity

The ICT industry covers a wide range of industrial activity, and the UK's ICT sector is among the largest in Europe with projections of over £29bn sales by 2012[53]. The ICT sector includes systems, telecommunications, photonics and IT services sectors (including software). All these areas of activity are represented by firms in the Cambridge area, and the CIR analysis of high-tech organisations in Cambridge suggest that some 30% of the organisations that they identify as high-tech may be classified as ICT[54] (CIR, 2008).

The size and scope of ICT organisations in Cambridge range from the local research centres of global businesses such as Microsoft, Philips, and Nokia, to start up and spin-out companies with one or two employees. Of the locally founded organisations only a small proportion have grown to above average size (Garnsey and Heffernan, 2005), however, four major local businesses that may readily be identified within the ICT sector are ARM, Autonomy, Cambridge Silicon Radio and Domino (see Table E.4). The structure of the sector in Cambridge continues to change as technology evolves and companies mature, some of whom break up, are acquired, and/ or produce their own spin-out companies[55].

Table E.4. Major ICT businesses that continue to be headquartered in Cambridge

Company	Origin and Main Activity	Established	Employment (worldwide)	Revenue (2010)
ARM	Spin out from Acorn Computers[56]; Semiconductor Intellectual Property supplier (rather than manufacturing chips)	1990	1700	£406.6m/ $662.7m
Autonomy	Spin out from Cambridge University Infrastructure software	1996	1900	£533.4m / $870m
Cambridge Silicon Radio	Spin out from Cambridge Consultants Wireless technology and audio	1999	1500	£491.4m / $801m
Domino	Spin out from Cambridge Consultants Coding and Printing technologies	1978	2200	£300m/ $489

Source: Company websites (accessed July 2011)

Whilst major companies have been attracted to the Cambridge area from elsewhere (e.g. Microsoft and HP), the case study has concentrated on locally derived companies to illustrate processes of knowledge creation in the Cambridge area, and in the following discussion these firms and their knowledge creation and learning processes are described

[53] UK government: http://www.ukti.gov.uk/investintheuk/sectoropportunities/ict.html
[54] Although the sectoral division that CIR use differs from the broad definition of ICT employed here.
[55] See Garnsey and Heffernan (2005) for a description of how Acorn Computers gave rise to a large number of spin out companies.
[56] Acorn was broken up in 1998

in some detail. The examples chosen illustrate experience within differing sub-sectors, differing structures (including spin outs from Cambridge University and subsidiary firms to technology consultants), and differing relationships with other organisations in the area (see Tables E.5 and E.6 for summary information on interviewed firms).

Each of the case study companies is at a different stage of development, with dates of foundation indicating the spread of corporate maturity. The differences between their business models may be traced to the differences between the nature of the knowledges employed within each organisation and the commercial imperatives relevant in each case. Firm A is engaged in close interaction with clients and provides technological solutions in response to the demands of the marketplace. In this respect it is similar to Firm B, a technology consultancy, but differs in the range of technologies and activities in which it is engaged. Firm C is a subsidiary to Firm B but is being developed with the possible objective of floatation. It has been formed as a vehicle to develop one of the technologies that originated within the 'mother' organisation. Finally Firm D, the youngest firm, is developing a novel product originating from R&D in Cambridge. The foundation and development of each of these companies reflect some of the general themes of the development of the ICT sector in the region.

Firm A[57]

Form A provides professional IT systems and services to a wide range of commercial, research and academic organisations. Having been established in Cambridge in 1978, the company has customers throughout the UK and overseas. The company's approach is to adapt existing technologies to customer requirements, bringing technological advancement to customers from a proven perspective, and innovating in terms of developing new solutions by applying known technologies and 'forward thinking' ideas in novel situations and contexts.

"…. in 1978 we set up a business around putting fairly low level technology onto people's desks, terminals and printers that were then connected to our computers miles away through telephone lines. Today they call it the cloud, and this was work we were doing 33 years ago."

(Firm A respondent)

The company was established in Cambridge largely because the three company founders were residents and had strong partnerships with the Computer Assisted Design (CAD) centre at Cambridge University, and some of the founders were also employed at the centre. The CAD centre was one of the leading centres in providing 3D technologies for designers and engineers, particularly for oil and gas industry pipe-work at the time. The late 1970's was also a time of industrial development in Cambridge that became known as the 'Cambridge Phenomenon' (SQW, 1985). This development created a local creative culture that contributed to the founders' motivation in establishing the company. The Cambridge Science Park was being established at this time and the founders took advantage of these conditions to start up the company and locate it at the Science Park.

[57] Contributors and interviewed firms are assured of anonymity in our research. However, Firm A have asked that they may be acknowledged as a contributor by name, and we are happy to oblige. They are Cambridge Online Systems Ltd.

Table E.5: Summary information on interviewees

Firm	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
A	Managing Director; Chairman; CEO (3 people)	BSc Computing	1; 34; 34 (respectively)	Client Services Director; Researcher (University); Finance director; Management (respectively)
B	Research Director	Not available	20	N/A
C	Research Director	PhD	5	Research Manager
D	Engineering Director	PhD	4	Technical Director

Source: Author Interviews and firm websites

Table E.6: Summary information on interviewed firms

Firm	Established	Sub-Sector	Turn over £m	R&D as % of turn over	Export as % of turn over	Employee No.	Patents No. or IPR	New products /processes 2008-2011
A	1978	software/ management systems	4.3	2.5	10	55	3	3
B	1988	technology consultancy	~40	50	70	400	N/A	N/A
C	1992	inkjet printing	4	50	100	32	160	2
D	2000	photonics	N/A	20	99	60	23	3 (plus adaptations)

Source: Author Interviews and firm websites

Firm B

Firm B is a technology and product-development company, formed in 1988, and one of a number of technology design consultancies that have been established in Cambridge. Firm B is owned by employees and ex-employees, and is also in receipt of some external investment. It is a holding company that currently includes the core company, a venture management company, which invests in IT and clean technology companies, a laboratory-scale instrumentation company that develops custom automation for life sciences companies, and Firm C, which has developed a digital printing process targeted at commercial and industrial applications (see further below). Firm B owns and manages a science park to the south of Cambridge on which group companies are located along with other tenants.

Firm C

Firm C is a prime example of the way that Firm B has developed a particular technology and formed, what is currently, a wholly owned subsidiary as a vehicle to commercialise and enhance the product.

Firm C was first registered in 1992 and is the home of the Firm C Intellectual Property and Firm B's contractual relationships with other companies relevant to the technology developed by Firm C. In 2008 Firm B decided to move Firm C on to become a stand-alone company. It currently employs thirty two people, and has a turnover of £4m all of which is generated from export sales. The company spends 50% of its turnover in financing R&D activity and has developed twenty patents applied in eight countries.

The company's focus is on digital printing for packaging material, and is part of a global sector that is worth some €170bn. Firm C has developed a different type of print technology to established print technologies such as bubble-jet (developed largely by Hewlett Packard), and electro-photography (Xerox). Over the last three years it had developed a specific print system and can printer, which are flexible printing system that enable short print runs on beverage cans, which can be in place at the consumer sales point at much shorter notice times than competing systems.

Firm D

Firm D has a narrow range of product and process activity having been established, in Cambridge, with the objective to make the world's best all optical matrix fixer: a device that flexibly connects optical fibres together, and demonstrates high performance in losing as little light as possible. The company holds some 23 unique patents in jurisdictions across the world and in the last three years have introduced a new series of products together with accompanying manufacturing process innovations. These innovations and new products have scaled up the capabilities of the company's device, tripling the number of possible connections and introducing innovative ways to cope with the larger number of fibre connections. The company is financed by venture capital and exports virtually all of its production to some 150-200 customers worldwide.

Firm D have been shipping products since 2003, and in 2005 merged with an American competitor that employed a different technical approach to offer a similar technological product, and which had been spun out of MIT in Cambridge, Massachusetts. The American operation has since been converted to a marketing and customer-servicing centre for what is Firm D's largest and most important market. Whilst none of the R&D personnel from the American company were relocated to the UK, knowledge built up within the American company has, over the six year period of association between the two locations, been absorbed into the organisation in Cambridge. Firm D employs some 60 people, 30 of whom are based in the UK, half a dozen in the customer service centre in the USA, and the balance in a manufacturing plant in Poland.

The company's engineering team is headquartered in the UK, and includes people with background disciplines of mechanical, software, hardware and electronics design plus system engineering knowledge. Whilst there are sales and customer support employees in the US and manufacturing operatives in Poland, some manufacturing is also located in Cambridge together with product development, new product introduction, and central administration functions. Given the relatively small size of the company, specific business-support skills that are not present, or for which there is insufficient demand to maintain in-house, are bought into the company by means of consultants such as financial specialists and software engineers.

Key findings:

- The ICT sector is diverse and includes systems, telecommunications, photonics and IT services sectors (including software).
- The size and scope range from local R&D centres of MNC to small spin-out companies
- Few local companies have grown to a global scale.
- Local companies have global markets and connections.

E.3. Types of knowledge and expertise required for local innovation

ICT companies in the Cambridge area engage with basic scientific and engineering knowledge applied to provide solutions defined by clients and other market actors. The closeness to sources of scientific research is variable, but ICT firms maintain close and dynamic relationships with customer and client base to shape and develop products. Bench level technical knowledge is, therefore, central to companies in this sector. Firm A, for example, rather than develop ideas from basic scientific research, is focussed on devising solutions to real and current problems as experienced by customers, and Firm B also works closely with clients to bring new products to market and to create new business opportunities from advances in technology. The two firms differ in that Firm B works across a broader range of technologies, and is engaged with earlier stages of science based technological development. It aims to combine strengths in science, engineering, and business development to recognise, create and exploit new technology while, through its group of companies, Firm B also incubates new technology and invests in early stage technology companies.

As is the case with the general Firm B model, while not directly engaged in primary scientific research Firm C links its technological expertise with customer requirements and understanding of the market. The personnel of the company is dominated by scientists and engineers, who have developed their careers within the company, and have experienced the demands of project management and development. Knowledge is created in all functional areas of the company and internal quality management is formalised as a process of learning from production and sales activities. The interaction between different aspects of company functions is an important element in its learning and knowledge generation process. Following the general model established throughout the Firm B group it is considered important to maintain control of the knowledge and know-how embedded in the various processes of the company, from manufacturing to sales and customer relationships.

A similar scenario applies for Firm D, and the most dominant type of knowledge deployed within the company is technical as opposed to scientific. Because of the technical focus important sources of knowledge are product and process patents, which are also important in advertising the company's competences.

" …what we produce is an unique combination of a number of 'known arts', but we combine them in a way to make the world leading product that we have. Do we need fundamental scientific research to do what we are doing – no. Do we need improvements in the components and in the sub-assemblies that go into our components to make them better, faster, cheaper? .. yes we do. So technical knowledge is the most important…"
(Firm D respondent)

Allied to technical knowledge, the company puts great value on customer feedback, and on understanding the competitive state of the marketplace. The diversity in the company's market place puts particular stress on software development, through which the company may add new features to their existing product.

Key findings:

- Firms engage with basic scientific and engineering knowledge applied to provide solutions defined by clients and other market actors.
- Bench level technical knowledge is central to companies in this sector
- Internal quality management is applied to formalise a process of learning from production and sales activities
- Commercial and technology management knowledge gains importance in firms as they mature and move from R&D to Production

E.4. Channels for knowledge and innovation creation

E.4.1. Inter Firm channels

As intimated above the relationship with client and customer is central and the challenges faced by customers guide knowledge generation in the firm. Firms must understand the demands placed by a number of stake-holders, including the users of a client's product or service, and the constraints that specific tasks place on technical solutions (see Box 1). The most technically efficient is often not an optimal solution, and successful products entail more than delivery of a technically competent system. Success often relies on a fit to particular conditions, highlighting the importance of knowledge gained by the company from its interaction with the customer or client

Box 1

An example of Firm A's interaction with customers is their work to develop online knowledge management systems in the aviation industry, specifically for the maintenance and airworthiness procedures of airlines. The objective is to replace current paper based system with digital systems (based on wi-fi enabled I-pads) that continue to satisfy the regulator, particularly by designing an electronic signatory that is acceptable as valid proof of job completion. This project is being developed in collaboration with an American company, specifically to comply with US regulation and to perform in the American aviation industry.

Firm B describes its interaction with clients in terms of the need to manage risks inherent in developing new products and processes. Working closely with customers to identify what they require and to fund development as it progresses reduces the risk, and aligns objectives more efficiently. Both Firms B and C note that while the kind of knowledge important for success resides with people who develop the technology, they must also have the ability to manage the relationship with the customer to ensure that the project remains fully funded at all stages of development, and that the intellectual property (IP) stays with the firm. The funding arrangement for new products and processes, which in these two examples comes wholly from clients rather than from venture capital or other investors, underlines the close relationship between Firms B and C and their clients.

"…an important part of this culture ..(is).. to go out to talk to people and to find out what they want and what was important to them….(and)…we had the ability and know-how within the organisation to manage the whole process and to keep this within.. (the company).."

(Firm C respondent)

Firm C builds a close relationship with customers and clients, particularly since many products are developed jointly with the customer and is based on addressing customer-defined needs. These relationships are with companies across the world (particularly centred on European, American and Japanese markets), and hence, the company's learning networks are also global. In contrast learning from competitors is not a significant channel of knowledge acquisition since in this instance the company's technology is sufficiently different for there not to be any directly competing firms from which the company might learn. Further illustrating the value of this channel of interaction is Firm D's experience of the UK market, which has until very recently substantially lagged their export market. Potential customers in the UK have been conservative when evaluating the potential benefits of the company's products and have only begun to show signs of change as the experience of competitors in other countries have demonstrated what may be possible.

Interaction with suppliers is similarly important, particularly to share experience at the business level, for example where major partners such as Microsoft and HP may host events at which technologists, sales, and marketing personnel from a number of companies have the opportunity to discuss new products or services. At user-group meetings the focus is on a particular product, and contacts made have the potential to develop into direct collaborative relationships. However, this kind of collaboration is often conducted at the commercial rather than technical development or scientific level given sensitivities about confidential company information and potential conflicts of interests. The supplier's networks can, however, offer an insight into the needs and requirements of other firms, for example in Firm C's case, where companies who manufacture inks that it designs, supplies other companies, and feeds knowledge about client requirements back to Firm C.

In general collaborative projects of any kind must align with something that a company does in any case. Given this condition, Firm D, for example, gets involved with projects that allow the company to multiply funds invested in their own R&D or to accelerate a particular objective. In this respect the company undertakes customer-funded or jointly funded activities, where a specific goal might be enhanced by collaboration, or a different

version of the product may be developed for a particular market[58] (see Box 2). In a similar way Firm B has, since its foundation, also established a number of joint ventures and has itself been the source of a number of spin-outs. A current example is collaboration with the Carbon Trust[59] to form an incubator that provides a portfolio of consulting services to accelerate the development of start-up and early-stage businesses in the low carbon sector.

E.4.2. University-Industry interaction and Networking

A large number of the ICT firms in Cambridge have been spun out of, or have had close contact with Cambridge University, and continued interaction with universities can be an important source of knowledge and innovation for these companies. There are a number of channels for interaction between Cambridge University and the high-tech sector, however, the relationship between firm and university is often less intense than might be expected (see also Smith and Bagchi-Sen, 2010). The channels employed include direct interaction between university departments and firms around specific projects either on a one to one basis or via collaborative fora. One example of this is the Institute for Manufacturing (IfM), which is contained in the Department of Engineering's Manufacturing and Management division and takes a cross-disciplinary approach to bring together expertise in management, technology and policy. IfM activities integrate research and education with practical application in industry via an university-owned company, namely IfM Education and Consultancy Services Ltd (IfM-ECS).

As noted above the founders of Firm A had direct contact with Cambridge University's CAD centre at the time the firm's inception. The firm was established on the Cambridge Science Park, which is a collaborative venture between Cambridge University's Trinity College and large research establishments, and this location created the ideal environment for the kind of business that Firm A was developing. However, once it had become established the company's relationship with the university became indirect. Whilst it maintained active interaction with other resident companies such as university spin off companies, research establishments, technology consultants and research support firms, direct contact with university researchers declined.

Other firms continue to interact directly with researchers at universities and research institutes. For Firm C this includes the IfM and particularly its Inkjet Research Centre (IRC), along with another specialist group of researchers at Leeds University. Firm D has formal interaction with researchers at Cambridge University through the Centre for Industrial Photonics (CIP)[60]: a centre that develops leading-edge technologies and transforms them into commercially viable processes for industry, including a number of areas that are directly relevant to Firm D. However, while firms attend university-organised evening meetings and other interactive fora, collaboration with universities that impact on current productive activities has become less important. Blue-skies research is often not directly relevant to the companies and their research activity, and whilst being useful is not considered as a major source of new knowledge. Close involvement with the university is of particular value in the early stages of technology

[58] Firm D has also been involved in collaborative activity exemplified by a six partner EU Framework Programme 7 (FP7) collaboration, which had initially come about as a result of informal collaboration with UK based companies and research organisations. The collaboration has been useful in terms of the scientific knowledge and experience gained, including scientific papers, and also in terms of the competence profile that the project presented. Large framework programmes are also beneficial in networking terms , which can often be of longer term value than the substantive goal of the project. However, it is a collaboration model that is more difficult to apply to small venture capital funded companies mainly because of the administrative and reporting burdens required by FP7 projects.

[59] The Carbon Trust is a not-for-profit company that was set up by the UK government to provide specialist support to help business and the public sector boost business returns by cutting carbon emissions, saving energy and commercialising low carbon technologies.

[60] The CIP is a part of Cambridge University's Institute for Manufacturing (IfM). In common with other centres at the IfM the CIP aims to address future manufacturing needs through collaborative partnerships with government, academia and industry. The Centre is also part of a global network of organisations involved in photonics-based research and education, technology transfer and business developments.

development, when access to specialist facilities is very helpful, but this need inevitably diminishes as companies build their own expertise, and equipment.

While direct or specific research-led interaction wanes as firms mature, firms continue to maintain more general networking contact with universities. In continuing its engagement with industrial companies Cambridge University has established or been a founding partner in a number of organisations designed to encourage wide ranging interaction that provide space and opportunity for establishing collaboration and for networking. In lieu of this involvement a number of partnerships and networks have been set up among local businesses and academic bodies, and such networking has been formalised through Cambridge Network Limited with which Cambridge University has been closely associated. This organisation aims to provide a way for local people from business and academia to interact with each other and with a global high technology community. Other networks include business based partnerships (e.g. Cambridge Futures), links between university and business (e.g. Cambridge Enterprise), and Cambridge Horizons[61], which was established to oversee the implementation of infrastructure objectives. Cambridge Futures is a broad based network made up of a group of business leaders, politicians, government officers, professionals, and academics and is one of the most prominent of these bodies. The participants collaborate in discussion of possible alternatives for the future of the Cambridge Sub-Region. Experience through these bodies indicate that relationships between local companies are good, with firms co-operating where there is mutual benefit, but with great sensitivity accorded to IP protection.

E.4.3. Non-University research organisations and networks

Firms also take advantage of non-university research organisations, both located in the Cambridge area and elsewhere, but such interaction, however, tend to be dependent on specific and well-defined requirements. Firm D, for example, has had a relationship with the Welding Institute (TWI)[62] and taken advantage of their expertise on materials and joining methods. Firm C, similarly, has taken advantage of the services of PIRA International Ltd[63], which can offer services such as industry conferences, online journals, webinars, and training.

Industry networks and associations also figure prominently as sources of knowledge for firms. There are a number of general networking groups and events in the Cambridge area, including the local business representative body (the Chamber of Commerce) and the Cambridge Network. Attendance at trade shows and industry conferences are important in affording opportunity to discuss directly with other companies and research institutions, but academic conferences are not such an important direct source of useable knowledge. Organised events provide the opportunity to discover other areas of interest, some of which may overlap with the company's own, and meetings provide the opportunity for discussion and initial assessment of the potential for further interaction. However, whilst firms may participate in a number of networking clubs and organisations within Cambridge and further afield, there is also some scepticism about the value of many such organisations and events, not least because so many are now available. According to some respondents the number of networking organisations and events may have reached a saturation point, and many of these (primarily) business networks are regarded as repetitive and less useful than those through which knowledge exchange may be enacted.

[61] Cambridge Horizon, after a number of years of successful operation is now winding up its activity.

[62] The Welding Institute is an independent research and technology organisations, (formerly known as the British Welding Research Association) headquartered in Cambridge since 1946, and with several facilities around the world. http://www.twi.co.uk/

[63] PIRA was originally a government funded industry research association but is now a privately run business knowledge service (or knowledge intensive business service)

Relevance and focus are, therefore, important criteria for deciding on involvement, and some firms concentrate on sector specific interaction rather than in becoming involved in more general networks. The main industry association that is relevant to Firm D, for example, is the South of England Photonics Network (SEPNET), which represents over 200 organisations active in photonics sub-sector and is supported by the Electronics, Sensors, and Photonics Knowledge Transfer Network. Such regional support networks are part of the knowledge transfer networks that are now supported by the UK Technology Strategy Board (TSB)[64], which is the UK government's national innovation agency. Whilst this is useful companies also express a need for more local network specifically related to photonics to enable a greater sense of cohesion than that which is achievable over a more dispersed regional network.

Key findings:

- Relationship with client and customer is central, and these include companies from across the world
- Knowledge from suppliers can be as important as knowledge from customers
- Collaborative projects of any kind must align with existing company activity
- Continued interaction with universities can be an important source of knowledge and innovation for spin-out companies
- Links with the university is of particular value in the early stages of technology development and established or mature companies tend to have reduced direct links with Cambridge University
- Companies' interaction with non-university research organisations is dependent on specific and well-defined requirements
- Firms gather significant knowledge through attendance at trade shows and industry conferences

E.5.Territorial elements supporting knowledge and innovation creation

E.5.1. Local supply of expertise

Local workforce quality is considered good across the sector particularly at the technology development level, and particularly at the research end of the R&D spectrum. This quality reflects the influence of higher education institutions in the area, but in addition a fairly active labour market for higher-end skills that exists within the greater Cambridge area. The high-tech labour market is facilitated by the sizable pool of companies who employ people with similar kinds of skills.

A cluster of ICT companies has built up in Cambridge over a period of some forty years, and has particular strengths in a number of sub-sectors. While many of the companies in the ICT sector are SME's, companies in the digital printing sector are exceptions and includes major players such as Domino, Xaar, Video Jet and Lynx, whose total annual turnover amount to over £500m. Together these companies represent the biggest cluster of such companies, with Chicago in the US being the only other cluster of note worldwide[65]. The cluster benefits companies such as Firm C in creating a pool of expertise and high level skills from which it may draw talent and knowledge. Firm C itself has not experienced high employee turnover, but has been able to attract some very

[64] The Technology Strategy Board is an executive non-departmental public body (NDPB), established by the UK Government in 2007 and sponsored by the Department for Business, Innovation and Skills (BIS).The activities of the Technology Strategy Board are jointly supported and funded by BIS and other government departments, the devolved administrations, and research councils. [http://www.innovateuk.org/]

[65] Other major players in the industry are located in separate towns such as Xerox in Rochester, USA, and Hewlett Packard in Palo Alto, USA.

good workers as other companies within the cluster made decisions to relocate manufacturing centres overseas[66].

The cluster of inkjet printing and similar companies in the Cambridge area also benefit the companies by the informal interactions that it may sustain. There is local and accessible expertise in realising technologies, and while there is strong competition between some of the companies in certain areas, not all the companies are engaged in the same markets. Recruitment from the locally available skill pool is, therefore, an important channel for accumulating knowledge (see Box 2), but collaborative activity with other companies that have complementary skills and expertise is also an important way of leveraging the value of combined knowledge.

Box 2

As a firm active in this subsector Firm C employs a mix of scientists including physicists, chemists, software engineers, electronic engineers, and very high skilled technicians who are designated as instrument makers in the company. This latter group are considered to be top flight designer/assemblers, who are local to the Cambridge area and have come through extensive training and hold long term experience that is highly valuable in the company.

> *"…They are all local (people). A lot of them have gone through various bits of the university- the university used to have an incredibly high quality training scheme… and then (also) Cambridge (Scientific) Instruments*, which used to make electron microscope, (and) used to have an apprenticeship scheme.. (which).. used to turn out extremely high quality people… …Although a lot of things are designed on computer and sent off to be milled on some precision CAD machine, having people who are very familiar with making things to microns (tolerance) is quite important.."*
>
> (Firm C respondent)

[* Note: Cambridge Scientific Instruments has since merged with Advanced Chromatography Systems and Unicam Chromatography, to form Ellutia and design and produce a range of gas chromatography instruments]

People who have received some craft training but who are unlikely to have post-school level education are employed for operator level and manufacturing functions, but there has been some concern about the supply of sufficient numbers of people with these skills. Firm D, for example has experienced difficulty in getting dedicated and motivated manufacturing staff from the region, and whilst there were other reasons for moving some production abroad, a major component of the decision was the difficulty of finding people with the appropriate skills and motivation in the Cambridge area. If there is a ready-made talent pool available at the intermediate skill level it is expensive and very much in demand, with competing employers in London and further north that pull talent away from Cambridge. Competing on the basis of pay rates runs the risk that the employees found will be too mobile and companies may suffer unacceptable staff turnover rates. Firms such as Firms A and D have reviewed their approach to recruitment at this level and, in addition to recruiting people already qualified to fill the technician level gap, now aim to take advantage of an apprenticeship scheme run by the Cambridge Regional College and Anglia Ruskin University.

Whilst an obvious potential source particularly for the R&D and engineering management functions, Cambridge University is not always significant supplier of employees. It was noted that, in contrast to the craft-based instrument makers (as in Box 2) graduate recruits are unavoidably inexperienced and often cannot contribute to the company's

[66] Lynx, Xaar, Domino, and Video Jet, all have a history of manufacturing in the Cambridge area but have also moved manufacturing out and back again into the area, for example Xaar moved their manufacturing to Sweden for historical reasons but have since decided to bring it all back to Huntingdon.

knowledge in the short run. However, those undergraduate and post-graduate students that are employed through job-experience programmes can be useful to companies, and this may include students on international exchange schemes[67]. Such schemes enable the company to identify suitable candidates for longer term employment, and such work placement students can also be independently productive within a period of four to six months. Some students that have entered firms on this basis have come from Cambridge University, but to date firms note that students are difficult to attract on a permanent positions for a mix of reasons, one of which in the recent past having been due to the greater financial attractions on offer from financial institutions in the City of London.

In general the available pool of labour is considered to be of high quality but expensive, with proximity and easy access to London ensuring that pay rates are relatively high. The effect of the London job market, however, can act in two ways: as a result of London-equivalent salaries companies may attract people from outside the immediate Cambridge area. However, since Cambridge is a relatively wealthy area it also has high living and housing costs and recruits may have to commute some considerable distances. Firm A notes that less than a half of the workforce lives less than ten miles from its location.

The city of Cambridge has a better qualified workforce than the remainder of the East of England region or the UK as a whole, which reflect the profile of both the educational institutions, research institutions, and high-tech companies (Simmie et al, 2006). Cambridge University has some 18,000 students and is regularly ranked as one of the leading research universities in the world, while Anglia Ruskin, established in 1992 with campuses at both Cambridge and Chelmsford, has a student population of some 31,000, including substantial part-time education provision. The pre-university education system is considered to be of a high standard, with a further education college complementing secondary school provision. The nature of education is also perceived to have changed in favour of the type of education and skills for which industrial companies are looking.

'University courses have become more focussed on creating employable people and the quality of engineering graduates both locally and nationally is extremely high".

(Firm C respondent)

Respondents to the case study, however, have also corroborated previous observations that identify a gap in business and management skills among many scientific and engineering graduates (Simmie et al, 2006). Whilst the Cambridge Regional College has introduced specific courses on management and business skills for science graduates and entrepreneurs, another factor reducing the pool of available talent for management functions is that the city does not host the headquarters of many large companies.

"Cambridge is not a big location – it is…a large town – and we don't have that range of head office companies here. There is no IBM HQ.. .(for example). Those bigger companies that are represented- like Microsoft – (it) tends to be their R&D outlets rather than their head office, and sales and personnel sections. We don't have that pool to tap into- to help some of those smaller companies to grow."

(Greater Cambridge Partnership respondent)

It has been noted in a number of reports that the vast majority of the high-tech firms in Cambridge are small, with an estimate that a third of Cambridge's high-tech firms employing five or fewer people, while another fifth do not employ more than twenty (Simmie, 2006).

"…(what) we don't have the critical mass for is to grow the company into world beaters. You can count on the fingers of both your hands - ten companies (like) Cambridge Silicon Radio, and ARM and so on - that have grown to be very large. We don't have a pool of what I would call head office corporate management be it marketing, personnel, financial management we don't have that corporate level of skills to encourage companies to grow."

[67] E.g. through the IAESTE programme: International Association for the Exchange of Students for Technical Experience (http://www.iaeste.org.uk/index.html)

(Greater Cambridge Partnership respondent)

The lack of business management skills is quoted as the main reason for the preponderance of small firms that do not grow, although another is that successful small firms are sold and acquired by larger companies.

Key findings:

- Local workforce quality is considered good particularly at the research end of the R&D spectrum Educational standards are high and the local workforce is better qualified than the UK average
- While labour is considered to be of high quality it can be expensive and in high demand
- There is an active labour market for higher-end skills within the area, but also a substantial pool of relevant skills
- The sector has developed over an extended period of some forty years and the sector includes firms in sub-sectors that represent the biggest cluster of such companies in the world
- Clusters of similar companies maintain active informal interactions
- There is concern about some technical/ operator level skills and there is a perceived gap in the business and management skills of scientists and technologists

E.6. Local innovation policy assessment and governance

The structure of representative local government, which has some impact on economic development, is organised on two levels namely the County Council and the District Council levels. Their major direct influence lies in providing services and infrastructure to support development, and to regulate those developments and the opportunities for development. Cambridgeshire County Council, for example, has responsibility for local road system planning and for traffic congestion, whilst Cambridge City Council, as the relevant District Council, is responsible for city planning and building control within the city limits. Other District Councils control the land use planning decisions in those areas in the environs of the city, which make up the Greater Cambridge Area.

The local authority structure has appeared to contribute to some lack of coherent planning around the city of Cambridge, which is manifested in terms of relatively high land costs, a shortage of housing for a range of income scales, and pressure on the transport infrastructure (Simmie et al, 2006). During the period from the turn of the century to 2010, however, there has been a change in the planning approach in the Cambridge area and an element of greater strategic coherence has been developed. This greater coherence has come about with the establishment of a number of institutions that aim to develop networks among local authorities, other public institutions and business.

In 1998 the Greater Cambridge Partnership (GCP) was established as an alliance of public sector, private business, academic, and community sector interests. These actors work through a framework established by the GCP to increase economic opportunities for businesses and individuals alike. The GCP has acted to represent the interests of the area at a regional, national and international level; to commission research; and to act as a conduit for government funding for initiatives (e.g. and up to the year 2010 being supported by the EEDA). In 2006 the GCP became a not-for-profit limited company, and describes itself as an enabler (and provider of resources including finance) that helps set the strategy and ensures its implementation via its partners. It also offers strategic advice and guidance; giving promotional support; providing sponsorship; hosting events; facilitating introductions; and acting as a general enabler.

The approach of the GCP has included assistance in the development of physical assets in the form of business and research parks to provide a suite of opportunities for companies at different stages of their evolution. These include pre-spin off entities; start up companies that may only employ a few people; and more developed ventures requiring greater amounts of space and different technical specification. Enterprises are also offered differing levels of advice and business management support as appropriate to their particular needs.

The GCP are also active in supporting enterprises through providing networking opportunities and events for individuals and firms, support seminars, consultation and research into the development of the high-tech sector. These activities, identified as 'softer support', in comparison to the provision of 'hard ware' in the form of buildings and other physical infrastructure, are considered to be as important, but both aspects of support are necessary. They include encouraging and sponsoring events such as a 'Business Plan' competition at the University of Cambridge, encouraging training, and support for high growth start ups, and trying to encourage entrepreneurs to interact with business support to encourage business to grow.Other organisations also organise networking events such as the Cambridge Corporate Gateway, run by Cambridge Network with support from a number of partners including the University of Cambridge. The Gateway is a technology partnering event that offers delegates from international companies and investment houses a bespoke programme of one-to-one meetings with leading University researchers and new technology companies in Cambridge.

In addition to the local government structure, economic development and business support institutions and government agencies have been developed to operate at a wider, more regional level (according to the NUTS classifications referred to above). However, the number of these institutions and agencies has been curtailed during 2011 in lieu of the change in emphasis on regional policies pursued by the current UK government, but some programmes will continue to exert some influence for some time into the near future. The most significant body that has been discontinued is the Regional Development Agency, the EEDA (East of England Development Agency). This is an organisation that offered a regional perspective to economic development in the area, and provided a range of business support programmes for businesses and individuals, and funding support for a number of large capital projects[68]. Many of its programmes continue under the guidance of other organisations, and the EEDA itself has been replaced by a Local Enterprise Partnership (LEP), which is a voluntary body that is made up of local government and business representatives. During 2011 the LEP for the area was successful in attracting one of the UK governments' Local Enterprise Zones, designed as areas within which companies are freed from some local taxes and regulation.

With the termination of the EEDA, direct financial support for businesses has been curtailed, but high-tech companies note that such support was never readily available for the ICT sector in Cambridge in any case. What may be available often requires some investment in developing, writing and justifying applications, and for small companies the overhead demands of making grant applications is an obstacle. Interaction with policy makers is similarly a time consuming process that small companies may not have the capacity with which to engage. Large companies are better able to develop such contacts.

[68] For example the EEDA provided £32m for the regeneration of the Ipswich waterfront area, £14m for a new campus for the University of Essex, and an £8m contribution to a deep water harbour at Great Yarmouth.

Key findings:

- Local government provide services and infrastructure to support development, and regulate developments and the opportunities for development
- Greater strategic coherence in terms of an alliance of public sector, private business, academic, and community sector interests has developed through the Greater Cambridge Partnership (GCP)
- The GCP aid the development of physical assets in the form of business and research parks and, together with other organisations, provide networking opportunities
- Changes in regional policies by UK government result in more emphasis on local partnership
- Central government support has never been readily available for the ICT sector
- SME find the overhead demands of seeking state support problematic on the occasion when it is available and applicable

E.7. Conclusions

As has been demonstrated in a number of studies over the last fifty years, Cambridge has undergone a transformation of its local economy that has largely been due to the greater commercialization of the research outputs of Cambridge University (e.g. Simmie et al, 2006; SQW, 2011; SQW, 1985). Whilst the main driver to the so called 'Cambridge Phenomenon' has been the presence and the intellectual output of Cambridge University, other academic and other research institutions have also contributed. In addition public agencies in the region comprising of the city of Cambridge and its environs have, in this period, built upon the strong pre-conditions for knowledge creation provided by its universities and research institutions, which offer a strong base and support to those technological and local business capacities that enable product and process innovation.

Firms in this region produce and develop new knowledge, utilizing research generated within the local universities and research institutions, within their own R&D activity, and in conjunction with customers. There is evidence of firms learning from their local networks, and taking advantage of the local concentration of expertise in various ICT sub-sectors, and these networks extend beyond the region. External knowledge networks are created along connections between the firm and clients (a large percentage of which are overseas), customers and suppliers, and firms are also able to directly profit from the scientific knowledge base within other regions through interaction with academic and other research institutions in those regions. Interaction with academic institutions, however, tend to diminish as firms become more mature and develop their own technologies and internal capacities, and engage with networks that are more directly related to their own products, processes and markets.

The area has seen what has been described as four waves of development to date, which have been principally associated with ICT, software, biotechnology and clean technologies. A large number of firms are started or spun off from universities, research institutes and other firms within this area. While the rate of formation of these firms has been high, a noticeable weakness has been the relatively small number that have grown to a large size, or which have become globally significant companies. One of the reasons for this is suggested to lie with deficiencies in technical management education in the area, deficiencies that local policy actors have identified and are addressing. Other local policy actions in support of the ICT and general high-tech sector also lie with supply side provision, including supporting technical education, improving transport infrastructure, and changing land use planning policies and procedures to enable greater industrial development.

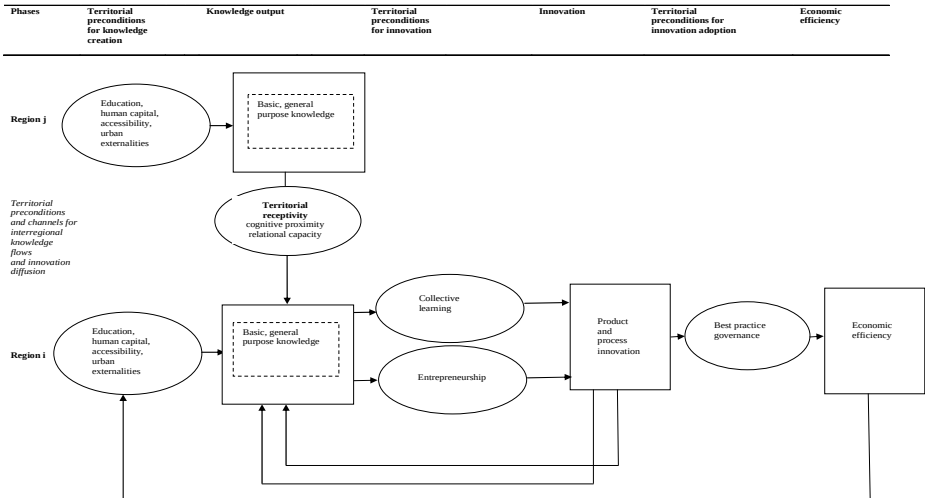
The conditions and characteristics outlined above and in the body of the case study suggests that the development pattern is that of what the KIT project has described as

an endogenous territorial innovation pattern (pattern 1 as described in in Chapter 2, Volume 1 of the Scientific report and reported in Figure E.1).

Key findings:

- Transformation of the local economy has largely been due to the greater commercialization of the research outputs of Cambridge University
- Public agencies in the region have built upon the strong pre-conditions for knowledge creation
- Firms utilize research generated within the local universities and research institutions, within their own R&D activity, and in conjunction with customers
- Firms profit from the scientific knowledge base within other regions through interaction with academic and other research institutions
- The relatively small number of firms that have grown to a large size, or which have become globally significant companies may be related to some deficiencies in commercial and technical management among firm founders

Figure E.1. An endogenous innovation pattern



Source: KIT final report

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F. The biotech sector in Oxfordshire[69]

F.1. Introduction and description of the case study area

F.1.1. Geographical context

The British Biotech sector case study is focussed on Oxfordshire, one of nine NUTS 3 regions in South East England (NUTS 2; UKJ2). Oxfordshire is predominantly a rural region (population 648,700), with the city of Oxford being the largest settlement (population 153,700)[70], and containing smaller towns such as Banbury, Bicester, and Didcot. The county has good transport links to other regions in the UK by means of two motorways and railways to London (80km) and its global connections. This infrastructure also links the area north to Birmingham and the English midlands, and west to Bristol and south Wales. The locations for high-tech firms include the city of Oxford, its immediate vicinity, and a number of other areas, particularly in the south of the county.

F.1.2. Local economic context

The industrial (workplace) profile of Oxfordshire is close to the UK norm. However, employment in the education sector is above UK average, and particularly concentrated in the city of Oxford, where Oxford University and Oxford Brookes University are located. Nearly half of the jobs in Oxford are accounted for by the universities and public sector jobs compared to 27% for the UK average, and this concentration raises the Oxfordshire level above average. In addition to the universities, Oxford is also host to research intensive hospitals such as the John Radcliffe and Nuffield Orthopaedic Hospitals. Other important industrial sectors in the county include Finance and Business services, Hotels and Restaurants, Publishing and IT, Retail and Manufacturing. Manufacturing is concentrated in the city of Oxford where car and car parts manufacturing plants are located.

Table F.1. Work place employment (Employee jobs) % share by industry (2008)

	Oxfordshire	Oxford	South East	UK
Manufacturing	9.8	8.0	8.1	10.2
Construction	4.0	2.2	4.5	4.8
Distribution, hotels & restaurants	22.3	16.8	24.6	23.4
Transport & communications	4.1	3.5	5.9	5.8
Finance, IT, other business activities	22.8	19.0	24.0	22.0
Public admin, education & health	30.1	46.0	25.6	27.0
Other services	6.0	4.1	5.6	5.3
Tourism-related*	8.1	6.9	8.2	8.2

*Source: ONS annual business inquiry employee analysis; *Note: Tourism consists of industries that are also part of the services industry; 'Employee jobs' exclude self-employed, government- supported trainees and armed forces.*

Business and research parks are located across the county, with a particular concentration in the south, an area that has been labelled as the Science Vale in recognition of the range of high-tech and scientific research facilities in the area. The Science Vale is centred on research and business campuses such as at Harwell, Milton Park, Culham and the Grove Technology Park, making it one of the largest science research and innovation clusters the world. The Harwell Innovation Centre houses some 150 organisations including UK Research Councils, start-up companies and organisations working on a range of commercial applications from biotech, healthcare, space, and detector systems, to computing, green enterprise and new materials. It is a joint venture between the public sector in the form of the UK Atomic Energy Authority and the Science and Technology Facilities Council, and a private property management group. Similarly Milton Park houses some 165 organisations and employs 6500 people while the Grove Technology Park and Culham are smaller with 77 and some 33 science-based and high-tech companies respectively. Culham also houses some major science facilities including the UK's fusion research programme laboratories at the Culham Centre for Fusion Energy (CCFE), and the JET (Joint European Torus) fusion experimental facility.

[69] This case study report has been written by Selyf Morgan, Cardiff University.
[70] UK Office of National Statistics (ONS) mid-year estimate, 2010

The Oxford Science Park and the Begbroke Science Park are two other centres for science based companies each jointly operated by Oxford University together with a property management company. Oxford Science Park (established by Oxford University's Magdalen College) has over 60 companies operating in a variety of industry sectors including the bioscience, computer, telecommunications and environmental science industries. Begbroke Science Park, on the other hand is more closely integrated with university science and technology departments, and acts as a conduit for knowledge and technology transfer between researchers and entrepreneurs. It has some 30 high-tech start up companies that have either spun out of the university or have located on site to benefit from close links with university research groups.

F.2. The biotech sector: Firm profiles and innovative activity

F.2.1. The biotech sector

The British biotech sector[71] is a European leader and tops the financing indicators in terms of most Venture Capital finance raised, the most capital raised, and largest number of financing rounds for European countries (OBN, 2011). The UK BioIndustry Association (BIA)[72] estimates that some 942 companies were involved in bioscience in the UK in 2010, including 345 companies directly involved in the development, manufacturing or selling of therapeutic products. These companies employed over 36,000 people with a turnover of £5.5bn, and there are significant clusters of biotech companies located in Cambridge, London, and central Scotland in addition to Oxfordshire.

In 2010 there were 163 companies employing approximately 7200 employees in Oxfordshire, a total that was 14% higher than in 2008 (OBN, 2011). OBN expects that employment in the bio-cluster will expand at a rate of 500 new employees per annum for the three years commencing from a 2008 base, and the growth rate of employees is normally a good indication of the growth rate for the bio-cluster as a whole. These companies are distributed across Oxfordshire, with concentrations at the city of Oxford, and at Cherwell, Abingdon, Harwell, and Didcot. The sector covers a wide range of activity ranging from drug discovery and development, medical devices, medical technology and diagnostics to laboratory reagents and supply and niche technologies (see Table F.2).

Table F.2. Major sub-sectors in the Oxfordshire bio cluster (2010)

Sub Sector	Number of firms	Percentage of firms
Drug Discovery and Development (DDD)	35	22
Medical Technology	30	19
Diagnostics	25	15
Laboratory Supply	25	15
Support for drug discovery and development	20	12
Others including bioinformatics; contract research; industrial biotechnology	28	17

Source: OBN (2011)

Research and development, and testing of research products typically take many years, and because of the uncertainties and risks involved commercialisation of knowledge and innovations is often undertaken via spin-offs and start up companies. A large number of the companies in the Oxford Biotech cluster are, therefore, relatively small and research oriented, and these take a central role in the success of the region. Approximately three-quarters of biotech firms are either small (11-49) or medium sized with the remainder being either micro-sized or large companies. Because of the extended periods of time required for research, development and testing, a number of seed and venture capital funding rounds are often undertaken to enable start up and subsequent growth stages. Many dedicated biotechnology firms (DBFs) do not earn revenues for lengthy periods since they are still at the stage of research and development, or in specific phases of clinical trials. A smaller number of biotech companies earn profits and some reach very high value market capitalisation.

[71] The exact definition of the sector is contentious to some degree, not least given that for some biotechnology is thought of as an 'enabling technology' rather than a industrial sector (e.g. DTI, 2001). For the purposes of this case study we shall continue to describe firms employing biotechnology as belonging to a biotech sector.

[72] www.bioindustry.org

Big pharmaceutical firms are another important group of players in the biotech cluster, and these firms regularly monitor the development of research led spin offs and look for ventures from which they may replenish their drug pipeline or complement their product or technology portfolios. These companies may also license new technologies, and/or enter into R&D partnership, or take over promising young firms.

The biotech sector in general in Oxfordshire, however, has continued to mature as larger proportion of the small firms are still active or independent after six years increase. By 2010, 70% of the companies were older than six years compared to only 50% in 2007, while 24 new biotech companies had been established in Oxfordshire since 2008. New Laboratory Supply and Medical Technology companies were established in this period, yet whilst the number of Drug Discovery and Development (DDD) companies remained more or less the same, the number of products in the development pipeline increased substantially from 143 in 2007 to 292 in 2010[73].

Investment has also increased substantially between 2007 and 2010: from $108 million to $168 million in Oxford, and from $433 million to $874 million overall across the UK (see also Table F.3). The companies that were most successful fundraisers in both Oxfordshire and the rest of the UK are mostly in the DDD sector. In the period from 2008 to 2011, OBN also notes that the main funding sources have changed from primarily venture capital and IPO's (initial public offering) to corporate venture funds and alliance with large pharmaceutical companies. Furthermore, the $275 million that was raised by companies in the cluster in the first six months of 2011 is equivalent to the total raised by the Oxford cluster during 2009 and 2010 combined. OBN notes that particularly for relatively established companies that generate revenues, and have feasible products, or have a clear exit strategy (and, therefore, are attractive to investors) future prospects seem very positive.

Table F.3. Significant fundraising ventures during 2011

Company	Financing £m	Sub-sector	Company Status
Oxford Nanopore	25	Diagnostics	Private
Circassia	60	DDD	Private
Oxford BioMedica plc	20	DDD	Public Limited Company
e-Therapeutics plc*	20	DDD	Public Limited Company
Lombard Medical Technologies	27.5	Medical Technologies	Public Limited Company
ProSonix	11.4	Medical Technologies	Private
OrganOx	2.8	Medical Technologies	Private
Microvisk*	6	Medical Technologies	Private

Source: OBN (2011); *Note that e-Therapeutics is headquartered in the north of England and Microvisk in north Wales; DDD: Drug Discovery and Development

F.2.2. Case Study Firms

Firms contacted for the study are distributed across a number of sub-sectors within the Oxfordshire biotech cluster, and cover firms at different levels of maturity. Interviews were conducted to follow a common interview schedule developed for the KIT project. Local government and industry bodies were also contacted to ascertain how local policies and actions to support the sector were being delivered in practice.

[73] Much of the data quoted in this study regarding the Oxfordshire biotech cluster is sourced from OBN, 2011.

Table F.4. Summary information on interviewees

Firm	Position in the organization	Degree	Number of years in the firm	Previous working experience in a different organization
A	Senior scientist	N/A	N/A	Research Scientist
B	Senior Administrator	N/A	N/A	N/A
C	Senior Sales/ Marketing	N/A	N/A	N/A
D	Senior Administrator/ HR	N/A	N/A	N/A
E	Senior Administrator	N/A	N/A	N/A
	Senior scientist	N/A	N/A	Research Scientist

Source: Author Interviews and firm websites (Notes: * In house and licensed; N/A: Not available/ applicable; **: Number of patents registered in 2008-2010)

Table F.5. Summary information on interviewed firms

Firm	Established	Sub-Sector	Turn over £m	R&D as % of turn over	Export as % of turn over	Employee No. (local)	Patents No. or IPR	New products /processes 2008-2011
A	2005	Medical Equipment	N/A	N/A	N/A	100	>300*	N/A
B	2006	DDD	N/A	N/A	N/A	16	21	N/A
C	2002	Diagnostics	N/A	N/A	N/A	79	N/A	1
D	1987	Laboratory Supplies	N/A	N/A	N/A	12	N/A	N/A
E	1994	DDD	19 ($30m)	N/A	N/A	98	>121**	N/A

Source: Author Interviews and firm websites (Notes: * In house and licensed; N/A: Not available/ applicable; **: Number of patents registered in 2008-2010)

Firm A was founded in 2005 as a spin out to develop and exploit a molecular analysis research project from Oxford University. It was established in partnership with a technology consultancy and management company that specialises in the commercialisation of intellectual property originating from research intensive institutions. Currently, Firm A continues to be focussed on technology development combining biological and electronic technologies and does not at present generate profit from products. It is developing a platform technology that may be adapted and used in a number of different areas from scientific research to medicine, crop research and security or defence interests. Firm A keeps spending on its R&D confidential but is financed from venture capital and other private financing rounds, which have raised over £75m for the company to date. The firm is based in Oxford, where its main R&D, production and quality control functions are located, but has recently also opened a further research laboratory in Cambridge. It also maintains contact with universities across the world and has developed alliances with firms to jointly develop particular elements of its research.

Firm B is a specialty biopharmaceutical company that is focused on developing immunotherapies, including allergy treatments and combating autoimmune conditions. Established in 2006 the firm's products are currently in mid- to late-stage development, having successfully completed a number of phase II clinical studies. Since its establishment, Firm B has raised over £93m ($159m) in four investment rounds, and is supported by a syndicate of leading institutional and venture capital investors.

Firm C is a medical diagnostics company that manufactures and markets diagnostic test products and services for laboratories and clinicians, which are marketed directly and via distributors in Europe, Canada and more than 40 other countries worldwide. The company also provides sample testing services for the diagnosis. The company was founded in 2002, is based near Oxford but also has locations in Massachusetts, USA. The company remains a privately owned company and has raised over $73m over five financing periods.

Founded in 1987, firm D is a well established firm that provides product and custom services for research in the biotech sector. Its market reach is global and the firm works in

partnership with mainly SME manufacturers to supply over 330,000 research products, research reagents and services, to end users. The company was originally formed in Spain, and became established in a number of other countries, including the UK over the following few years, funded by venture capital and private funding sources. It has been in collaboration with a number of firms to develop sales and marketing of products, and with a number of academic institutions across the world. It has facilities in Switzerland and Germany in addition to the UK. The UK (Oxfordshire) facility houses logistics, distribution, marketing and technical staff.

Firm E is also an international firm of relatively long standing, having been founded in 1994. It has sites in the USA, Canada and the UK and employs some 1800 people in total. Founded in Cambridge, Massachusetts, the British subsidiary is based near Oxford, and the firm's activity in the Oxfordshire area is focussed on R&D to discover, develop and commercializes innovative therapies. The site in Oxfordshire employs scientists from various disciplines and backgrounds.

Key findings:

- The bio-tech sector in the region has a number of sub-sector including diagnostic, Drug Development and Discovery, Medical Technology, Laboratory Equipment, Diagnostics, Contract Research, Bioinformatics and Laboratory Supplies.
- The area has a high number of start-up and spin out bio-tech firms that commercialise the products of university research projects.
- Venture Capital and other financial investment and support firms form an essential level of expertise to support innovation and development in the region.
- Big Pharmaceutical companies are active participants in the sector in Oxfordshire, either through local R&D facilities, production, or internal corporate knowledge exchange and financial support.

F.3. Types of knowledge and expertise required for local innovation

Biotechnology, and in particular the therapeutic and drug development segments, relies to a high extent on academic and university based analytical knowledge[74], and knowledge in biotech has been described as being of a documented and codified nature (Zucker et al, 1998; Cooke, 2004). Within the sector firms can also encompass a range of scientific disciplinary knowledges and expertise that relate to different sub-sectors (see Table 2). However, as firms become established, develop and commercialise basic research, the demands and disciplines of the market become more prominent, and commercial, financial and market knowledge increase in importance. These disciplines impact directly on the research and productive activity of the firm and influence the type of expertise required from staff members.

In addition to differentiation on the basis of sub-sector, the distribution of job skills within companies may be said to reflect their level of maturity, with recent spin-offs more likely to have a greater proportion of staff employed directly in R&D as opposed to other aspects of the business. For firms that work primarily in Diagnostics and DDD, scientists, engineers and informaticians constitute the large majority of the staff and the majority of those are employed in R&D activity. Given the state of development of many of these R&D intensive firms, many will not have a large sales and marketing staff. Sales and marketing rise in prominence as the company develops its product range and progresses to a position of revenue generation beyond product development phases.

Firms that make the transition to production dominated activity will also increase demand for management and internal business services. Firms that are more dominated by R&D often collaborate with specialist technology development consultancies that assist in arranging seed, venture capital, and other funding, and deal with location and the development of premises.

[74] It is suggested that analytic knowledge exploration is based on cognitive and rational processes, analytical techniques and/ or formal models in contrast to synthetic knowledge that is derived from combinations of already available knowledge, and symbolic knowledge that is related to aesthetic attributes of products, design, images and the creation of cultural artefacts (Cooke et al, 2007)

Key findings:

- Scientific and bench level knowledge dominate requirements for the start up and spin out companies.
- As firms mature and develop processes and commercial product capability, commercial knowledge related to the base scientific knowledge increases in importance.
- Commercial, market and general management knowledge is essential to maintain firm growth and/ or to manage transition through collaboration, merger, and/ or acquisition.

F.4. Channels for knowledge and innovation creation

F.4.1 Internal and local channels

Innovations in biotech often results from basic scientific research and are frequently radical. Links between companies and university scientists and departments are, therefore, important, and are often formal and contract based (Zucker et al, 1998; Powell et al, 2005). In this case study firms that spin out of Oxford University maintain a continuing relationship with the institution. The depth of this relationship may vary over time and sector, but is normally constituted principally with the original department from which the firms emerge. Many of these relationships are also based on continuing collaboration and further development of either the original research area or allied work projects.

Firms also maintain relationships with public research institutions, some of which may also be customers (e.g. Firm A) or with whom collaborative work is carried out. Collaborative work is frequent between firms in the biotech sector and hospitals, and in Oxford particularly so with university teaching hospitals, which maintain active research programmes. Some biotech firms also double up in agro-food biotech or may also act as clinical research organisations that conduct drug testing and trialling, or work with pharmaceutical development companies that may not have in-house R&D facilities.

There is also interdependence between large pharmaceutical companies that need smaller specialist drug discovery R&D biotech firms (Dedicated Biotech Firms, DBFs) to carry out basic laboratory science to originate new drug candidates for licensing. DBFs often lack the resources to develop their own drug candidates beyond pre-clinical and early stage clinical trials. These relationships are not necessarily local, however, and many of these kinds of relationships may develop between firms in the Oxford region and those anywhere in the world (particularly in the USA).

Firms in the region have varying attitudes to local networking with other biotech companies. Organisations such as Oxford BioNet (OBN) maintain a high level of networking activity (see further below), and many firms in the region are also members of trade and sector bodies such as the BIA (BioIndustry Association) and the EDMA (European Diagnostic Manufacturers Association). The EDMA[75] represents national associations and major companies that are engaged in the research, development, manufacture, or distribution of *In Vitro* Diagnostic (IVD) tests in Europe, and has a membership of over 500 companies across Europe.

However, not all firms in the sector within the region participate in organised networking structures and networking events as fully as others, and there is some suggestion from respondents in the case study that this may be related to the size and maturity of the firm. Firms that have a well-defined and narrow research that is focussed on developing a specific

[75] The mission of EDMA is to raise awareness of the importance, usefulness and added value that diagnostic information can provide to healthcare. For this purpose, EDMA aims to cooperate with European institutions, patients groups, trade associations, health professionals and academia to support an appropriate regulatory system, to work towards a realistic economic environment for healthcare in Europe and to be an effective voice in globalisation.

research project idea, for example, often have very targeted approach to collaboration and interaction with other companies and institutions. They have well defined requirements and understanding, developed through the contacts built up during research interaction, of the people and institutions with whom they might wish to interact. In such cases general networking within the region, even within the biotech sector community, may be considered relatively unnecessary. Firms are also aware of their competitive situation, a factor that may limit local collaboration.

Time is also at a premium for smaller firms, especially at the spin out stage, and generalised networking activity or issues are often considered less of a priority. Networking of this type is characterised by some firms as of little value given their experience such interaction as often focussed on sales and marketing contacts rather than being opportunities for knowledge exchange or discussion. Joint ventures, while also well developed for some companies are not useful forms of collaboration for others. Some smaller firms prefer the relative simplicity of collaboration based on service provision and fee payments rather than the more intimate relationships that may ensue from joint ventures.

F.4.2. External channels

As noted above local and global relationships are evident in a number of examples (see also Cooke, 2004; McKelvey, 2004; Gertler and Levitte, 2005). Firms in this sector routinely interact in a global marketplace. DBFs in particular (and universities) enter into collaboration with overseas partners in addition to domestic partners for product innovation, distribution, licensing deals and supply contracts, although many international DBFs maintain manufacturing facilities in the UK. In research into the UK biotech sector structure, its innovation characteristics and spatial distribution, in 2003/04, Cooke et al (2007) found that UK bio-pharmaceutical firms interact most with global partners, then with UK partners, and then with cluster and EU partners. Firms, however, can behave distinctively in relation to their own specific requirements, particularly with regard to relationships leading to innovation as distinct from other interactions such as open ended research, joint patenting, purchasing or supplying and other informal collaboration. To a large extent, therefore, geographical proximity is relatively unimportant.

Biotech firms are to a large extent necessarily global-facing firms and maintain collaboration globally. Academic conferences have often provided the basis for the pursuit of many of these collaborative activities, starting in many cases within academic projects, but being maintained and developed as firms are spun out of universities. Such collaboration for biotech firms in the Oxford area includes joint work with institutions across the world, including leading American universities with strengths in biotech analytical technology. Agreements with British and American Universities are made to exclusively develop and commercialise discoveries from their research that utilises the core technology that firms have themselves developed. Firm A provides a very active example of such collaboration and in order to maintain and strengthen these links, it has also set up a panel of specialist academics from the University of Oxford and its collaborating universities in the United States.

Strategic alliances are also formed, with companies based in other centres of biotech (predominantly USA) to develop, manufacture, and market life-science tools and integrated analysis systems. Such alliances may be part of financing and investment processes, and may include a commercialization agreement and equity investment. Under the terms of the commercialization agreement, the US firm will exclusively market, sell, distribute, and service products developed by the Oxfordshire-based company on a worldwide basis, and companies share profits generated from sales.

Firms may have a number of working arrangements with a range of life science companies and service providers worldwide, including clinical and contract research organisations, product development and manufacture, molecular diagnostics and research products, and pharmaceutical manufacturing. Expansion from the base in Oxfordshire may also involve developing joint ventures in other countries and regions and may include the acquisition of

worldwide development and commercialization rights, e.g. for therapeutic treatments, in licensing agreements with other research-led pharmaceutical companies.

Key findings:

- Given that spin out and other start up companies are science based, internal channels for knowledge creation is largely through the R&D department of the firms, which can constitute the major part of smaller firms.
- Production and process knowledge is also gained through internal channels, and these may include internal corporate channels in the case of larger firms and firms that have been acquired by larger biotech and pharmaceutical companies.
- Local channels for knowledge exchange with other companies can be limited by competitive motivations.
- Firms have well-defined collaboration targets that may be global as well as local and need to use general local networks sparingly.

F.5. Territorial elements supporting knowledge and innovation creation

Notwithstanding their global-facing nature, bio-tech firms are also found to cluster in specific regions. The reason for location choice is given primarily on the basis of proximity and access to University research. Other influences on location choice include the presence of specific service expertise; legal, financial, specialist property, and other business related services; the presence of skilled workforce, including technical skills; and regional development agencies and their financial support (see for example Table F.6, and also Smith, 2004; Smith and Bagchi-Sen, 2010). Biotech firms may be said to cluster for research but innovate with distant collaborators (Cooke et al, 2007).

Table F.6: Ordering of proximity factors for UK genomics firms

Proximity Factor	Position
University research	1
Qualified workforce	2
Business environment	3
Genomics services	4
Regional agency/ grants and Other public research	5
Collaborators/ competitors	6
Suppliers	7
Technology transfer	8
Private research and customers	9

Source: Biotechnology Collective Learning Survey in Cooke et al, 2007 (Sample size: 156 firms)

The presence of a highly skilled workforce is an important consideration for firms. The link with Oxford University is considered very useful for many firms but staff recruitment is not restricted to the local area or to local HE institutions. Firms in the Oxford area are also able to draw on a wide spread region beyond Oxfordshire that may include the whole of south East England, and Cambridge in particular. London and Cambridge, themselves have strong local clusters of biotech companies, but given that distances are relatively short, firms in Oxfordshire are able to take advantage of the skills built up in this wider area. Even so the local cluster of companies employing staff with similar skill sets is a strong draw for companies and a strong reason to establish and remain in the area.

The development of the biotech cluster has also produced long standing institutional support for the sector and includes a number of different organisations. Interactions between public and private sectors involving academic institutions have focussed in particular on supporting small and start-up companies. Much of the engagement by Oxford University with industry is through its wholly owned company Isis Innovation Limited that was established in 1988. Isis Innovation aims to help university researchers to commercialise intellectual property arising from research, to support patenting and technology licensing, and to help companies spin out of the university. Since 1997 it has assisted in the formation of some 70 University spin-out companies, with five of these listed on London's AIM stock market in 2011. Isis Innovation also manages a consulting subsidiary (Oxford University Consulting), which helps researchers to engage in consultation opportunities and facilitates interaction between firms and the

university's research base. It also manages Isis Enterprise, which is itself a consulting venture that manages technology transfer to recipients in both public and private sectors, and Isis Angels Network which introduces private investors and venture capitalists to spin out companies from the university.

A number of other networking and support organisations have been established over the same period. A major example is Oxford Innovation, founded[76] in 1987 to provide services to innovative start-up companies, and to government bodies that promote enterprise. The company is a spin-off from The Oxford Trust, which is an independent charitable foundation that works to encourage public engagement, study and application of science and technology in addition to encouraging growth through innovation and technology transfer. The Trust has developed a number of projects and played a leading role in developing innovation centres and incubation facilities for high-tech companies and venture angel networks (such as Oxford Innovation) that are now being delivered and developed by other organisations. It has, for example, been involved in the development of the 'Venturefest' event, which is a day-long networking event at which entrepreneurs present ideas to potential investors.

Oxford Innovation[77] has expanded operations to manage innovation and business centres across the UK. One such innovation centre that focuses on the biotech sector is the DiagnOx that provides a range of services to start up companies from technology audits to laboratory facilities, and advice about IP, seed and developmental funding, partnering and specialist services. It was set up initially with public money via the UK government's Department for Trade and Industry (DTI) Biotechnology Exploitation Platform (BEP) Challenge in 1995. A network of interested organisations from across the sector has been set up to support its activities, including the British In Vitro Diagnostics Association (BIVDA); The Diagnostics Club; Universities and NHS Trusts (IP generators); and major international diagnostic companies and smaller companies. Another part of Oxford Innovation, namely Innovation Services, supports high growth and start up companies to access finance including funds provided through three investment networks also organised under Oxford Innovation namely the Oxford Investment Opportunity Network (OION), the Thames Valley Investment Network (TVIN), and Oxford Early Investments (OEI), which collectively have helped raise £19.5m for over 90 local companies since 2006.

These investment networks target different sized companies and investment opportunities. OION operates on the basis of investments between £200,000 and £2m and for between 10 and 15 companies per annum and has been in operation since 1995. More recently established in 2004 OEI focuses on companies at the very early stages of technical and commercial development. It provides capital support of between £20,000 and £150,000 to develop products beyond an initial 'proof of concept' and makes use of links between universities, research institutes, large companies and individual entrepreneurs.

The Oxford Trust also established the Oxfordshire BiotechNet in 1997, which was supported by the DTI and SEEDA. This organisation was designed to provide expert help at the incubation stage of start up companies, many of which have since relocated to the Milton Park Innovation campus at Abingdon. Oxfordshire BiotechNet has since been replaced by the Oxfordshire Biotechnology Network (OBN), which was established as a not-for-profit business network providing support for *biotech* and *medical technology* companies in Oxfordshire and elsewhere in the UK. OBN delivers group purchasing services, advice and information dissemination to and on behalf of its members. It runs a major partnering event through its investment conference named BioTrinity, which attracts upward of 700 delegates from across Europe and elsewhere. A regular networking event, which attracts between 70 and 130 delegates is organised as the BioTuesdays series in London and Reading as well as in Oxfordshire.

[76] Oxford Innovation, founded by Sir Martin Wood, co-founder of Oxford Instruments plc, is an example of it the entrepreneurial interaction that has been developed between academia and industry in the region.
[77] Oxford Innovation is now part of the SQW Group of economic development research and consultancy companies.

Key findings:

- Firms locate in the region because of the positive effects that clustering provides in terms of available skill levels, research culture, and collaboration.
- The Biotech cluster has benefited from a long term build up of institutional support from industry, university and public sector bodies.
- A dedicated networking organisation ensures constant opportunity for maintaining contacts throughout the sector and helps to link companies with sources of finance.

F.6. Local innovation policy assessment and governance

Local public sector responsibility for economic development in Oxfordshire resides with Oxfordshire County Council and the City Council. The County Council has developed local structure plans that set out its strategy for development and encouraging the efficient use of land and other natural resources. Such structure plans are modified in response to wider regional strategies for the South East of England. There has been a long standing policy approach taken by local and regional policies to promote developments that build on Oxford's strengths (such as the Bio-Science sector). However, the regional public sector structure is currently undergoing a process of change following the abolishment of Regional Development Agencies (RDA)[78]. Established in 1999, the relevant RDA for Oxfordshire was the South East of England Development Agency (SEEDA), which led the development and implementation of the Regional Economic Strategy (RES). It is being wound up in March 2012 and the South east regional plan will be lost.

Some of the functions of the RDAs are to be taken on by what are termed Local Enterprise Partnerships (LEP) established by the UK government in 2011. The Oxfordshire LEP is a voluntary body made up of representatives from business, academia and the wider public sector. The Partnership's overarching aim is to facilitate economic and commercial development through innovation and growth, and this aim has been bolstered by the award of an Enterprise Zone status to the Science Vale area of southern Oxfordshire. The Enterprise Zone is forecast to add 8,400 high-tech jobs and to generate additional a substantial income up to the local economy. Other local business networks include the Federation of Small Businesses and the Oxfordshire Chambers' Network, which allow access for their members to local, regional, national and international events.

The LEP represents the most recent manifestation of a locally based structure for co-operation between actors in the private and public sectors, but the county and city councils have generally been active in co-operating with a number of business organisations and networks to support high-tech companies, including those in the biotech sector. The County Council and all the District Councils in Oxfordshire have worked together to contribute to the SPIP (Spatial Planning and Infrastructure Partnership) to ensure that all public sector organisations are working together to support the infrastructure requirements of key industrial sectors (e.g. in extending super-fast broadband networks). The Local Authority bodies have also participated with others in developing a ten year economic development strategy for the county in 2006 through the Oxfordshire Economic Partnership (OEP, 2006). The OEP, formed in 1998, is a network of business support organisations, local authorities, academic institutions and Oxfordshire-based businesses. Its objective was to motivate private, public and social enterprise partners to align their activities towards achieving shared economic goals. The strategy took into account other strategies and development plans produced by local authorities (e.g. the SEEDA's RES, and the Local Area Agreement) to encourage enterprise, and to develop skills and physical infrastructure. The OEP has since evolved into Oxfordshire Business First (OBF), and structured as a not-for-profit company.

[78] RDA's only applies in England as opposed to the whole of the UK since the devolved administrations in Wales, Scotland and Northern Ireland are responsible for their own provision in this area.

Local authorities contribute most directly to encouraging economic development through control over land, premises and spatial planning policy. The most relevant assets to the bio-tech sector are the science parks referred to above, and the Oxford Core Strategy supports the creation of a new strategic employment site on council owned land while encouraging the Universities and Hospitals to develop research uses on their own land holdings. The local authorities planning control is also relevant to the level of housing costs in the region, which are above national averages, and which adds to the costs of living (and therefore of employing staff) in the region. Oxford City Council is also active in promotional activity and regularly organises a two day event known as 'Venturefest'[79] which provides a showroom for firms seeking capital for new projects. UK central government support for the biotech sector is centralised and financial resources are provided via research councils and medical charities, and the Technology Strategy Board, whilst Regulatory Bodies and regulatory rules set important framework conditions and strong regulation that guide the development of the sector.

Although many of the firms include in the case study have benefitted from start up grants, interaction with government support programmes is more limited once they become established ventures. To a large extent these firms outgrow the need for support, and becoming large enough to ensure their own development. Government grant support often appears less attractive since it can also carry obligations that may constrain the firm and the overhead burdens (in terms of administrative demands) of becoming involved with such programmes can be inhibiting. Receipt of grant money, for example, often entails recording and detailing work procedures and processes, but more importantly also often demand disclosures of sensitive information that firms often prefer to keep confidential. Training support can also fail to match firm needs, often because of the slowness of formal channels of support. One of the respondent firms commented that if the firm identified an area for which more staff support or training was required it was often more worthwhile for the firm to respond internally and to address the requirement as it arose rather than to try to access government support programmes, which normally took time. Given the speed of change and competitive nature of the sector a worthwhile initiative had to be addressed as soon as possible, and government programmes were not designed to work or react quickly.

Finally, while the universities in Oxford and elsewhere provide the major source of graduate level staff for the biotech companies in the region, educational provision at a less advanced level is also of importance to companies. A new 'Skills Board' is being set up in Oxfordshire to take forward the skills agenda, and will include partners such as the City and County Councils, Further Education college, schools and other training providers, together with government organisations such as the jobs agency Job Centre Plus.

Key findings:

- Local government actors have been active in encouraging the bio-tech sector in the region for a number of years and identify it as one of the strengths of the region.
- Local government support is manifested in planning decision to release land for development of science parks and other high growth sectors, infrastructure, and skill development.
- Regional strategies have been curtailed with change of emphasis at UK government level.
- A new business led partnership has been established to encourage entrepreneurial businesses (LEP and Enterprise Zones)
- Government grants are not always relevant or useful to high growth biotech companies, which may quickly outgrow the need for support.
- The biotech sector is competitive and fast moving, and government programmes often cannot respond sufficiently swiftly.

[79] This is organised together with The Oxford Trust.

F.7. Conclusions

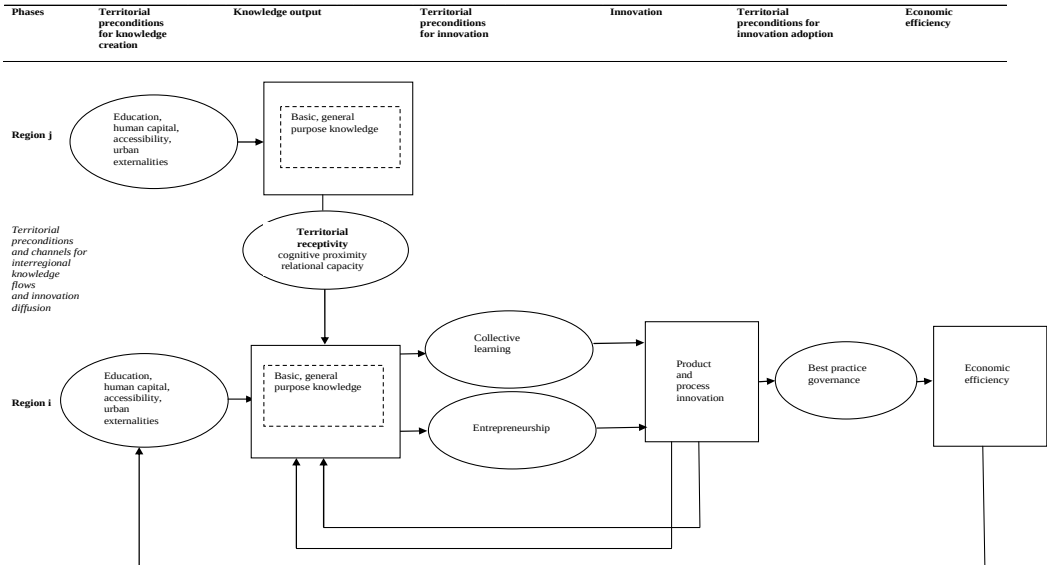
Activity in the biotech sector in the Oxfordshire region is based on a long standing and high quality scientific base in the region, which is represented most strongly by Oxford University, but the region is also home to a number of public sector research institutions and hospitals that engage in basic and applied research activity. In addition to research activity directly relevant to the biotech sector, the region has strong basic research capacity in a number of other scientific sectors that contributes to a local familiarity with the institutions and opportunities related to a high-tech culture. A milieu of leading edge research and entrepreneurship has been created that is supported by the range of institutions that have developed over an extended period of time, as well as by a high performing educational system in the region. Firms in the region also have links to those in other regions (both within the UK and globally) that are home to strong research-led biotech sectors.

In terms of interaction and collaboration the extent of activity varies between firms, but in all cases an important consideration for their location is the local availability of expertise that has been built up in an extended area. This expertise is manifested in terms of research teams in universities and other research institutions, in advanced training related to leading research, and in terms of the rich source of qualified staff that is available to the local labour market. The region also has strong networking structures available to firms, which includes collaboration between firms, university research institutes, medical research laboratories, and clinical application research in local hospitals. However, for many firms, interaction with local universities can be indirect, and more important collaborative relationships are found with entities in other regions across the world. For some of these firms local networking activity is often restricted to general contact rather than to specific knowledge exchange.

The presence of well established industry and sector bodies that support local networking in the region provide opportunity for intensive interaction between the sector and different levels of government, and with government agencies. While the scope of local government is largely restricted to general infrastructure development and in regulating local land availability, these powers can be important in providing support to the sector. At the national level, changes in policy has re-emphasised the local rather than the regional scale and is aimed at encouraging more local partnership working (through the LEP) to develop. National support for the sector is also of a relatively diffused nature, and specific sector support is manifested most clearly in research grant awards and general infrastructure measures rather than in specific sectoral programmes of support.

In general, the biotechnology sector case study for the Oxfordshire area in the UK conforms to the endogenous territorial innovation pattern that is outlined in the KIT project (also labelled in Chapter2 , Volume 1 of the Scientific report as Pattern 1; see Figure F.1). The region has the territorial preconditions necessary for knowledge creation in the biotechnology sector and contributes to basic general purpose knowledge within the sector. The sector displays strong levels of entrepreneurial activity in this region as the rate of new firm formation indicates. New product and process innovation is apparent by the establishment and development of new firms, but the region is also of interest to established large pharmaceutical companies, some of which have located sites for their own R&D activity, engaged in joint ventures, and have been active in acquiring locally formed dedicated biotechnology firms (DBFs), many of which remain as the local R&D sites of the new parent firms. Governance structures, both internal to the sector and in relation to local and national government are generally conducive to further development and to expansion of the sector in the region.

Figure F.1. An endogenous innovation pattern



Source: KIT final report

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