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1. Executive summary

This paper explores the relationships between institutions, regional innovation systems and global innovation networks. The review of the literature suggests that institutionally thick regions are more prone to be involved in global innovation networks.

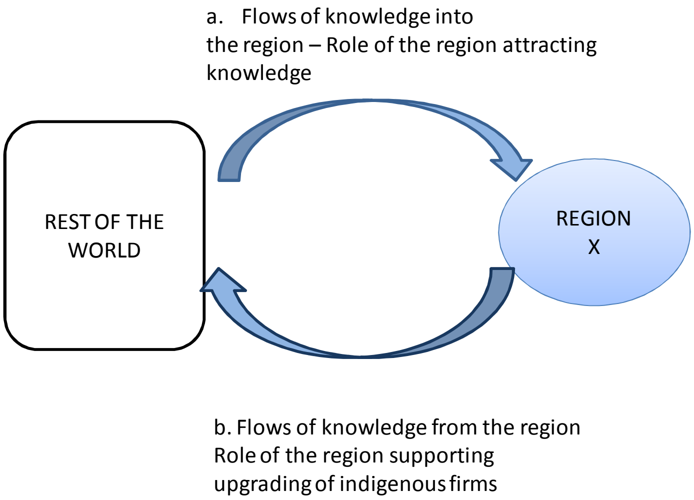
Contrary to what we expected, GINs may emerge in regions which are neither institutionally too thick (like Tier 1) or too thin (like Tier 3). Firms that are located in institutional thick regions, tend to network with other firms and organizations that are in close proximity or with domestic actors. Intra-firm networks are also more common than extra-firm. Transactions take place more often between different units of the same organization rather than with external firms or knowledge providers, also pointing out to the transaction costs associated with engaging in networks with other organizations, independently of their geography.

What the results seem to suggest in line with Barnard and Chaminade (in this same special issue) is that engaging in global innovation networks is costly and hard to maintain and only when the firm cannot find the resources they need to innovate in their close proximity or when they need larger markets, they will engage in different forms of GINs. But even when the need exists (like in Tier 3) firms may not have the capabilities to engage in GINs. Tier 2 firms are in general medium or large firms, with a high proportion of subsidiaries. They have the need but also the possibility to engage in global innovation networks. Firms located in Tier 1, may have the possibility, in terms of capabilities, but they may not have the need as they are able to source technology from within their internal network or externally network for innovation at local or domestic level. Firms located in Tier 3 regions, may have the need, but not the possibility. Most of the firms are of smaller size and stand-alone firms.

Firms located in Tier 3 regions are probably the ones with more need from support from the Government. They need to be involved in GINs to access the resources that are lacking in their innovation systems but they do not have the capabilities to do so. Supporting the acquisition of innovative capabilities, the access to international clients, suppliers and machinery may be fundamental to upgrade.

2. Background

The objective of WP4 is 1) on one hand to understand the role of certain regions in GIN from low cost producers to innovation hubs and 2) to understand in these regions the regional institutional frameworks in fostering (or not) the accumulation of capabilities at regional level.



In order to understand the role of the regions supporting the emergence and development of GINs we adopted a Regional Innovation System perspective. An innovation system is generally defined as ''all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring'' (Lundvall 1992: 12). A RIS is consequently defined as the "institutional infrastructure supporting innovation within the production structure of a region" (Asheim and Gertler, 2004: 299). To analyze a system of innovation one often looks at the components of the system, that is: organizations, their relationships and the institutional framework.

This report draws on three main inputs of the project: desk research, the survey and a selection of cases.

1. Desk research: Some of the information on the regional innovation system is already available in existing publications like the number and type of universities and research centers available in the region, regional policy, etc.
2. Survey: There were two questions in the survey directly related to this work package. These two questions were elaborated with the participation of all partners in this WP.
3. Cases: The information collected in the survey will only provide a snap shot of the importance of local endowments for the emergence and development of GINs. The objective of the cases is to answer the questions of why are the phenomena identified in the survey occurring and to provide insights in the dynamics of networks. The cases are the regions although the unit of analysis are the firms located in the region and other organizations.

This deliverable was conceived as a research paper. The paper is going to be structured as follows. First, section 1 introduces the relationship between regions and global innovation networks. Section 2 presents the main concepts used in the paper, like regional innovation systems, institutional thickness and globalization of innovation. Next, the methodology used for the paper is presented. Section 4 is devoted to the empirical evidence on the relationship between regions, institutional frameworks and global innovation networks. Section 5 concludes. We have included as Annexes to this research paper the intermediate reports prepared by the different teams involved in this WP, as they provide abundant data on the knowledge infrastructure of the different regions (Beijing, Bangalore, Cape Town and Gauteng) as well as interesting firm-based cases on the complex relationship between regional endowment and globalization of innovation activities.

3. Introduction

The access to global innovation networks (GINs) has been extremely unequal across regions around the globe. For certain countries, while the country as a whole may not be playing a role in GINs certain sub-national regions do, pointing out to the role of regional innovation systems and sub-national institutional frameworks in the emergence and development of GINs.

This paper explores the role of the region in the emergence and development of GINs in a selection of European (Norway, Sweden, Denmark, Germany and Estonia) and non-European countries (India, Brazil, China and South Africa).

The starting point of the paper is the literature on economic geography in general and regional innovation systems in particular (Cooke 1992; Asheim and Isaksen 1997; Cooke et al. 1997; Cooke 2001) which argue that even when economies have become much more globalized, most innovation activity is still concentrated in certain regions around the globe. Agglomeration economies can be explained, among other factors by the tacit nature of knowledge and its sticky character (Asheim and Isaksen, 2002). Tacit knowledge is more likely to be spread among firms and organizations that are located in the same geographical area. This, in turn may facilitate innovation as the success of regions like Third Italy, Baden-Wuttenberg in Germany or the Sillicon Valley has shown (Piore and Sabel 1984; Saxenian 1994; Staber 1996).

However, the rise of internet and the increase in the codification of knowledge may make face to face and inter-personal communication less necessary. Knowledge (codified) can be transferred across large geographical distances without the need of local interaction but it still requires a certain common understanding between the partners involved in the knowledge exchange for that knowledge to be useful for innovation. Relational proximity can link together actors that are geographically distant, thus enabling the transfer of knowledge even when geographical proximity is absent (Amin and Cohendet 2005; Gertler 2008).

While some authors predicted that the increased globalization of economic activities will put a threat to the regions, the reality has shown that globalization has come hand in hand with an increase in the role played by certain regions in the global economy (Amin and Thrift 1994; Amin and Thrift 1994; Amin and Thrift 1996; Chaminade and Vang 2008). Despite the opportunities opened by information and communication technologies for the transfer of (codified) knowledge, some regions remain power houses or knowledge hubs in global value chains and networks (Chaminade and Vang 2008). In other words, global processes are still "pinned down" in certain regions around the globe (Amin and Thrift 1994).

Hitherto, the literature is very limited when it comes to relating different types of regions with the geography of their knowledge linkages, particularly their international spread. We know very little about how regions influence the way in which firms participate in global innovation networks and even less about how different regional institutional frameworks may facilitate or hamper the access to global networks of innovation and knowledge. This paper deals with these questions.

Using firm-level data collected through a survey and case studies in 2009-2010, this article systematically compares the patterns of globalization of innovation in regions with different institutional thickness. The paper shows that these patterns differ substantially across regions and discusses relationship between regions, institutional frameworks and different forms of globalization of innovation.

More specifically, the paper addresses the following questions:

1. Do we observe different patterns of globalization of innovation activities in different regions?
2. Do we observe different patterns of globalization of innovation of the same industry in different regions?
3. What is the role of the institutional frameworks explaining the observed differences?

4. Main theoretical framework

4.1 Globalization of innovation

There is a general consensus among scholars that the internationalization of production and innovation activities is not a new phenomenon. But the globalization of production and innovation is something new. Globalization implies not only the geographical spread of economic activities across the globe but also a high degree of functional (des)integration (Dickens, 2007). Multinational firms may locate different functions of the organization in geographically distant places to exploit ownership, location or internationalization advantages (Dunning 2001***)***. It is only recently, that scholars in the international business literature as well as innovation studies have started to pay attention to the globalization of innovation activities (Zanfei 2000; Le Bas and Sierra 2002; Cantwell and Piscitello 2005; Cantwell and Piscitello 2007; Dunning and Lundan 2009).

Already back in the mid-nineties, Archibugi and Michie (1995) proposed to distinguish between three forms of globalization of innovation: the global exploitation of innovation, the global research collaboration and global generation of innovation. The **global exploitation of innovations** refers to the international commercialization of new products or services and has its economic equivalent in the export of new products or services or in the international licensing of patents. The **global research collaboration** alludes to the joint development of know-how or innovations with the participation of partners from more than one country. This collaboration can take a variety of forms, including R&D joint-ventures, R&D alliances, contractual R&D, etc. and can involve a variety of actors, including firms, research centres, universities or the government, among others. Finally, the **global generation of innovations** refers mainly to the location of R&D activities in a different country and it is associated with R&D related foreign direct investment.

In the context of developing countries, there is a forth category of globalization of innovation worth considering (Plechero and Chaminade 2010): **the global sourcing of technology (and innovation)**. More often than not, firms in developing countries depend on technology acquired from the developed world. Their innovation capacity is often limited and they rely more on the acquisition of technology and its adaptation to the local context than on the development of new technology.

As recent evidence is starting to show, different regions are specialized in different forms of globalization of innovation (Plechero and Chaminade, 2010). For example, firms located in the Pune region in India are more specialized in the three types of globalization of innovation and in particular in the exploitation of innovation more than firms located in Beijing (Plechero and Chaminade, 2010). However, the existing evidence is limited in terms of the number of regions considered in the analysis as well as in providing some useful explanation of why this is so. A deeper look into the innovation systems of those particular regions may provide some insights to why different regions get involved in different forms of globalization of innovation.

4.2 Regional innovation systems and institutional thickness

It is generally accepted that innovation is socially embedded and that it is the result of continuous interactions and exchange of knowledge between organizations (Kline and Rosenberg 1986; Freeman 1987; Lundvall 1992). For long, economic geographers have argued that due to the tacit nature of knowledge those interactions often take place at local level, that is, between organizations that are geographically close (Cooke 1995; Storper and Venables 2004; Asheim and Gertler 2005; Boschma 2005). Thus, geographical proximity may facilitate interactive learning and innovation through the exchange of both tacit and explicit knowledge among the individuals and organizations located in that particular region.

A regional innovation systems (RIS) can be defined as the "institutional infrastructure supporting innovation within the production structure of a region" (Asheim and Gertler, 2004:299). Universities, technological centers and organizations providing funding for technological projects would be, among others, part of the institutional infrastructure while firms will be the main actors in the production structure.

Despite the fact that institutions are at the heart of the very definition of regional innovation systems, there are very few authors that have dealt explicitly with the role of institutions in regional innovation systems (Doloreux and Parto 2005). Among the exceptions are the works of (Amin and Thrift 1994; Amin and Thrift 1996; Cooke et al. 1997; Asheim and Isaksen 2002; Morgan 2007; Gertler 2010; Tödtling et al. Forthcoming 2011). Innovation in general, and knowledge sharing in particular, is a social process that is shaped by soft and hard institutions like culture, habits, convention and routines but also by laws and regulations. Most of the institutions have a very strong regional character and this is particularly the case for soft institutions. The same industry, operating in the same national institutional framework may behave very differently in two sub-national regions, due to the different regional institutional frameworks in the two regions (Gertler, 2010).

The institutional "thickness" of a particular region is defined as a combination of different elements (Amin and Thrift, 1995): a strong organizational infrastructure, high levels of interaction, a culture of collective representation and shared norms and values which serve to constitute the social identity of a particular locality. Thick regional innovation systems tend to play a more significant role globally than thin RIS (Amin and Thrift 1996). Institutionally thin RIS are usually to be found in less urbanized regions and are characterized by the strong presence of SMEs with limited innovative capacity, lack of support organizations and low level of agglomeration as compared to thick regions. Institutionally thick regions, in comparison, are often located in metropolitan areas. Firms in this regions benefit from a dense network of support institutions, interactions take place often and in general, these regions show high levels of innovation

The institutional thickness of a particular region also influences the geography of the knowledge linkages, or in other words, how different regions engage in global, domestic or regional networks. In a study of ICT firms in Austria, Tödtling et al (Forthcoming, 2011) show that thin RIS, firms will tend to establish more international linkages while thick RIS will tend to establish more domestic. The extent to which this observed relationship between institutional thickness and internationalization of innovation holds for both developed and developing countries will be investigated in this paper.

5. Method

5.1 Sample

This paper is based on a firm-based survey conducted in 2009 across 9 countries: Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark, as well as case studies conducted in four emerging regions: Beijing, Bangalore, Cape Town and Gauteng.

For the survey, each country focused on just one industry: ICT, Automotive or Agro-processing. In all industry there was always at least one European and one non-European country to be able to perform North-South comparisons. Each institute conducting the survey across the nine countries chose a sector which was of economic importance within their national or regional context. In all sectors and across all countries 1215 responses were collected. The combined INGINEUS sample was dominated by ICT responses. This was in part due to the size of the Indian and Chinese market but also due to the nature of the agro processing and Auto industries which tend to be more concentrated (Barnard and Ismail

2010a). Table 1 below offers a summary of the results and number of responses received from each sector and each country.

Table 1: Survey results by country and industry

Countries	**ICT**	**Auto**	**Agro**
Brazil		69	
China	243		
Estonia	17		
Denmark			49
India	324		
Germany		53	
Norway	181		
South Africa			84
Sweden	171	24	
Total sector	**936**	**146**	**133**

More than half of the sample are standalone companies (681), about 250 are subsidiaries of a multinational company and only 133 are the headquarters of a Multinational. About 46 % of the firms have less than 50 employees, 30 % have between 50 and 250, and the rest are large companies with more than 250 employees. Only 100 companies have more than 1000 employees.

5.2 Survey and questions selected for analysis

The survey questionnaire consisted of 14 questions covering some background information on productive activities, firm size, market, sales information and R&D activity. Most of the questions were focusing on types of innovation, geographic network and collaborations with customers, suppliers, Universities, research institutions, government etc., offshoring and regional attractiveness and the institutional framework (mainly at national and international level).

This paper is based on the analysis of the four questions capturing the four forms of globalization of innovation:

- Global exploitation of innovation: As a proxy we asked the firm about their largest market, being the options internal to the enterprise, regional, domestic or export.
- Global collaboration for innovation: we use question on the geographical spread of innovation networks which asked the firm “regarding the development of the most important innovation of your firm in the last 3 years, who did you actively collaborate with and in which geographical location?”. The question provided different options as partners: clients, suppliers, competitors, consultancy companies, government and universities. Firms where asked to indicate if the partners with whom they collaborated where located in the region (sub-national), country or a list of other international

locations (North and South America, Western and Central & Eastern Europe, Africa, Japan and Australasia and Rest of Asia). In this paper I have collapsed all international interactions under one category called "International".

- Global sourcing: we use question 5 which asked the firm to indicate which is the most important source of technology for the enterprise. The firms were given 5 options: "we produce most technological inputs in house"; "we buy inputs from other branches of our own MNC", "we buy from MNCs not formally connected" ; "we buy from non MNC firms" or "we buy from universities and other public organizations".
- Global generation: as a proxy, we use questions number 9.1 in which firms were ask to indicate if they were off shoring production or innovation activities.

In order to assess the relationship between different forms of globalization of innovation (and thus innovation networks) and regions, all the cases in the sample were codified as belonging to a region considered as Tier 1, Tier 2 or Tier 3. To define the three Tiers, quantitative information was used to capture the strength of organizational infrastructure and qualitative for the other 3 elements of institutional thickness (levels of interaction, culture of collective representation and shared norms and values). In the project, each country collected data about one particular industry. Statistics broken down at the level of industry and region are scarce or even not available at all for developing countries. Information on the number of firms for the specific industry in a particular region, number of employees and, in some cases[1], the volume of exports was collected if that information was available in the country[2]. The available information is included on page 26-27. Information on the availability of specialized universities, research centers and intermediate organizations in the region was also collected, when available[3]. This information was used as a proxy for organizational infrastructure and it is the only pseudo-quantifiable indicator. Consultation with country experts in the project as well as review of the literature on clusters in those specific industries for each country was used to acquire information on levels of interaction, culture of collective representation and shared norms and values (qualitative).

Basically, regions with the highest concentration of firms and employment in that particular industry in that country, with frequent interactions and a strong identity in that particular industry were considered as Tier 1. Regions with an average or above the average number of firms and employment in the industry and some specialized supporting institutions and with less strong interactions, culture and shared norms were classified as Tier 2. Those regions that have no specialization in that particular industry were classified as Tier 3. The final classification of the regions in Tiers was checked once again with industry experts in the country.

Tier 1 regions can be considered as thick regional innovation systems, usually located in metropolitan areas and that show a strong specialization in that particular industry. For example, Stockholm in Sweden and Bangalore in India are considered to be the most

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[1] For example in India, as most of the ICT firms

[2] Most of the countries did not have information broken down to both region and industry. Information on the number of employees and number of firms per region was available for Brazil, Germany, Norway and Sweden. Information on the volume of exports on ICT per state was available for India.

[3] In most cases, when information is available it does not refer to a particular industry.

important clusters in the ICT industry, while Baden- Württemberg (Germany) or Sao Paulo (Brazil) are the equivalent for the automotive industry. They are not only considered to be the strongest hub in the country but they are also strong regions globally, for that particular industry.

On the other side of the spectrum, Tier 3 regions are usually institutionally thin regional innovation systems for the particular industry considered. The number of firms specialized in that particular industry is low and there are not so many specialized support organizations. Kwa-Zulu Natal in South Africa or Hasrstad in Norway are examples of Tier 3 regions.

In the middle, we are considering another category, Tier 2 regions. These are usually secondary regions in the country, in which there is a significant number of firms specialized in that industry, there is also presence of support institutions but that are yet not so well networked, not attracting so many multinationals and in general, do not show the same institutional thickness than those regions considered Tier 1.

Table 2 below summarizes what is considered to be Tier 1, 2 or 3 in each industry and country.

Table 2. Distribution of cases by Tiers

Country	Industry	Tier 1	Tier 2 (example)	Tier 3
Brazil	Automotive	Sao Paulo	Minas Gerais	Porto Alegre[4]
China	ICT	Beijing	Shenzhen	Shanghai
Denmark	Agro-process	Århus, Glostrup, Græsted, Greve, Ishøj København,	Ansager, Bjerringbro, Gråsten, Kjellerup Kolding Ejby, Faxe, Lynge,bRingsted, Slagelse, Sorø and Viby Sj	no
Estonia	ICT	Tallin	Tartu	no
Germany	Automotive	Baden-Württemberg Bayern	NRW, Rheinland Pfalz, Thüringen,	Hessen, Saarland
India	ICT	Bangalore	New Delhi (incl. Noida, Gurgaon) Mumbai Chennai, Hyderabad Pune	Cochin, Trivandrum Chandigarh
Norway	ICT	Oslo, Trollåsen Lisaker, Bergen, Stavanger, Fornebu	Moi, Trondheim, Brumunddal, Sunndalsøra,	Hasrstad

[4] Only one case.

South Africa	Agro-process	Gauteng	Western Cape	Eastern Cape, Free State, Kwa-Zulu Natal Limpopo, Mpumalanga, North West, Northern Cape
Sweden	ICT, Auto	Stockholm, Kista and Solna (ICT) Gothenborg (Auto)	Malmö, Gothenborg (ICT) Trollhättan, Södertälje (Auto)	Jönkoping, Helsinborg (ICT) Rest (Auto)

As a result 419 firms were classified as Tier 1, 430 as Tier 2 and 198 as Tier 3. The sample is also quite well distributed by industries. ICT has 308 firms located in Tier 1, 377 in Tier 2 and 156 in Tier 3; Agro-processing has 32 firms in Tier 1, 64 in Tier 2 and 20 in Tier 3; finally automotive has 44 in Tier 1, 72 in Tier 2 and 31 in Tier 3.
Table 3 next summarizes the distribution by type of firm and size of firm. As can be observed, Tier 1 has more headquarters of multinationals but it is also a region that is dominated by SMEs. Tier 2, in comparison, has the highest proportion of largest companies as well as the higher number of subsidiaries of MNCs. Tier 3, finally, is dominated by standalone companies and also SMEs.

Table 3: Type of firm and size by Tier

	Region Cluster Tier			**Total**
	First Tier	**Second Tier**	**Third Tier**	
A standalone company	269	270	142	681
A subsidiary of a MNC	74	122	47	243
The headquarters of a MNC	65	61	8	134
Fewer than 10 FTE employees	49	37	42	128
10 to 49 employees	160	114	84	358
50 to 249 employees	113	138	43	294
250 to 999 employees	63	86	18	167
1000 or more employees	34	55	11	100

6. The role of regions in global innovation networks

From the literature review we may expect that firms located in strong innovative regions will innovate more and collaborate more often with domestic and local actors than those located in more marginal regions, as a consequence, they will be more innovative and regionally networked, thus facilitating the emergence of innovation networks. For example, we would expect ICT firms located in Kista (a knowledge hub for the ICT industry in Sweden) to collaborate more with other actors in Kista than, for example, an ICT firm located in Umeå (a remote region in North of Sweden). Similarly, we would expect firms located in Bangalore to interact more at regional and domestic level than firms located in Maharashtra, just simply because there are more knowledge-intensive firms located in that specific region.

6.1 Regions and the global exploitation of innovations

The first analysis is to look at the relationship between different regions and the exploitation of innovations. We use the information on the most important market as a proxy, as the question was not asking specifically about market for new products or services. Table 4 shows the proportion of firms targeting the different markets per type of region. The results are significant at 1%. The largest proportions of firms that target international markets are to be found in Tier 2 regions (52,3 per cent of all the firms that export) followed by Tier 1. Firms in Tier 1 tend to commercialize their products mainly in the domestic market.

Table 4: Regions and global exploitation of innovations

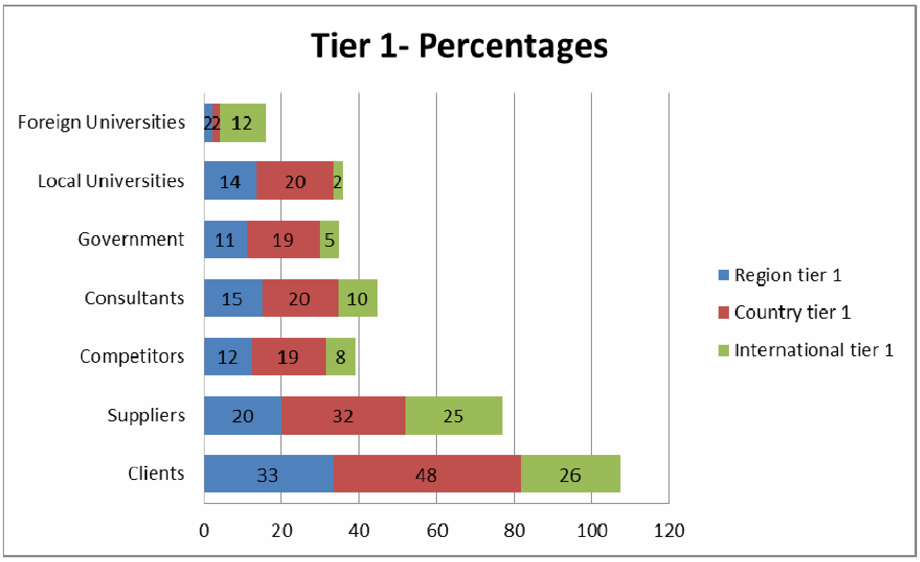
4.1 In geographical terms, is your enterprise's largest market?			**Internal to your enterprise**	**A regional market (local region in your country)**	**Domestic market (rest of your country)**	**An export market**	**Total**
Region Cluster Tier	First Tier	Count	4	72	247	89	412
		% within Region Cluster Tier	1,0%	17,5%	60,0%	21,6%	100,0%
		% total in that market	22,2%	34,8%	48,0%	27,5%	38,7%
	Second Tier	Count	11	85	182	176	454
		% within Region Cluster Tier	2,4%	18,7%	40,1%	38,8%	100,0%
		% total in that market	61,1%	41,1%	35,3%	54,3%	42,7%
	Third Tier	Count	3	50	86	59	198
		% within Region Cluster Tier	1,5%	25,3%	43,4%	29,8%	100,0%
		% total in that market	16,7%	24,2%	16,7%	18,2%	18,6%
Total		Count	18	207	515	324	1064
		% within Region Cluster Tier	1,7%	19,5%	48,4%	30,5%	100,0%
		% total in that market	100,0%	100,0%	100,0%	100,0%	100,0%

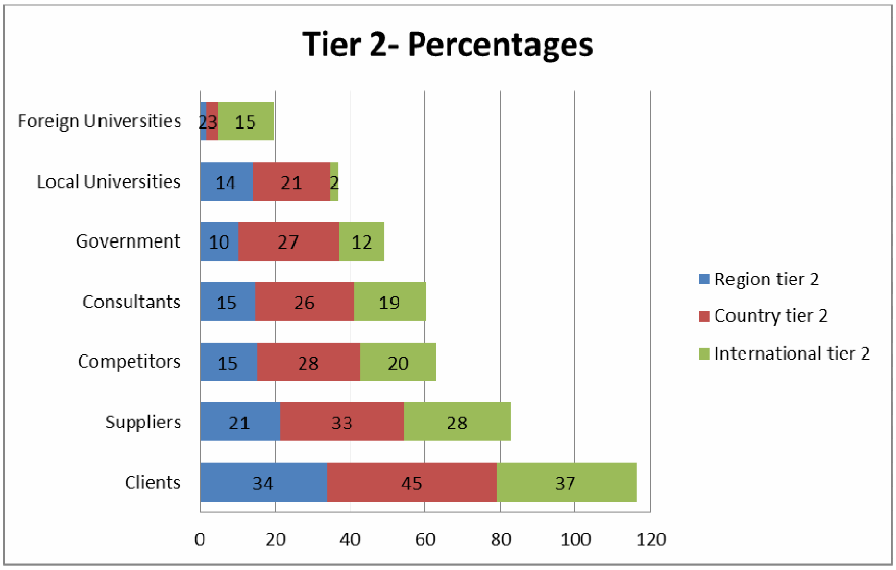
Chi2: 46,891, significant at a 1%.

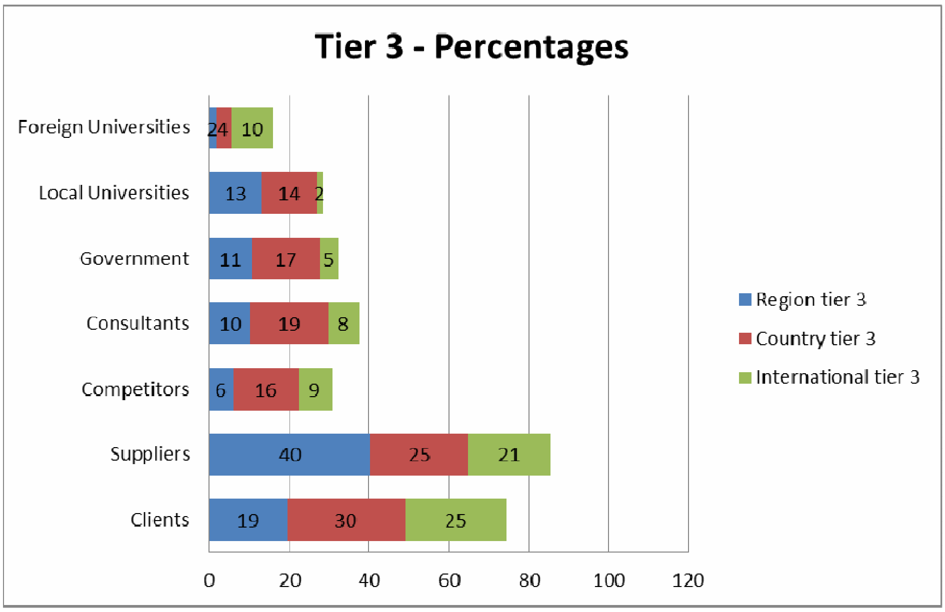
6.2 Regions and the global collaboration for innovation

To investigate if firms in stronger regions collaborate more at regional level, we calculate the percentage of firms, in that particular region, that collaborate with each of the potential partners for innovation. The results are plotted next, one graph per region.

Graph 1: Collaboration for innovation







Contrary to what we would have expected, it is firms located in Tier 2 regions tend, in general to collaborate more with partners not only at regional level, but also at international levels. They are more networked than firms in Tier 1. The only exception is the collaboration with regional suppliers in Tier 3 regions, which is higher than in Tier 1 and 2.
So, while Tier 1 regions tend to concentrate a larger number of innovative firms, they are less prone to participate in international networks. It is firms in Tier 2 that collaborate with a larger variety of international networks. Although a deeper analysis of the data is needed, preferably in a more quantitative way, the descriptive analysis suggests that it is firms in Tier 2 regions that are more internationally networked, that is, they participate more often in global innovation networks.

6.3 Regions and the global sourcing of technology

There is a significant relationship between the type of region and the global sourcing of technology. In terms of sourcing of technology, the majority of firms in all three tiers produce their own technological inputs in house. However, in Tier 1 we find the higher concentration of firms that acquire their inputs from other branches of their own MNC. This is coherent with the fact that it is in this Tier 1 that we find more headquarters of MNCs.
In Tier 2 we find the higher proportion of firms that acquire the inputs from non-multinational firms or from MNCs that are not formally connected to the firm. This reflects the external character of the networks of firms in Tier 2, as compared to the more internal character of the networks in Tier 1.

Table 5. Regions and global sourcing of technology

5. Which is the most important source of technology for your enterprise (including hardware, software and knowledge)?			We produce most technological inputs in-house	We buy most of our inputs from other branches of our own MNC	We buy most of our technological inputs from non-MNC firms	We buy most of our inputs from MNCs with which we are not formally connected	We buy most of our inputs from public-sector organizations, e.g. research institutes, universities etc	Total
Region Cluster Tier	First Tier	Count	258	48	30	60	8	404
		% within Region Cluster Tier	63,90%	11,90%	7,40%	14,90%	2,00%	100,00%
		% over total number in that source	42,20%	44,90%	24,60%	39,00%	34,80%	39,70%
	Second Tier	Count	241	34	69	80	11	435
		% within Region Cluster Tier	55,40%	7,80%	15,90%	18,40%	2,50%	100,00%
		% over total number in that source	39,40%	31,80%	56,60%	51,90%	47,80%	42,80%
	Third Tier	Count	112	25	23	14	4	178
		% within Region Cluster Tier	62,90%	14,00%	12,90%	7,90%	2,20%	100,00%
		% over total number in that source	18,30%	23,40%	18,90%	9,10%	17,40%	17,50%
Total		Count	611	107	122	154	23	1017
		% within Region Cluster Tier	60,10%	10,50%	12,00%	15,10%	2,30%	100,00%
		% over total number in that source	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Chi2: 30,761 significant at 1%

6.4 Regions and the global generation of technology

We take as a proxy for the global generation of technology the question on whether the firms has offshored production or innovation (we cannot distinguish which one). As can be observed in Table 6, Tier 2 hosts a higher proportion of firms offshoring production and innovation than Tier 1 and 3. The Chi2 tests are, however, not significant, pointing out to a weak relationship between different tiers and the globalization of production and innovation.

Table 6: Regions and global generation of technology .

9.1 Regarding internationalisation, does your firm offshore (or has your firm offshored) production or any R&D activities?			No	Yes	Total
Region Cluster Tier	First Tier	Count	283	114	397
		% within Region Cluster Tier	71,3%	28,7%	100,0%
		% within firms offshoring	39,4%	37,6%	38,8%
	Second Tier	Count	290	141	431
		% within Region Cluster Tier	67,3%	32,7%	100,0%
		% within firms offshoring	40,3%	46,5%	42,2%
	Third Tier	Count	146	48	194

	% within Region Cluster Tier	75,3%	24,7%	100,0%
	% within firms offshoring	20,3%	15,8%	19,0%
Total	Count	719	303	1022
	% within Region Cluster Tier	70,4%	29,6%	100,0%
	% within firms offshoring	100,0%	100,0%	100,0%

Chi2: 4,347, not significant

6.5 Illustrative cases[5]

Tier 1 – Beijing

Beijing is considered to be a Tier 1 region in China, both in general but also with regards to the ICT industry. Beijing regional innovation system is composed both by a large number of multinational companies as well as a dense network of small and medium size enterprises (90% of the firms in Beijing are small). In terms of MNCs, Beijing has become the second largest cluster with headquarters of MNCs in the Fortune Top 500. At the end of 2007, there were approximately 280 R&D labs of MNCs located in Beijing (Lv and Liu, 2011). In 2010, Beijing hosted around 20000 high tech enterprises. There are around 39 Universities located in Beijing, including some of the best in China and worldwide like Tsinghua University, Peking University or the Graduate University of the Chinese Academy of Management (CAS). The R&D personnel at higher education institutions (HEIs) is around 25000 full time equivalent. CAS is one of the most important actors in the regional innovation systems and some of the most important Chinese ICT enterprises, like Lenovo, were spin-offs from CAS. Beijing is responsible for almost a third of all R&D by R&D institutes in China. There are several high-tech parks in Beijing, concentrating a large amount of firms, being one of the most important ones the Zhongguancun Science Park. IBM China research laboratory, Microsoft R&D Center, Intel China Research Center, Motorola China R&D institute or Bell Labs research China are located in Zhongguancun Science Park (Lv and Liu, 2010:17). The Zhongguancun science Park collectively represents the firms located in the Park, which is another issue contributing to the thickness of the RIS. There are a number of Government promoted initiatives to increase the number of alliances between firms located in Beijing. Hitherto, initiatives like the software alliance, the IGRS (Intelligent Grouping and Resource Sharing) Industrial Alliance or the Zhongguancun Cloud Computing Industry Alliance have supported the establishment of more than 100 industrial alliances involving more than 5000 members (Lv and Liu, 2010).

In terms of networks, the analysis of the INGINEUS survey shows that although local interactions are important, most collaboration for innovation take place at domestic level and with clients. This is not surprising. The most important reason why MNC companies locate in Beijing is to access the domestic market, followed by accessing knowledge infrastructure.

[5] This section relies heavily on the intermediate reports produced by GUCAS, HSRC and IIITB for this work package. The full reports are included as annexes to this research paper.

They collaborate with the domestic clients in order to develop products that suit the domestic market. They also source domestically, to take advantage of the lower costs of production in China as well as the knowledge infrastructure. There is, of course, a strong international linkage between the subsidiaries and the headquarters of the firms, particularly for the sourcing of technology; about 75% of the firms in the survey indicated that they produce their technological inputs in-house (internal sourcing of technology). This is not the case for the exploitation of innovation. Only 1,7 % of the firms indicate that their main market is internal to the firm. 60% indicate that it is the domestic market. From this data, we can infer that MNCs locating in Beijing source technology internally, but sell their new products to the domestic market. In terms of collaboration of innovation, firms also collaborate mainly with domestic clients and domestic suppliers, although some collaboration at regional level also exists. Some of the Beijing-based firms have engaged in the global generation of technology. The survey indicates that as much as 10% of the firms have engaged in offshoring of R&D. For example, Lenovo has an R&D centre in USA and another in Japan (Lv and Liu, 2011)

Two cases can help illustrate the interactions of the firms with the regional innovation systems, one of a Chinese-based firm and another from a MNC located in Beijing. VOICE[6] is a high-tech company spin-off of a research institute of the Chinese Academy of Sciences. VOICE develops speech recognition engines and Audio Signal Processing Modules, which are sold in three ICT markets: telecom services; embedded services (MP3; MP4; learning machines); and speak control systems (e.g. interface to control telematic system in the cars). - The company is global leader for speech recognition technologies but it is mainly targeting the domestic market. The main partners for innovation are their customers- for example a Chinese mobile company that is a leader in the market as well as the Government. As a spin-off of the Chinese Academy of Sciences, they still keep very strong linkages with CAS. This partnership, provides them with access to a large pool of researchers as well as R&D funds. The sourcing of technology is internal to the company and the exploitation of innovation as well as the collaboration takes place at national level. One significant local interaction is with CAS, which supplies all the R&D resources needed to develop the innovation.

SOFTSERV, on the other hand, is a MNC company established in Beijing. They provide R&D services (where they develop, test and localize the product) and IT services (e.g. enterprise solutions that require more business domain knowledge than technical expertise). Although they started as an internationally oriented company, developing products for international clients (mainly US), currently they are shifting their focus to the domestic market. When the interview took place (2009) their objective was to increase the revenues from the Chinese Market to 50% (when it was 30%). In terms of collaboration for innovation, the company develops its open standard processes to share and to use as a base to construct later the services in collaboration with their customers. Therefore the 'innovation' is done also in cooperation with their clients, which are international, domestic and also local. Sourcing of technology is also done domestically, tapping on the expertise of the different branches around the country.

[6] The names of the two firms are finctional. The real name is kept confidential.

As the two examples illustrate, both firms are located in Beijing to serve the domestic market (SOFTSERV also the international market). They benefit from the pool of qualified human capital in Beijing, as well as some clients, but the bulk of their technological sourcing, exploitation of innovation and collaboration for innovation takes place at domestic level. The strong institutional framework supports innovation in the sense of providing human capital and proximity to competitors and some clients, but when the objective is the domestic market and the client is the main source of innovation (together with the internal employees), interactions take place domestically.

Tier 1- Bangalore

Bangalore is considered to be the most important ICT hub in India and, for many, also in the world. It is an interesting case as Bangalore firms, in contrast to Beijing firms, have traditionally been more oriented to the international market than to the domestic one. Bangalore can be considered an institutionally thick regional innovation system. In terms of organizational infrastructure, there are about 2100 software firms registered in Bangalore, which are responsible for a third of the national exports (Parthasarathy and Rabganathan, 2011:6). According to the INGINEUS survey, about half of the firms are standalone companies, 16% subsidiaries and 28% headquarters of MNCs. Whereas there are many large firms (about 40% has more than 250 employees. While Bangalore started as a low-cost provider of software services, it has been upgrading gradually and currently is an important provider of high-added value services. The industrial structure combines both a large pool of SMEs with a large number of MNCs, many of which have located also R&D centers in Bangalore. In terms of research infrastructure Bangalore is home of the Indian Institute of Science and the International Institute of Information technology (IIIT_Bangalore) and has branches of some international universities like Chicago as well as other well-known HEIs like the Indian Institute of Management. Some MNCs have also opened their own campuses of firms like Hewlett Packard, Infosys, Siemens and Wipro (Parthasarathy and Rabganathan, 2011:12). As many scholars have pointed out, one of the main reasons why MNCs started to locate in Bangalore was the availability of highly skilled human capital (Arora et al, 2001). According to the INGINEUS survey, accessing specialized knowledge, qualified human capital and other knowledge infrastructure and services continues to be the main reason for firms to offshore production and innovation activities in Bangalore (Parthasarathy and Rabganathan, 2011:16).

Networks in Bangalore have evolved reflecting the evolution in the strategies of the firms: from strong linkages with MNCs during the outsourcing wave to more complex alliances for the provision of embedded systems which forces chip vendors to develop alliances with service providers, both at regional, domestic and international level. While regional networks are not still fully developed, Bangalore shows a higher propensity to collaborate with regional actors than firms in other parts of India. As indicated by Parthasarathy and Rabganathan, 2011:23 "Bangalore stands out as much higher percentage of firms have worked with every type of regional collaborator than firms in other regions", and this differences are particularly higher with regards to the collaboration with universities and consultants. So, regional networks are very significant in Bangalore and, in contrast to other Tier 1 and other regions in India, regional networks for innovation are even more important than domestic[7]

In Bangalore there is a strong culture of collective representation and collective action. In 1997 Karnataka took the initiative to developed its own information technology policy, being one of the outcomes of that policy the establishment of the IIITB mentioned before. The Government has been very active in developing the institutional framework supporting the IT industry in Bangalore. Additionally, the India semi-conductor association was created in Bangalore in 2004 to represent the interests of the emerging embedded system industry centered in Bangalore (Parthasarathy and Rabganathan, 2011:20).

Using the INGINEUS survey data, one can see that sourcing of technology is mainly internal to the firm, although the proportion of firms that source from their own MNC or from other MNCs is higher than in other Tier 1 regions (like Beijing). In terms of exploitation of innovation, half of the Bangalore firms are targeting export markets (global exploitation of innovation) while other half are targeting domestic. However, the international orientation of the clients may change in the future as the number of firms that develop innovation (for the poor) in interaction with local customers increases (Parthasarathy and Rabganathan, 2011:23). Firms like HP, Microsoft, Motorola or Siemens have opened R&D labs in Bangalore precisely to develop "innovations for the poor".

A case that can illustrate this shift towards domestic market and the development of innovation for the domestic market and in collaboration with local and domestic actors is Hewlett Packard. As Parthasarathy and Rabganathan (2011:24) account, HP became involved in the development of an affordable and easy to carry solar powered digital camera with a small printer. The innovation was developed to serve one particular purpose (help woman report their social events) but it has the potential to be further developed into a product that can be commercialized for India and elsewhere. The development of this innovation was done through the interaction with domestic clients, although it may be exploited internationally.

Tier 2 – Cape Town

The Western Cape, is considered to be a Tier 2 region. The RIS is dominated by small and medium size enterprises (Kaplan et al, 2010) which are not specialized in high-added value activities. There are four universities in the Cape Town region, accounting for about 2200 research staff. One of them, the University of Cape Town is considered among the top 200 Universities in the world and the highest ranked in Africa (Lorentzen and Muller, 2010:7). Although the Cape Town has some specialization in agro-processing, it is not so strong in ICT. There is a considerable amount of ICT firms and the desire of the government to make this industry a landmark in the region, but it has not crystallized yet. There are also a number of sector associations and initiatives, like the Cape IT Initiative, the Bandwidth Barn and the Silicon Cape.

[7] See Table 8 in Annex 2 paper « The role of regions in supporting the emergence and development of GINs : the case of Bangalore »

In terms of networks, there is a certain degree of collaboration between university, industry and the government, but firms report that interactions with local knowledge producers are marginal (Lorentzen and Muller, 2010:10).

How this RIS affects the insertion of firms in Global Value Chains can be illustrated with a case. DCM[8] is a Cape Town based firm specialized in high speed digital signal processing technologies for radar and sonar applications. DCMs principal customer is a South African engineering company based in Gauteng (domestic link) that, in turn, sells both domestically (second domestic link) and internationally (insertion in global innovation networks –global exploitation of innovations- through the node of the client) and has two large European defence companies as shareholders (Lorentzen and Muller, 2010: 18). DCM sources from international sources, as the quality of the domestic and local sources is considered low (global sourcing of technology). So, DCM has not very strong linkages in the Cape Town region. Its clients are domestic (with further international linkages) and its suppliers are international. The only strong linkages with the regional innovation systems are for the recruitment of staff, which is done locally (Lorentzen and Muller, 2010: 19).

The RIS in Cape Town can be considered as neither too strong institutionally nor too weak. It is clearly a Tier 2 region. There is some organizational infrastructure both in terms of firms as well as strong universities (especially Cape Town University), some initiatives and support from the government. There is some interaction taking place between firms, government and universities, but collaborations work sub-optimally and they seem to be only marginal to innovation. There is an emerging culture of collective representation in the form of initiatives to create an ICT hub in the Cape Town region and there seem to be a strong Cape Town identity, reported in the cases. Yet, the technological capabilities of the local firm are not strong enough and firms tend to source technology internationally and sell their products to domestic or international clients.

7. Final remarks

When taking all the industries together, the data shows that there are significant differences across regions with regards to three out of four forms of globalization of innovation: global exploitation of innovation, global research collaboration and global sourcing. In general, firms located in Tier 2 regions participate more often of global innovation networks that firms in Tier 1 and Tier 3. Tier 1 firms seem to be more engaged in intra-firm networks rather that extra-firm. Transactions take place more often between different units of the same organization rather than with external firms or knowledge providers.
Tier 1 regions, like Stockholm, Beijing or Bangalore could be considered *Globalized regional innovation systems* (Cooke et al, 2007). They are characterized by a large presence of multinationals and in general large corporations, surrounded by a network of SMEs. They host a number of research institutes, providing qualified human capital and research to the

[8] DCM stands for Defense Components Manufacturer. The real name of the firm is confidential (Lorentzen and Muller, 2010)

productive system. Although innovation is higher in these regions, collaboration for innovation is not as high as in Tier 2 regions, despite the high density of their institutional environment. Our results seem to confirm that research is rather internal to the firm than external (Cooke et al, 2007) and more confined to the domestic arena rather than the regional or international one (Tödtling et al, forthcoming).

Tier 2 regions, like Shenzhen, Western Cape or Malmö could resemble what Cooke et al call *Interactive regional innovation systems*. The productive structure is a mix between large and small firms. They network with a variety of actors for innovation, at all three geographical levels (regional, domestic and international). Firms in Tier 2 regions are more integrated in global flows of innovation, particularly the global exploitation of innovation, global sourcing of technology and global research collaboration.

Finally, Tier 3 regions, like Pune, Easter Cape or Jönkoping could resemble a *Localist innovation system*, dominated by small firms and with limited research capabilities. Interactions take place within the value chain, with suppliers and clients for example. It is in this region where we find that interactions with regional suppliers are higher. It is also in this region where we find also collaboration with international clients. The picture that emerges is of firms that collaborate regionally with suppliers and internationally with clients.

Following this, we may expect that firms located in Tier 2 regions may be more prone to participate in global innovative networks (GIN). Firms in Tier 3 may have linkages with global clients but there are not so innovative and not so networked (gin). Finally, firms in Tier 1 regions, may be more innovative, but they are not so global (at least not with regards collaboration for innovation) and not as networked as firms in Tier 2 (gIn).

It is interesting to link these findings with the institutional thickness of the different regions. What these results seem to suggest is that, contrary to what we expected, GINs may emerge in regions which are neither institutionally too thick (like Tier 1) or too thin (like Tier 3). Regions that are institutionally thick are better networked domestically than internationally. They may have reached some form of institutional congestion that hampers instead of promoting the kind of networking that characterizes less institutionalized regions. Regions that are too thin institutionally may force firms to collaborate with international clients or suppliers, thus supporting the emergence of global value chains (not so much networks).

It is regions that are neither too thick nor to thin institutionally -like Tier 2 regions- that are more supportive for the emergence and participation of GINs. This could also explain why most of the firms that are truly innovative, networked and global are located in non-European regions (institutionally less thick), rather than in European ones (Barnard and Chaminade, forthcoming).

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Organizational infrastructure by region

Country/ Industry	Tier 1	Tier 2	Tier 3	Sources
Brazil / Auto	The greater Sao Paulo (including the ABC) is responsible for 67% of employment; 76% of the firms are located there (Large Sao Paulo Area)	14 % of employment in industry	Aprox 4,5 % of employment	Sindipecas. www.sindipecas.org.br (accessed 17 June 2011)
China / ICT	Data on number of firms or employment in ICT not available at the level of the region. Classification in Tiers based on information of local experts.			--
Denmark / Agro-process	Data on number of firms or employment in agroprocessing not available at the level of the region. Classification in Tiers based on information of local experts.			--
Estonia / ICT	Between 60-70% of the employment in the ICT industry is in Tallin.	About 30-40 % of employment.		Kalvet (2004) "The Estonian ICT manufacturing and software industry: Current State and Future Outlook". IPTS report.
Germany / Auto	Baden-Wûrttemberg responds to 25% employment in Auto in germany	Thûringen employs 5% of auto in Germany		Germany Trade Invest www.gtai.com (Accessed 17 June 2011)
India / ICT	Employment in Karnataka state is 554000 in software industry (2009) Software exports above 17 billion US$ (34% of total in India in 2008/9)	Exports between 3 to 1 billion US$	Less than 1 billion US$ in exports	Malik and Ilavarasan (2011) "Trends in the ICT industry and ICT R&D in India" . http://is.jrc.ec.europa.eu/pages/ISG/PREDICT/documents/2PayalMalikfinal.pdf.(Accessed 17 June 2011)**ndia**

Country/ Industry	Tier 1	Tier 2	Tier 3	Sources
Norway / ICT	Aound Oslo there are 3 ICT clusters. About 60% of the ICT companies are located here. Aprox. 45000 Employees in the ICT.	Aprox. 10000 employees in Trondheim.		Rekene project report .- http://www.nordregio.se/rekene/maps.htm (accessed 17 June 2011) and Hansen & Serin (2010) "The European ICT clusters" http://rucforsk.ruc.dk/site/files/32956338/the_european_ict_clusters_web_0.pdf (Accessed 18 June 2011)
South Africa / Agro	Gauteng – Aprox 50000 employees (2007), 50% of the firms (about 4000 companies)	Data on number of firms or employment in agroprocessing not available at the level of these other regions. Classification in Tiers based on information of local experts.		http://www.gautengcompanies.co.za/pls/cms/ti_secout.secout_prov?p_sid=13&p_site_id=128
Sweden / Auto	Regions with more than 15000 employees in the auto industry	Regions with 5000-15000 employees in auto	Regions with less than 2000 employees in auto	Invest Sweden Agency (2009) "Automotive". Stockhom: ISA
Sweden / ICT	The Stockholm area employs around 100.000 people in the ICT industry.	The Skåne region, employs around 23000 people in the ICT industry.		Hansen & Serin (2010) "The European ICT clusters" http://rucforsk.ruc.dk/site/files/32956338/the_european_ict_clusters_web_0.pdf (Accessed 18 June 2011)

ANNEX 1 - Intermediate report – the role of regions supporting the emergence and development of GINs: the case of Beijing

Authors: Ping Lv (lvping@gucas.ac.cn) and Xielin Liu (liuxielin@gucas.ac.cn)

Participant no.2: Graduate University of Chinese Academy of Sciences, China (GUCAS)

1. Introduction

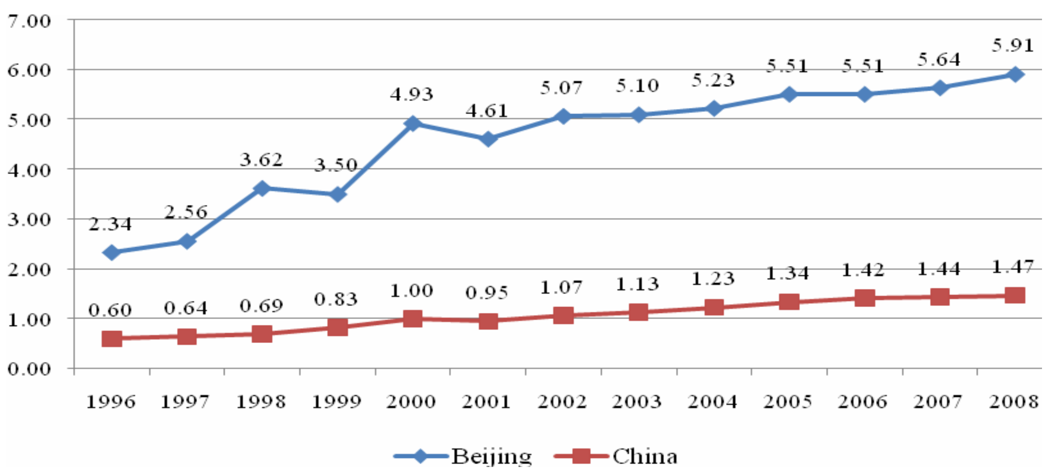
In the globalised learning economy, continuous innovation is a prerequisite for sustainable competitiveness of both nations and regions, while innovation capability arises increasingly from complex interactions at world, national and local levels between enterprises, universities, research institutes, government and other elements of innovation system. Beijing, as the capital and also political, cultural and educational centre of China, is one of the regions with the highest level of economic and science development national-wide. In 2009, the regional GDP of Beijing was 173.72 billion US dollars, and GDP per capita has reached 10,070 US dollars, which was more than the average of middle-income countries and regions in the world (Beijing Statistical Information Net, 2010).

In recent years, Beijing has been regarding Innovative City, Science and Technology Beijing, and World City as the main line of development, which gives a clear positioning and development direction for Beijing to become an important knowledge hub in GINs. In January 2006, the local government of Beijing proposed the goal of developing Beijing into an innovative city by 2010 in the "Beijing Eleventh Five-Year Plan on Economic and Social Development". After the successful host of 2008 Beijing Olympic Games, the local government timely proposed a new development strategy of "Humanity Beijing, Science and Technology Beijing, Green Beijing". Based on such a strategy, in March 2009, the "Plan of Action (2009-2012) on 'Science and Technology Beijing': Action to Promote Indigenous Innovation" was issued as a comprehensive strategic plan guiding Beijing to be an innovative and science and technology-based city, at the same time, this plan aimed at developing Beijing into a global science and technology centre during the construction of Science and Technology Beijing. In March 2010, the official reply to the "Beijing Overall Plan of Urban Development" by the State Council proposed the goal of building Beijing into a comprehensive, coordinated and sustainable city in economic, social and ecological development and entering into the ranks of world cities around 2050.

In fact, with the development of regional innovation system, Beijing has accumulated abundant resources and manifested many unique advantages to play an increasingly important role in GINs. Firstly, Beijing has been the Chinese city most endowed with top-quality universities and research institutes, and has developed a rich scientific and technological talent pool. For example, 1/3 of advanced computer and software professionals, nearly 1/2 of advanced intelligent system integration professionals, and more than 1/2 of experts in semiconductor of China are working in Beijing, which is one of the most key reasons why Beijing's ICT industry is so competitive in the whole country.

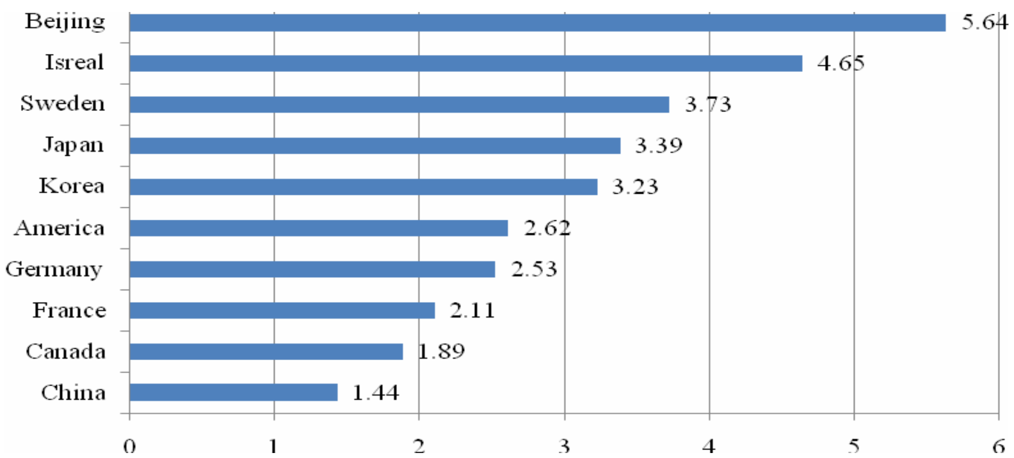
Secondly, Beijing invested heavily in innovation activities and has strong research infrastructures. For example, nearly 30% of State Key Laboratories and 1/3 of National Engineering Research Centers of China are located in Beijing. Beijing's R&D intensity, measured by R&D/GDP, has improved rapidly in recent year and accounted to 5.91% in 2008 (see Figure 1), which is not only much higher than the average level of China, but also takes the leading position among the most developed countries (see Figure 2).

Figure 1: R&D/GDP of Beijing and China, 1996-2008 (%)



Data source: MOST, Sceince and Technology Statistical Database, 2009.

Figure 2: The ratio of R&D/GDP in selected countries in 2007 (%)



Source: MOST, Main S&T Indicators Database, 2008.

Thirdly, high-tech industries have been the pillar industries of Beijing in the past three decades. In 2009, the high-tech industrial added value of Beijing has reached 230 billion yuan, accounting for more than 20% of GDP. High-tech industries are playing a leading and radiation role in promoting Beijing’s economic and social development. Furthermore, some successful high-tech companies have emerged on the world stage, such as Lenovo, Aigo, Vimicro, Baidu, Loongson. Based on the development of high-tech industries, three types of industry clusters have taken in shape in Beijing with distinctive features: (1) high-tech industry cluster centred on Zhongguancun Science Park; (2) modern manufacturing cluster centred on Beijing Economic and Technological Development Zone; (3) modern service cluster centred on Financial Street and Central Business District (CBD).

Fourthly, Beijing has been a cluster with headquarters of large multinationals, as well as a cluster with R&D institutions established by them in the world. Up to now, 30 multinationals in Fortune Top 500 has located their global headquarters in Beijing, and Beijing has become the second largest cluster with headquarters of Fortune Top 500, following with Tokyo, which has 49 global headquarters established by Fortune Top 500. With the trend of globalization of R&D activities, 278 R&D institutions have been established in Beijing by foreign multinationals by the end of 2007 (Ministry of Commerce, 2009).

Beijing’s innovation capability can be mirrored in various objective indicators of performance. In terms of publications, 48,076 scientific and technological publications in Beijing were listed SCI, EI, and ISTP in 2008, ranking absolutely 1st in the national-wide and accounting for 17.75% of the total number in China. According to the patent activities, the number of patent applications of Beijing amounted to 43,508, ranking 6th in the national-wide and accounting for 6.07% of the total number of patent applications in China. Patents registered in China are classified into three categories: invention, utility model and (appearance) design. Design refers to new appearance and utility model refers to functionality modification or improvement without substantial technological contents. The invention patents are thus presumably more R&D intensive than the other two types of patents. In 2008, the number of invention patent applications accounted for nearly 2/3, utility model patents account for 1/4, and design patents account for only less than 10% of total number of patent applications in Beijing. However, the situation was totally different from ten years ago. In 2000, the number of invention patent applications in Beijing account for 1/3, utility model patents account for nearly half and design patents account for 1/5 of the total number of patent applications (see Table 1). This transition indicates the significant improvement of Beijing’s innovation capability.

Table 1: Three types of patent applications of Beijing, 2000-2008 (Piece, %)

Year	Total	Invention		Utility Model		Design	
		Number	Percentage	Number	Percentage	Number	Percentage
2000	10344	3409	32.96%	4984	48.18%	1951	18.86%
2001	12174	4984	40.94%	5114	42.01%	2076	17.05%
2002	13842	5785	41.79%	5920	42.77%	2137	15.44%
2003	17003	7833	46.07%	6665	39.20%	2505	14.73%
2004	18402	8608	46.78%	6321	34.35%	3473	18.87%
2005	22572	12102	53.62%	6940	30.75%	3530	15.64%

2006	26555	14226	53.57%	8200	30.88%	4129	15.55%
2007	31680	18763	59.23%	8819	27.84%	4098	12.94%
2008	43508	28394	65.30%	11157	25.60%	3957	9.09%

Source: China Statistical Yearbook on Science and Technology, 2001- 2009.

Beijing has increasingly been an important knowledge hub in GINs, but less study has been done on how this has happened, especially under the effect of regional innovation system. Therefore, in this report, we would explore the roles that the regional innovation system of Beijing has played in the emergence and development of GINs. Section 2 introduces the brief history of regional innovation system of Beijing. Section 3 describes the composition of regional innovation system of Beijing, including its enterprises system, universities and research institutes, government, intermediary organizations, and financing system. Section 4 analyzes the functioning of regional innovation system of Beijing in supporting the emergence and development of GINs. Section 5 is the challenges of regional innovation system of Beijing. Section 6 is conclusion.

2. Brief history of the Regional Innovation System

2.1. Evolution of Regional Innovation System

The development of regional innovation system of Beijing started from the early 1980s, i.e. the commencement of China’s reform and opening-up policy. Chen Chunxian, a researcher from CAS made three investigative visits to Highway 128 in Boston and to Silicon Valley, after which with a sense of mission an idea of establishing a “technology diffusion zone” in Zhongguancun came out in order to explore a path for China’s situation in technology diffusion and transforming scientific and technological achievements into productivity. In October 1980, he took the lead in setting up the first private institution “Advanced Development and Technology Services Department of Beijing Institute of Plasma” in Zhongguancun. Since then, private technology enterprises, such as Kehai (1983), Jinghai (1983), Stone (1984), Xintong (1984), have been successively set up in Zhongguancun area. By the end of 1986, more than 100 such technology enterprises have emerged, and the world-famous “Zhongguancun Electronics Street” has gradually taken shape.

In the early 1988, the central government conducted a comprehensive investigation on “Zhongguancun Electronics Street”, highly confirmed the direction of developing high-tech enterprises in Zhongguancun area, and proposed the recommendation of setting up a new technology development zone here. In May, the State Council approved and issued the “Interim Provisions on Beijing New Technology Industry Development Experimental Zone”, [9]which marked an important step in the promotion and development of high-tech industries,

[9] “Beijing New Technology Industry Development Experimental Zone” was the predecessor of “Zhongguancun Science Park”.

as well as the incubation of a regional innovation system in China (Zhu and Tann, 2005). During the four years from the end of 1987 to the end of 1991, the number of enterprises in the experimental zone has increased sharply from 148 to more than 1300, the annual income of technology, industry and trade has increased from 0.7 billion yuan to 3.7 billion yuan, the annual industrial output has increased from 0.5 billion yuan to 1.2 billion yuan, and the annual export has increased from 3 million US dollars to 45 million US dollars, the average annual growth rate was 53.9%, 36.9% and 125.7% respectively.

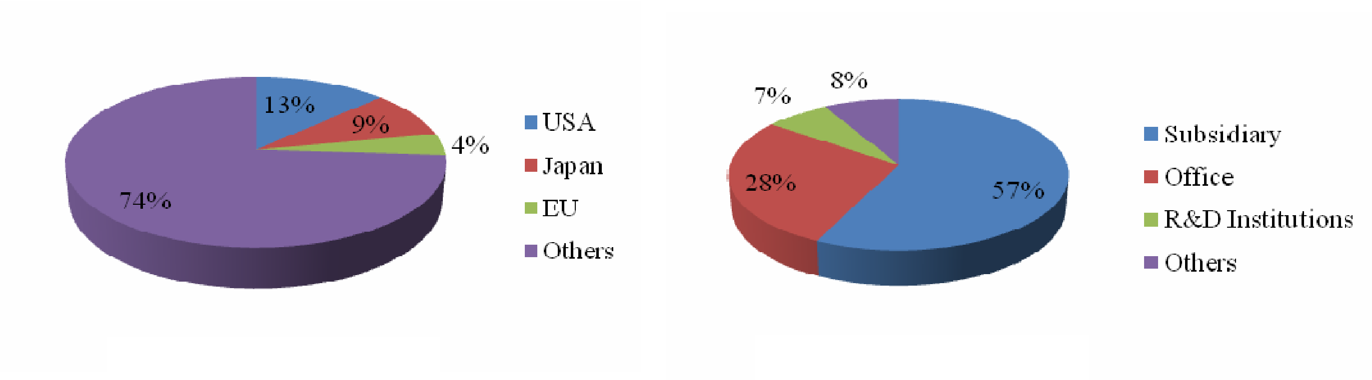
In June 1999, “Beijing New Technology Industry Development Experimental Zone’ was renamed “Zhongguancun Science Park”, and the State Council proposed the goal to establish Zhongguancun Science Park into a world-class science park. In 2006, a new area plan for Zhongguancun Science Park was approved by the State Council, and Zhongguancun Science Park has gradually become a high-end park crossing administrative region with “one district and ten parks”. These ten parks distribute all over Beijing, including Haidian Sub-Park, Fengtai Sub-Park, Changping Sub-Park, Electronics City Sub-Park, Yizhuang Sub-Park, Desheng Sub-Park, Yonghe Sub-Park, Shijingshan Sub-Park, Tongzhou Sub-Park, Daxing Bio-Medicine Park.

In March 2009, the State Council approved the construction of Zhongguancun National Indigenous Innovation Demonstration Area, and planned to build it into a scientific and technological innovation center with global impact in 2020. Strategic emerging industries such as new energy, energy-saving and environment protection, electric vehicles, new materials, new medicine, bio-breeding, information are the key fields to develop in the Demonstration Area.

After more than 20 years development, Zhongguancun Science Park has been a very important part of regional innovation system of Beijing. Now, nearly 20,000 high-tech enterprises, 39 universities including Tsinghua University and Peking University, more than 140 research institutes affiliated to CAS and ministries, 57 national-level key laboratories, 26 national engineering research centers, 29 national engineering technology research centers, 14 university science and technology parks resided in Zhongguancun Science Park. In 2008, the total revenue of enterprises in Zhongguancun Science Park has reached 1.02 trillion yuan, among which 62.2% were from electronic-information industries. The revenues of software enterprises accounted for 1/7 of the total in China. The number of listed companies has reached 149, among which 89 are domestic listed companies, and 60 are overseas listed companies.

With the great improvement of their capabilities, more and more domestic enterprises are expanding globally to access external knowledge. On the one hand, some domestic high-tech enterprises, such as Lenovo, Founder, Stone and Rainbow, began to establish overseas branches including R&D institutions. For example, Lenovo has established Raleigh R&D center in USA and Daiwa R&D center in Japan. Domestic enterprises in Zhongguancun Science Park have established 249 branches abroad by the end of 2008, among which 1/4 are in developed countries (USA, Japan and EU), and 7% are R&D institutions (see Figure 3). On the other hand, a small number of domestic enterprises merged or acquired foreign companies. For example, the acquisition of IBM’s PC division by Lenova in amount of 1.75 billion US dollars in 2004 was the largest bidding by Chinese company. IBM got 18.9% of equity share of Lenovo. The acquisition expanded Lenovo’s operations from 3 billion US dollars in revenues to 10 billion US dollars. Lenovo’s basic objectives in buying the IBM operation were to acquire a brand and core technology in order to become a high-end and global PC maker.

Figure 3: Overseas branches established by enterprises in Zhongguancun Science Park (%)



Source: Yearbook of Zhongguancun Science Park, 2009.

2.2. Evolution of Foreign Direct Investment in Beijing

With China's reform and opening-up policy, the development of local enterprises and industries of Beijing was also accompanied by the entry of foreign capital. As a knowledge hub in GINs, the development of regional innovation system has been greatly affected by FDI. Beijing is one of the earliest cities in China to attract the investment of multinationals. On April 21, 1980, Beijing Air Catering Co., Ltd., the first foreign direct investment enterprise of China, was approved to be established. During the past 30 years, 28,000 foreign direct investment enterprises have been approved to establish in Beijing, and the accumulative actual utilized value of foreign direct investment in Beijing has reached 37.61 billion US dollars. Foreign direct investment plays an important role in the regional innovation system of Beijing, the development of which can be roughly divided into three phases.

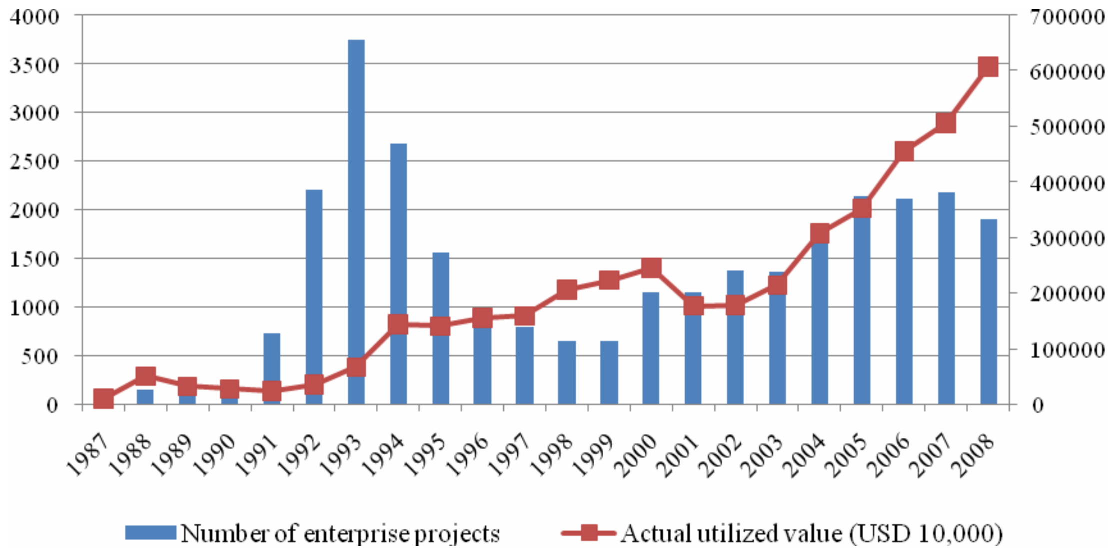
The first phase is from 1980 to1990, which is an exploration period to attract FDI. As affected by the long-term constraints of planned economy, it was very difficult for Beijing to attract FDI at the early stage. Beijing started from the tourism industry to attract FDI and established joint venture in hotels and catering sectors. For example, the first joint venture hotel in China, Jianguo Hotel, was established in 1980; in 1983, another joint venture hotel, Great Wall Hotel was also established in Beijing. In the following years, a set of manufacturing projects were implemented, such as Jeep, Panasonic color CRT, Schindler Elevator. However, FDI in this period grew slowly with only small size investment and focused on very limited sectors. Only 1561 foreign enterprises were approved to enter Beijing in this period.

The second phase is from 1991 to 2000, which is a rapid growth period to attract FDI of Beijing. Deng Xiaoping's southern tour speech in 1992 became a key turning point for

China's open up to attract FDI. The number of FDI projects in Beijing has reached its peak in 1993, and 3753 FDI projects were approved in this year. More and more famous multinationals came into Beijing in this period, and high-tech industries and service industries became the focus of investment. 15435 foreign enterprises were approved to be established in Beijing in this period, and the actual utilized value of FDI of Beijing reached 16.61 billion USD.

The third phase is from 2001 to now, during which the size and quality of FDI were simultaneously improved. Since China joined in WTO in 2002, the investment environment of Beijing has matured increasingly. A set of modern manufacturing projects were introduced in this phase, such as Nokia Star Network Industrial Park, Hyundai Motor, Semiconductor, TFT-LCD of BOE, Mercedes-Benz Motor, all of which changed the industrial structure of Beijing and improved the competitiveness of its manufacturing industries. In addition, modern service industries also developed rapidly, which included specialized consultancy, finance and insurance, modern logistics, commercial retailing, cultural creative industry, and so on. About 11,000 enterprises were approved to be established in Beijing in this period, and the actual utilized value of FDI has reached more than 20 billion USD.

Figure 4: Number of FDI projects and actual utilized value of FDI of Beijing, 1987-2008



Source: Beijing Statistical Yearbook, 2009.

Up to now, Beijing has become a hot magnet of foreign direct investment with the actual utilized FDI jumping to 6.08 billion USD in 2008 from 95.34 million USD in 1987 - an increase of 63 times within 21 years (see Figure 4). In 2008, the key investment sectors included manufacturing, leasing and business services, information transmission, computer services and software, as well as real estate. Table 2 shows the FDI breakdown by sectors.

Table 2: FDI by sectors of Beijing, 2008 (USD 10,000)

Sector	FDI projects		Actual Utilized FDI	
	Number	Percentage (%)	Value	Percentage (%)
Total	1897	100	608172	100
Manufacturing	105	5.54	150056	24.67
Leasing and Business Services	569	29.99	132541	21.79
Information Transmission, Computer Services and Software	317	16.71	105396	17.33
Real Estate	16	0.84	78787	12.95
Wholesale and Retail Trade	510	26.88	34677	5.70
Hotels and Catering Services	71	3.74	3357	0.55
Agriculture, Forestry, Animal Husbandry and Fishing	7	0.37	2032	0.33
Construction	7	0.37	1715	0.28
Others	295	15.55	99611	16.38

Source: Beijing Statistical Yearbook, 2009.

From Table 2 we can see that the actual utilized FDI in manufacturing sector was 1.50 billion USD as the first, accounting for 24.67% of the total; followed by FDI in the leasing and business services sector of 1.33 billion USD as the second, accounting for 21.79% of the total. Information transmission, computer services and software sector came as the third with actual utilized FDI of 1.05 billion USD and a proportion of 17.33 percent, followed by the real estate of 12.95 percent, wholesale and retail trade of 5.70 percent, hotels and catering services of 0.55 percent, agriculture, forestry, animal husbandry and fishing of 0.33 percent, and construction of 0.28 percent. These figures show that foreign direct investment in Beijing largely concentrated in manufacturing, business services and ICT sectors, and the FDI growth in Beijing was partly propelled by global manufacturing relocation for cheap labour and other costs, as well as abundant technology and talent resources.

Overall, the local government of Beijing has been in a more positive attitude in attracting foreign capital in the past 30 years. In January 1999, Beijing Municipal Government issued the "A Number of Provisions on Encouraging Multinationals to Set up Regional Headquarters in Beijing". In May 2009, Beijing Municipal Government introduced a new policy with the same title replaced the previous one, which gave more preferential treatment to multinational to establish regional headquarters in Beijing, for example, newly-established or newly-moved regional headquarters after January 1st 2009 with a registered capital of more than 100 million yuan (inclusive) would obtain different grades of subsidies. Anyway, foreign investment has made a certain contribution to the development of high-tech industries of Beijing according to the fields they have invested, as well as the relevant demonstration effect and spillover effect.

3. Composition of the Regional Innovation System

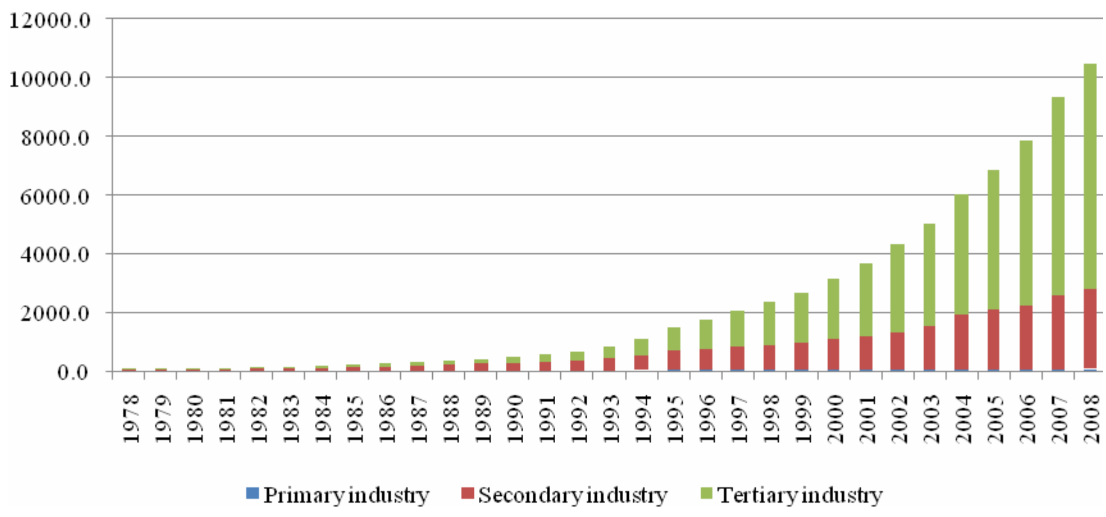
3.1. The enterprise system

Here, the enterprise system includes the following three aspects: industrial structure, enterprises, and venture businesses by returnees from abroad, which are also distinctive features of Beijing’s enterprise system.

3.1.1. Industrial structure

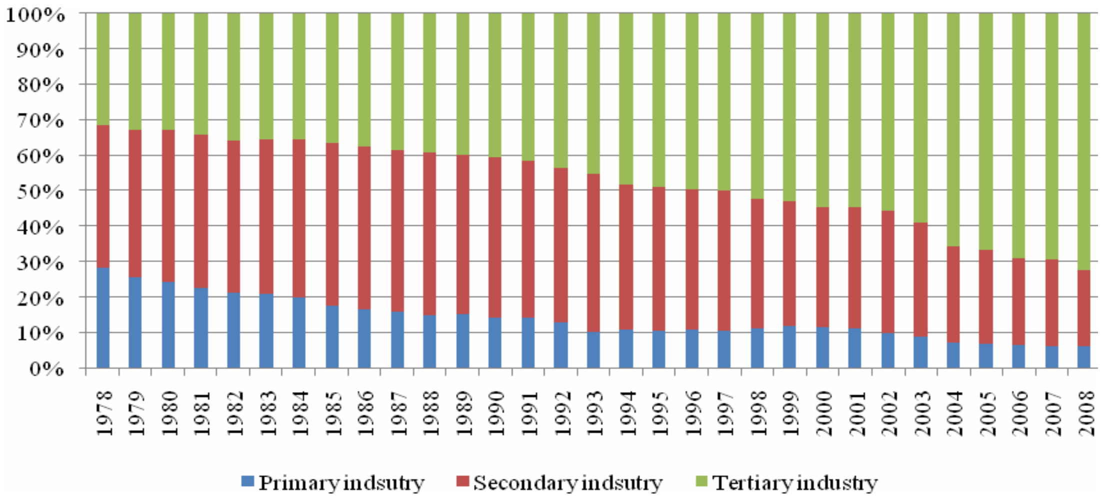
Since China’s reform and opening-up in 1978, Beijing has made great economic achievements with China’s rapid development. The GDP of Beijing has changed from 11 billion yuan in 1978 to 1049 billion yuan in 2008, and the economic structure of the primary industry, secondary industry and tertiary industry has also changed a lot, which can be seen from Figure 5. During the past 30 years, the absolute value of these three industries has increased by 1914.29%, 3379.59%, and 29675.19% respectively, however, the proportion of primary industry has decreased from 5.15% in 1978 to 1.08% by 2008, and the secondary industry has decreased from 71.14% to 25.68%, while the tertiary industry has increased from 23.71% in 1978 to 73.25% by the same period. Meanwhile, the structure of employee composition by primary, secondary and tertiary industries changed correspondingly (see Figure 6), by 2008, the number of employee in the three industries account for 6.4%, 21.2% and 72.4% of total employees in Beijing respectively. So Beijing has undergone a dramatic transition from a manufacturing-based region into a service-based one.

Figure 5: GDP and structural evolution of primary, secondary and tertiary industries of Beijing, 1978-2008 (billion yuan)



Source: Beijing Statistical Yearbook, 2009

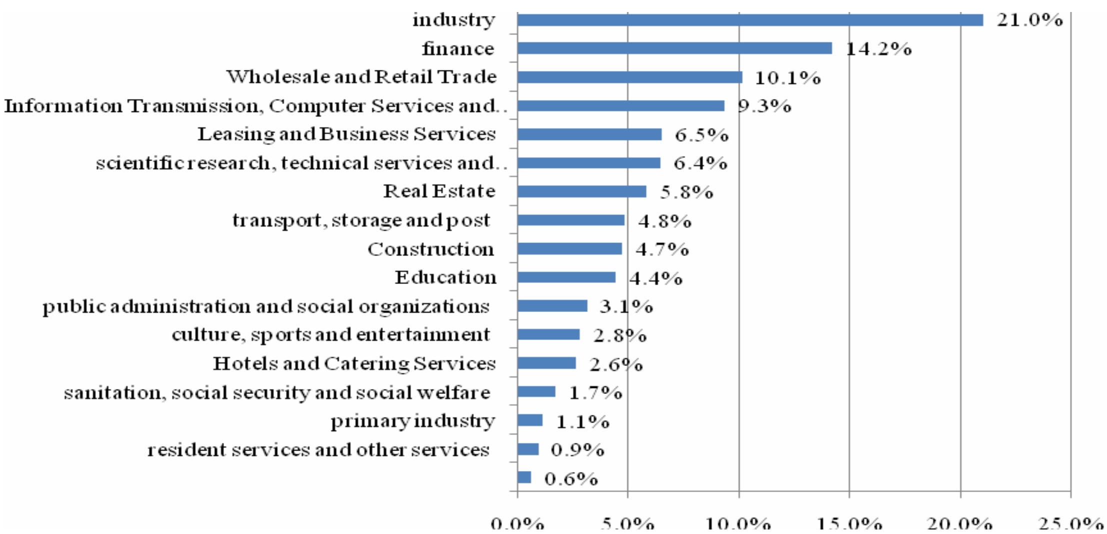
Figure 6: Employee composition in percentage by primary, secondary and tertiary industries of Beijing, 1978-2008 (%)



Source: Beijing Statistical Yearbook, 2009

In order to present the contribution of different sectors to GDP in a clearer way, we listed the composition of GDP by sectors of Beijing in 2008 in Figure 7, which indicates that industry has the largest proportion of 21.0% in GDP, followed by finance, wholesale and retail trade, information transmission, computer services and software, leasing and business services, with the proportions of 14.2%, 10.1%, 9.3% and 6.5% respectively. The above five largest industries account for more than 60% of total GDP, and became the pillar industries of Beijing.

Figure 7: The Composition of GDP by Sectors of Beijing, 2008 (%)

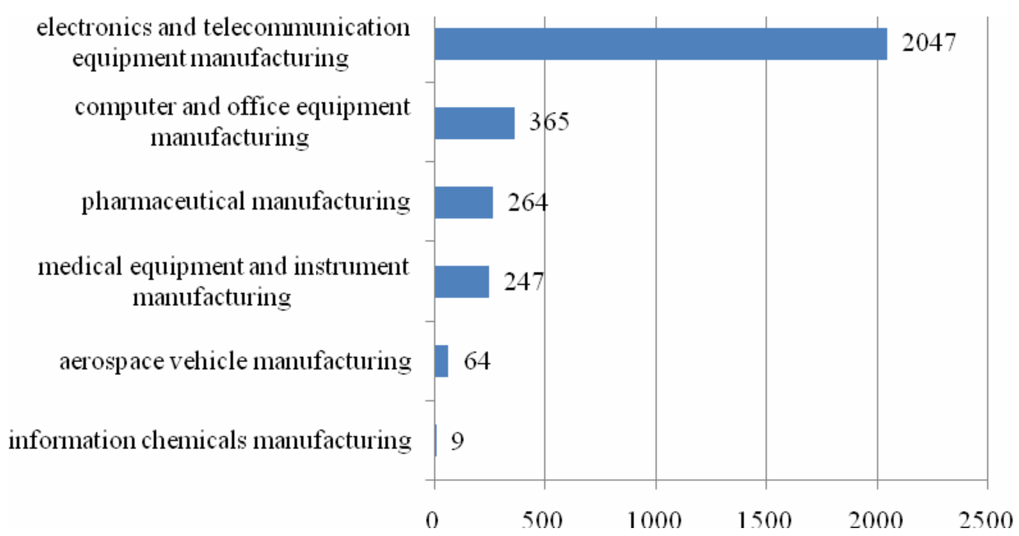


Source: Beijing Statistical Yearbook, 2009

It was in the year 1993 that Beijing's tertiary industry surpassed the secondary industry in the absolute value for the first time (also see Figure 5), and since then, Beijing's industrial structure has been dominant by the tertiary industry, and whose percentage in GDP has also increased rapidly year by year. Up to now, Beijing's export of high value-added services, such as communication, insurance, financial services, computer and information services, the use of exclusive rights and licensing, consulting, advertising, film and audio-visual services, has reached 10 billion US dollars, accounting for 40% of the total export of high value-added services and ranking first in China. Thus, Beijing has become an important base for China's service trade.

Notably, when great efforts have been made to develop the tertiary industry, Beijing's internal structure of the secondary industry has also been constantly adjusted and optimized, and the development of resource-intensive industries have been brought under effective control: from 1999 to 2004, about 20~30 enterprises each year engaged in resource exploitation or resource processing would move out from the inner fourth ring road of Beijing city; in 2005, Shougang Group, a very famous steel enterprise group in China with a long history of more than 80 years and whose financial contribution account for 1/4 of the total of Beijing, moved its steel-related businesses out of Beijing. At the same time, Beijing has been facilitating the development of high-tech industries in recent years. For instance, the output value of high-tech manufacturing industries in 2008 reached 299.59 billion yuan, among which the electronics and telecommunication equipment manufacturing industry had the largest proportion of 68.31% in the output value of high-tech manufacturing industries and reached 204.65 billion yuan. The output value distribution of main high-tech manufacturing industries in 2008 was shown in Figure 8.

Figure 8: Output value of high-tech manufacturing industries of Beijing, 2008 (100 million yuan)



Source: Beijing Statistical Yearbook, 2009

3.1.2. Enterprises

By 2007, there were 293,476 enterprises in Beijing, among which 280,410 were domestic enterprises, accounting for 95.55% of the total, and 13,066 were foreign enterprises, accounting for 4.45% (see Table 3). Here, foreign enterprises include those from HMT (Hong Kong, Macao and Taiwan) and foreign countries.

Table 3: Number of enterprises registered in Beijing, 2005-2007

Year	**Domestic Enterprises**		**Enterprises from Hong Kong, Macao and Taiwan**		**Enterprises from foreign countries**	
	number	percentage	number	percentage	number	percentage
2005	250300	96.45%	2710	1.04%	6511	2.51%
2006	268604	96.18%	3025	1.08%	7660	2.74%
2007	280410	95.55%	3845	1.31%	9221	3.14%

Source: Beijing Statistical Yearbook, 2006-2008.

There were 7206 industrial enterprises in Beijing by the end of 2008, among which 6555 were small-sized enterprises, accounting for 90.97% of the total; 595 were medium-sized enterprises, accounting for 8.26%; and 56 were large enterprises, accounting for only 0.78%. Small-sized enterprises are active in innovation activities, so a large proportion of small-sized enterprises could facilitate the development of regional innovation system. Among all the industrial enterprises, 78.88% are domestic ones, 5.45% are from Hong Kong, Macao and Taiwan (HTM), and 15.67% are from foreign countries (see Table 4).

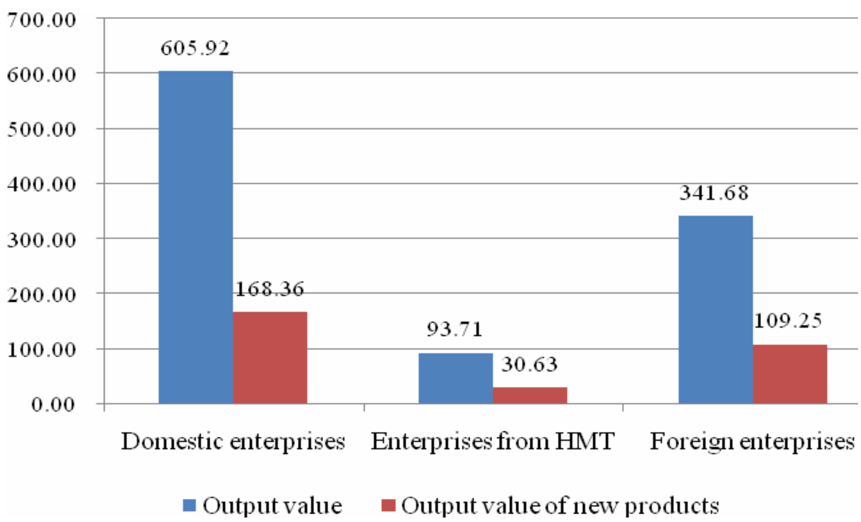
Table 4: Industrial enterprises by size and ownership in Beijing, 2008

Types	Number	Percentage	Types	Number	Percentage
Small	6555	90.97%	**Domestic Enterprises**	5684	78.88%
Medium	595	8.26%	**Enterprises from Hong Kong, Macao and Taiwan**	393	5.45%
Large	56	0.78%	**Enterprises from foreign countries**	1129	15.67%
Total	7206	100%	Total	7206	100%

Source: Beijing Statistical Yearbook, 2009.

Correspondingly, domestic industrial enterprises have much higher output value and new product output value than enterprises from HMT and other countries (see Figure 9). However, the new product ratio of domestic enterprises is 27.79%, lower than enterprises from HMT with the ratio of 32.69% and foreign enterprises with the ratio of 31.97%, which indicates that the innovation capability of domestic enterprises in Beijing is lower than foreign enterprises. In addition, though the industrial economic scale of Beijing was dominant by domestic enterprises with the proportion of 58.19%, there is a big gap between domestic enterprises and foreign enterprises in high-tech manufacturing industries. In 2008, the output value of high-tech manufacturing industries created by foreign enterprises was 238.31 billion yuan, accounting for 79.55% of the total output, while the proportion of domestic enterprises was only 20%.

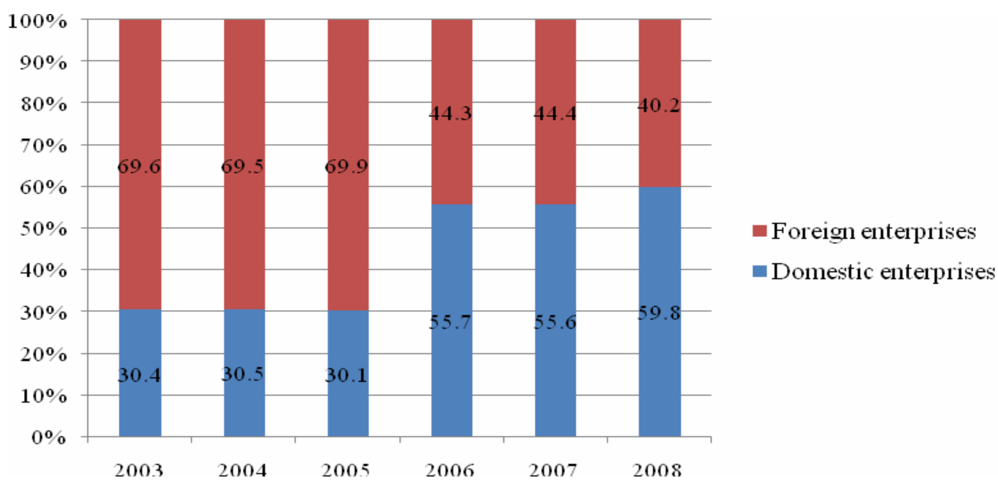
Figure 9: Output value and new product output value created by domestic and foreign industrial enterprises, 2008 (billion yuan)



Source: Beijing Statistical Yearbook, 2009.

For the export generated by foreign enterprises and domestic enterprises, before 2006, the proportion of export by domestic enterprises had been keeping at 30%. But it jumped into 60% in 2006, and since then it has maintained at this level (see Figure 10).

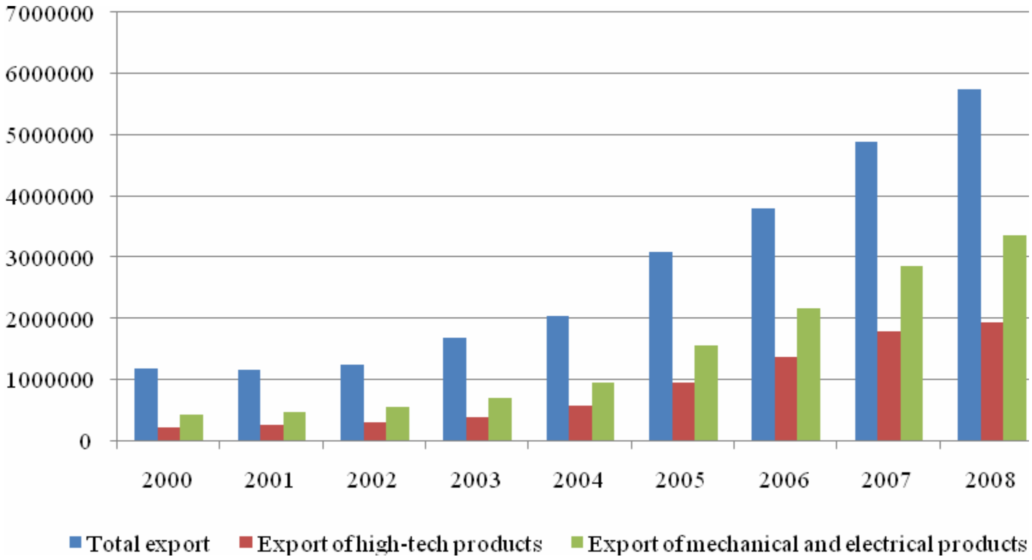
Figure 10: Proportion of export by domestic and foreign enterprises, 2003-2008 (%)



Source: Beijing Statistical Yearbook, 2004-2009.

The export of Beijing has increased from 11969.16 million US dollars in 2000 to 57454.24 million US dollars in 2008, among which 1/3 (33.89%) are high-tech products, and more than half (58.50%) are mechanical and electrical products10 (see Figure 11).

Figure 11: Export and its composition of Beijing, 2000-2008 (USD 10,000)



Source: Beijing Statistical Yearbook, 2009.

There is no precise data about how many enterprises have R&D labs for total but only for large and medium-size enterprises. A surprising fact is that many large and medium-sized enterprises have reduced their R&D labs in the three years after 2001; the reasons for this phenomenon may be out of merging, joint venture and ownership transformation which made them to cut off their previous R&D labs (Table 5). But after 2005, the share of enterprises with R&D labs has increased and reached 28.7% by 2007. Though large and medium sized enterprises have continuously increased their R&D, it still remains at a low level. In 2007, their R&D spending relative to sales was only about 0.8%.

[10] Here, high-tech products mainly include computer and telecommunication technology, electronic technology, and life science technology; mechanical and electrical products mainly include metal products, mechanical equipment, electrical equipment and electronic products, instrument and meter.

Table 5: R&D expenditure and R&D labs in large and medium-sized enterprises in Beijing, 2000-2007

Year	Number of enterprises	Share of enterprises with R&D labs (%)	R&D expenditure (10,000 yuan)	R&D/sales (%)
2000	486	26.1	-	-
2001	621	18.7	-	-
2002	565	18.2	-	-
2003	432	18.1	359535	-
2005	520	19.0	396471	0.7
2006	567	22.1	588451	0.9
2007	606	28.7	612204	0.8

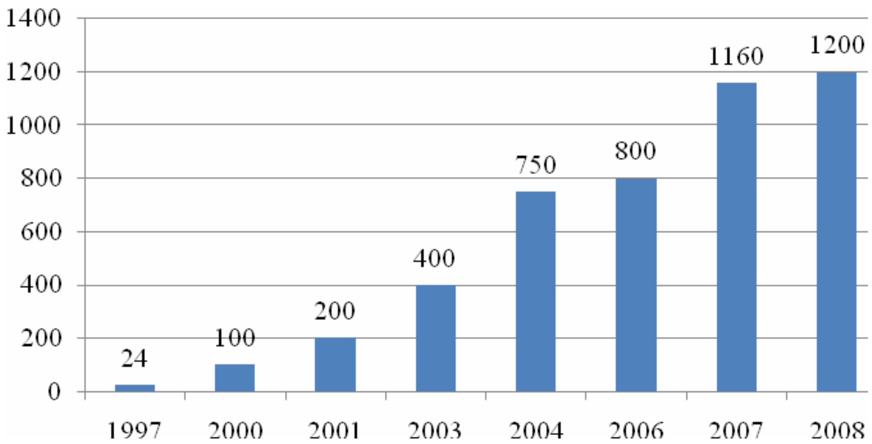
Note: no data of 2004.

Source: China Statistical Yearbook on Science and Technology.

Meanwhile, the internationalization of R&D has represented a potentially very significant change in the structure and performance of the regional innovation system. Except that some local enterprises began to establish R&D institutions abroad or implemented overseas M&A describes as section 1, with the rapid development of China's economy and science and technology, more and more multinationals started to localize their R&D and establish R&D centres in China in order to acquire huge market and take advantage of China's cheap R&D human resources. 11In 1994, Northern Telecom of Canada established a joint R&D centre with Beijing University of Post and Telecommunication (BUPT), which was the first R&D institution established by multinationals in China, and followed with the introduction of "Approach on Encouraging the Establishment of Sino-Foreign Cooperative or Joint R&D Center" by Chinese government in 1997, setting up R&D institutions in China has become a boom for multinationals. By the end of 2008, there have been 1200 foreign R&D institutions in China (see Figure 12), among which 465 were independent R&D institutions with the total investment of 12.8 billion US dollar and registered capital of 7.4 billion US dollars. Although suffering from the global financial crisis, the desire of multinationals to set up R&D institutions in China continues unabated.

[11] According to UNCTAD (2005), 61.8% of multinationals choose China as their most preferred location for overseas R&D in 2005-2009, followed by USA (41.2%) and India (29.4%).

Figure 12: Number of R&D institutions established by multinationals in China



Source: Ministry of Commerce (2009).

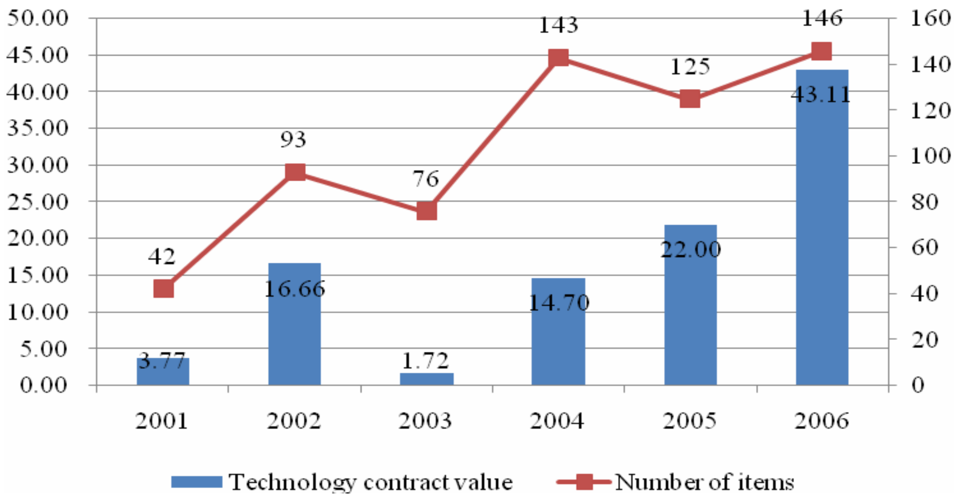
As Beijing is an important innovation centre with great talent pool and strong scientific and technological resources, it undoubtedly becomes the first choice for multinationals to establish R&D institutions when entering into China. By the end of 2007, there were 278 R&D institutions established by multinationals locating in Beijing, accounting for 1/4 of the total number of China (Ministry of Commerce, 2009). In June 1999, the local government of Beijing introduced "The Interim Provisions on Encouraging the Establishment of Research and Development Institutions in Beijing", which was the first local policy specially for R&D institutions established by multinationals, and greatly promoted the foreign R&D investment in Beijing. It is worth mentioning that Zhongguancun Science Park plays an important role in attracting R&D facilities established by multinationals, which is the earliest region with the emergence a cluster of R&D facilities established by multinationals in China. In September 2005, IBM China Research Laboratory (CRL) was established in Zhongguancun, and followed by Microsoft China Research & Development Center in the same year, Intel China Research Center (ICRC) in 1998, Motorola China Research and Development Institute (MCRDI) in 1999, Bell Labs Research China in 2000, Novo Nordisk (China) R&D Center,[12] most of which were very famous multinationals. Up to now, more than 70 multinationals in "Fortune Top 500" have set up their R&D institutions in Zhongguancun Science Park. R&D institutions established in Beijing are focusing on the fields of ICT and bio-technology.

Figure 13 shows the technology deal activities of these R&D centres established by multinationals in Beijing. The number of technology items sold by these R&D centres have increased in recent years and reached 146 in 2006, the contract value of which was 4.31

[12] Novo Nordisk (China) R&D Center was initially established in Beijing Economic-Technological Development Area on Jan 25th, 2002, and was relocated to Beijing Zhongguancun Life Science Park on July 1st, 2004. This center was registered as an independent company in April 2006, and named "Beijing Novo Nordisk Pharmaceuticals Science and Technology Co., Ltd." up to now.

billion yuan. This indicates that these R&D centers established by multinationals are very active in R&D activities.

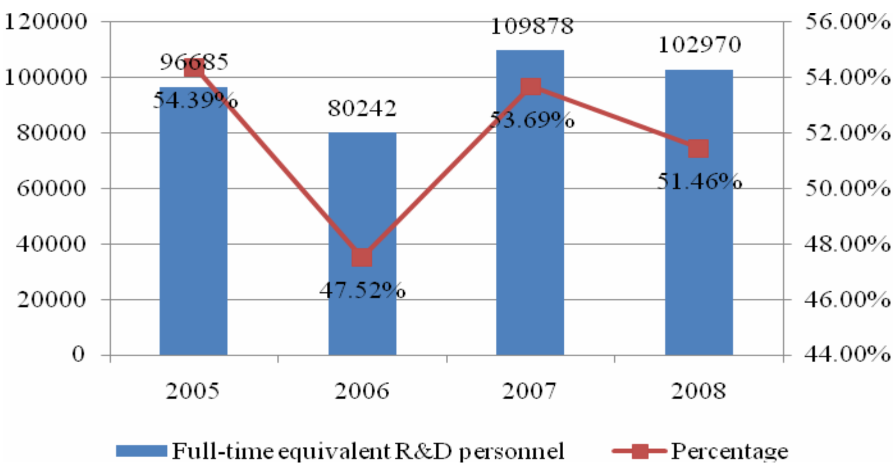
Figure 13: Technology items and contract value sold by multinationals with R&D Centres in Beijing, 2001-2006 (item, 100 million yuan)



Source: OTMM, 2007

In recent years, the number of full-time equivalent R&D personnel in enterprises has maintained at the level of 100,000, and the percentage of which in Beijing's total full-time equivalent R&D personnel was around at 50% (see Figure 14).

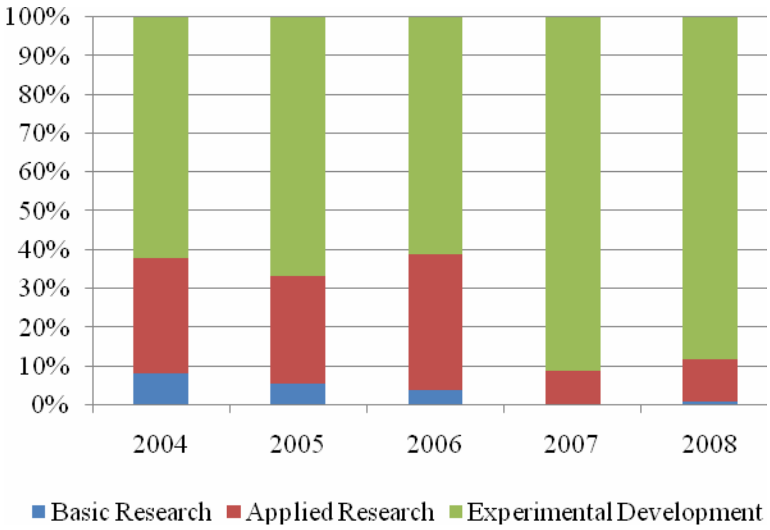
Figure 14: Full-time equivalent R&D personnel in enterprises and its proportion of Beijing, 2005-2008 (person year, %)



Source: Beijing Statistical Yearbook, 2006-2009.

Before 2007, about 60% of R&D expenditure in enterprises was performed on experimental development, more than 20% was performed on applied research, and only less than 10% was performed on basic research. While since 2007, the proportion of R&D expenditure on experimental development has increased into 90% (see Figure 15).

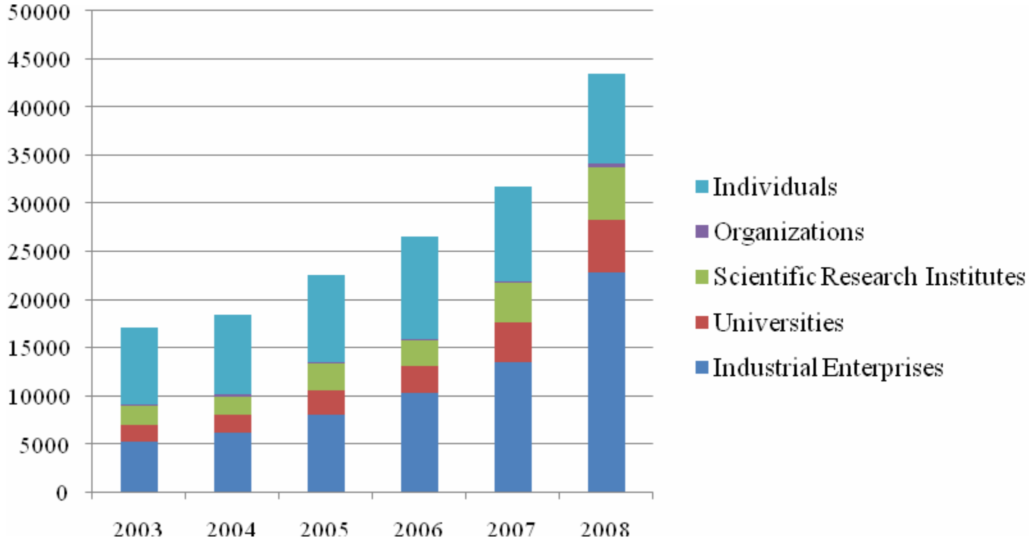
Figure 15: The structure of R&D expenditure of enterprises in Beijing, 2004-2008 (%)



Source: Beijing Statistical Yearbook, 2005-2009.

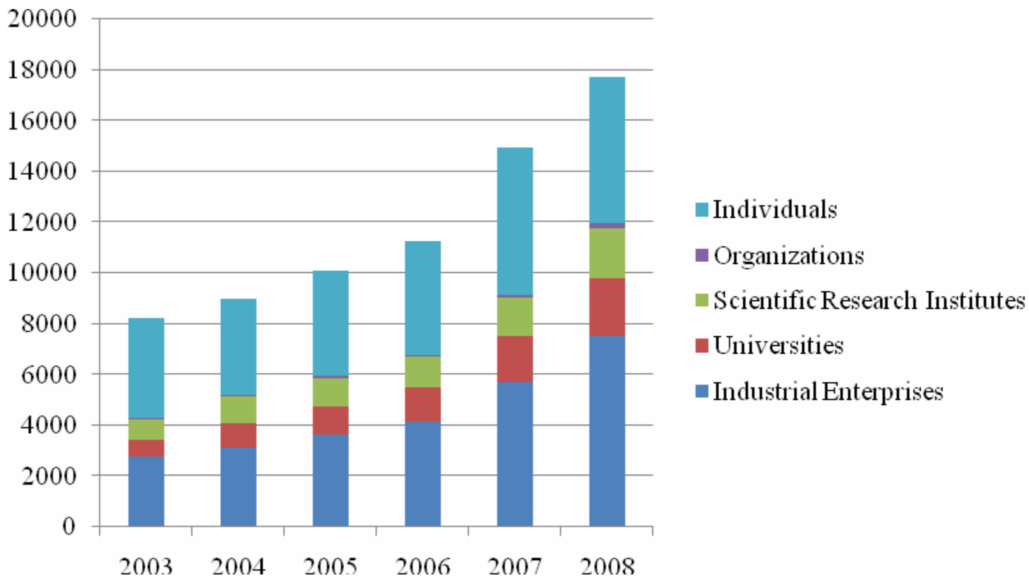
Compared with other innovation actors such as universities and research institutes, the number of patent applications and granted patents by industrial enterprises has experienced a very fast growth. Their patent applications has reached 22792 in 2008, which is three times greater than that (5253) of 2003 (see Figure 16); and granted patents has increased by 1.71 times from 2778 to 7518 in the same period (see Figure 17). Moreover, the proportion of patent applications by industrial enterprises in total has increased from 30.89% in 2003 to 52.39% in 2008, and the proportion of granted patents has increased from 33.68% to 42.36%. This indicates that the innovation capability of industrial enterprises in Beijing has significantly improved in recent years.

Figure 16: Patent applications by different actors of Beijing, 2003-2008 (%)



Source: Beijing Statistical Yearbook, 2004-2009.

Figure 17: Patents granted by different actors of Beijing, 2003-2008 (%)



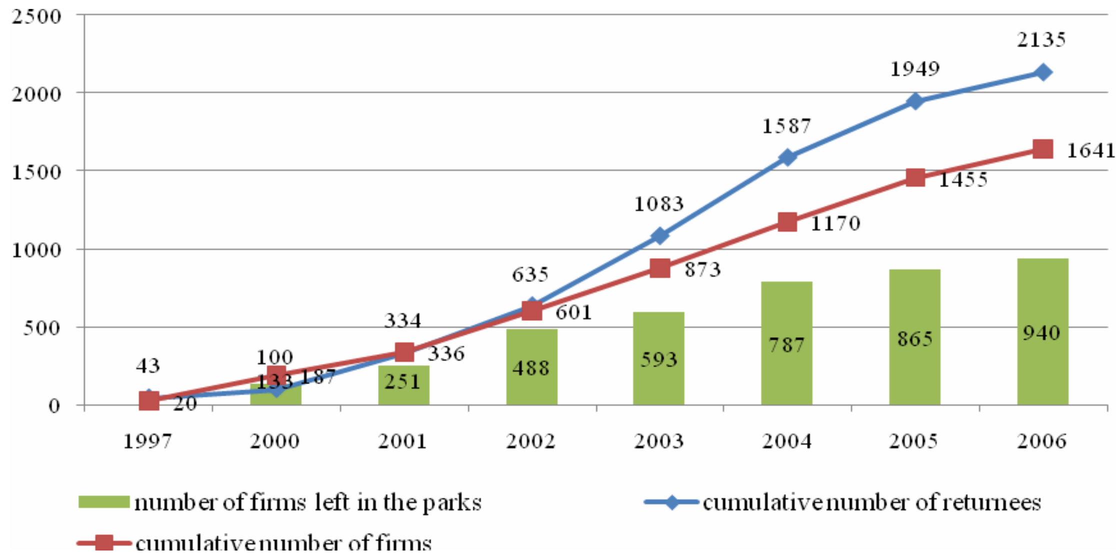
Source: Beijing Statistical Yearbook, 2004-2009.

3.1.3. Venture businesses by returnees from abroad

Entrepreneurs are the most important source for high-tech enterprises in long-established, as well as in newly founded, technology-based firms (Zhu and Tann, 2005). China has a large pool of human resource in the world. How to use this pool, particular attracting them to come back to be entrepreneurs is a critical problem for China's national or regional innovation policy. The entrepreneurship park is an important vehicle to introduce, cultivate and make full advantages of returnees from abroad, and is a business base where they could display their talents. Through introducing returnees from abroad, the entrepreneurship park could introduce high-tech programs host by them, and help them realize the commercialization and industrialization of technological programs. It is estimated that more than 80% of returnees tend to work in Beijing, and more than 50% of returnees tend to work only in Beijing rather than other cities, because of Beijing's great attraction.[13] In 1997, Beijing Overseas Students Service Center and Haidian Entrepreneurship Service Center of Zhongguancun Science Park co-established Beijing Haidian Entrepreneurship Park for Returnees from abroad, the first entrepreneurship park for returnees in Beijing region. Up to now, Beijing has established 23 entrepreneurship parks for returnees, which formed an entrepreneur network.

By the end of 2006, all the entrepreneurship parks in Beijing has attracted 2135 returnees from abroad and they have established 1641 firms. In 2006, 940 firms were still running within the park, other 701 firms have left the parks, and among which 562 firms left because of regular graduation (see Figure 18). Among all the returnees in these parks, 36.46% hold doctoral degree and 55.62% hold master degree.

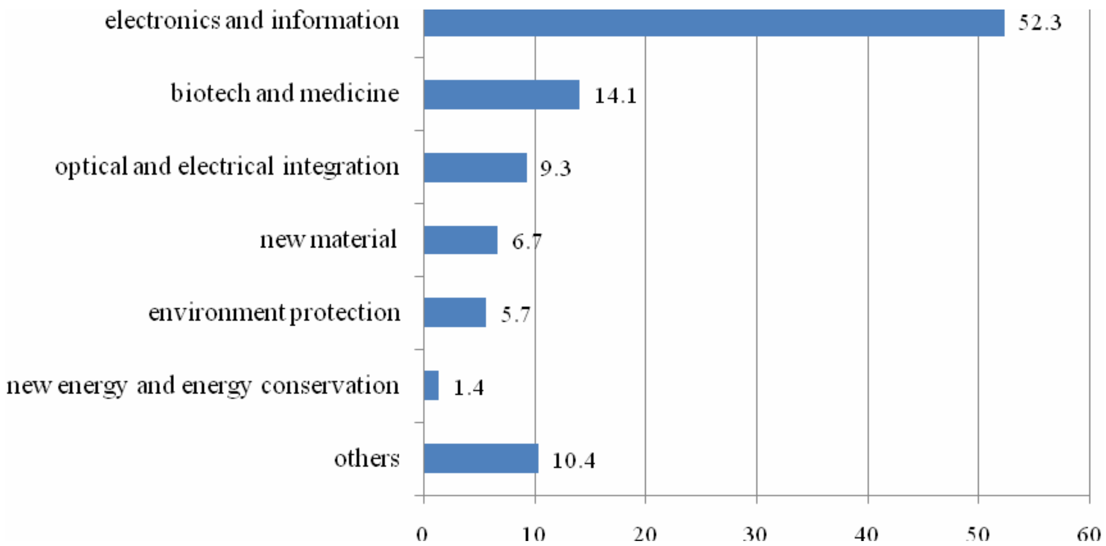
Figure 18: Number of returnees from abroad and enterprises established in entrepreneurship parks of Beijing



[13] Beijing Youth Newspaper, July 2, 2007.

Though the number of firms established by returnees from abroad is limited compared with the total number of firms in Beijing, they play an increasingly important role in the regional innovation and the upgrading of economic structure. For the 940 firms running in the parks, 52.3% are in the electronic and information industry, and 14.1% are in the biotech and medicine industry (see Figure 19). All the industries shown in Figure X are high-tech industries promoted by the government of Beijing.

Figure 19: Industry compositions of enterprises established by returnees from abroad in entrepreneurship Parks of Beijing



Beijing Entrepreneurship Parks for Returnees from Abroad have the following characteristics: First, most entrepreneurship parks in Beijing are incubator-based, assuming the function of incubating start-ups in their early stage established by returnees from abroad. In China, there are two types of entrepreneurship parks for returnees: incubator-base and development zone-based. All the entrepreneurship parks in Beijing are the former one except for 2 parks, Daxing Entrepreneurship park and Airport Entrepreneurship park. These parks would provide a incubating space of 40~60 square meters for start-ups. Generally, the incubating period is 3 years, during which various incubating services would be provided, such as special technological funds, venture capital support, loan guarantee, the return of registered capital, specialized training, and so on.

Second, most entrepreneurship parks for returnees of Beijing are co-established by multi-party, including government department (such as Beijing Overseas Students Service Center, Administrative Committee of Zhongguancun Science Park, Bureau of Personnel), public institutions (such as Institute of Automation of Chinese Academy of Sciences), universities (such as Tsinghua University, Peking University) and enterprises (such as Shouchuang Group). This pattern can benefit from pooling of resources of different actors. Notably, in

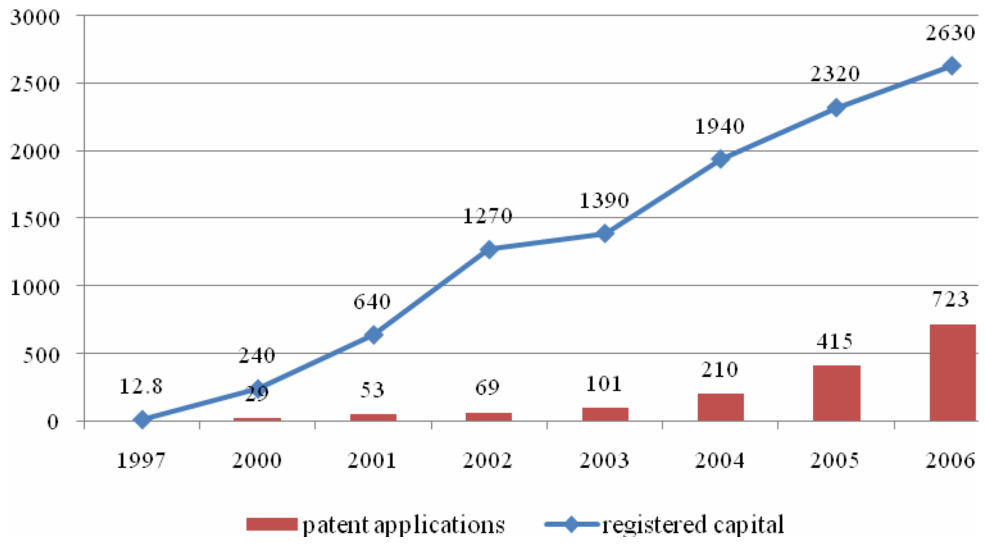
Beijing, the university entrepreneurship parks for returnees are unique in China, there are 11 university entrepreneurship parks here, account for 48% of all the entrepreneurship parks in Beijing.

Third, after years of development, most of entrepreneurship parks in Beijing have transformed from a comprehensive one into a specialized one by means of identifying a set of industries to attract returnees from abroad. For instance, Haidian Park focuses on electronic and information, as well as biotech and medicine industries, Entrepreneurship Park of Beijing University of Science and Technology is focusing on new material industry, Entrepreneurship Park of Beijing University of Posts and Telecommunications is focusing on communication industry, Zhongguancun Integrated Circuit Entrepreneurship Park is focusing on integrated circuit research and development, both Zhongguancun Software Entrepreneurship Park and Entrepreneurship Park of Beijing University of Aeronautics & Astronautics are focusing on software industry, both Entrepreneurship Park of Renmin University of China and Zhongguancun Digital Entertainment Entrepreneurship Park are focusing on cultural and creative industries.

Fourth, the distribution of entrepreneurship parks in Beijing is reasonable. Among all the 23 parks, 16 parks distribute in Haidian Park, which is a concentrated area of research institutes and universities. In other key development areas of Beijing, parks have also been established to promote balanced regional economic growth.

With the expansion of entrepreneurship parks and a growing number of admitted firms, the registered capital of firms established in the parks have increased from 12.8 million yuan in 1997 to 2.63 billion yuan. Though the size of most firms in entrepreneurship parks are small, their patent applications increased very rapidly, in 2006, the number of patent applications has reached 723 pieces (see Figure 20).

Figure 20: Registered capital and patent applications of enterprises in entrepreneurship parks of Beijing (million yuan; piece)



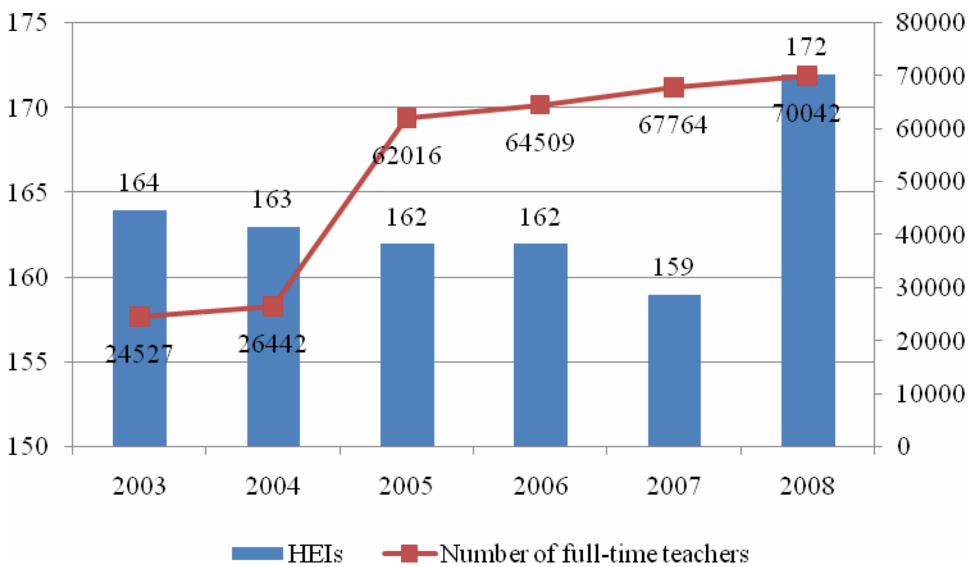
3.2. Educational and Research Infrastructure

In knowledge economies, university and research institutes are vital actors in the creation, acquisition, dissemination, and utilization of knowledge (Nelson and Rosenberg, 1993). They can also be key elements in regional innovation systems because of the geographic spillovers of knowledge both through their roles as a human capital provider and as a technology incubator (Chen and Kenney, 2007). Beijing is the centre of education and research in China, most endowed with top-quality universities and research institutes. In 2008, 172 higher educational institutions (HEIs) and 117 research institutes (RIs) were located in Beijing, and the most prominent of these were Tsinghua University, Peking University, and Chinese Academy of Sciences (CAS).

3.2.1 Educational Infrastructure

Beijing is the centre of the Chinese university education system. By 2008, there were 172 HEIs in Beijing, among which 82 were regular HEIs, 26 were adult HEIs, and 64 were private HEIs. The number of full-time teachers in HEIs of Beijing increased sharply by 1.3 times than the previous year in 2005, and since then it has kept a steady growth, by 2008, it has reached to 70,042 (see Figure 21). In the latest university ranking of 2010, 25 of the top 100 universities of China are located in Beijing, among which 4 universities were in the top 10. Of the eight Chinese universities listed in the top 100 Asian Pacific universities, the top two are Tsinghua University and Peking University (Shanghai Jiaotong University, 2005).

Figure 21: Number of HEIs and full-time teachers of Beijing



Source: Beijing Statistical Yearbook, 2004-2009.

Not only HEIs, but also most research institute in Beijing play the role as a human capital provider, while the latter could only recruit and train graduate students rather than undergraduates. In Beijing, more than 90 research institutes recruit and train graduate students each year. Table 6 shows the number of graduates getting bachelor, master and doctoral degrees from Beijing and China respectively in recent years. In 2008, the number of these three kinds of graduates of Beijing account for 4.55%, 14.86% and 25.82% of the total number of graduates of China, from which we can find that Beijing made a great contribution to provide senior talents, particular master and PhD students, for the whole country. For Beijing is a most attractive place for talents, as well as most graduates would choose to stay in the same city after graduation, Beijing have developed a talent pool with all kinds of excellent personnel, which become a key characteristics of the regional innovation system of Beijing.

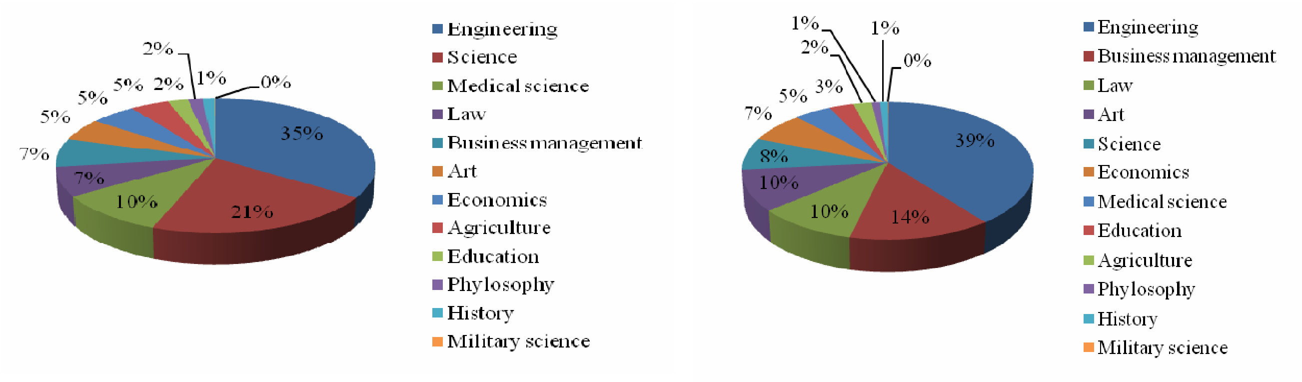
Table 6: Graduates with Bachelor, Master and Doctoral degrees each year of Beijing and China, 2004-2008 (Person)

Year	**Bachelor**			**Mater**			**Doctor**		
	Beijing	China	Percentage	Beijing	China	Percentage	Beijing	China	Percentage
2004	72679	1465786	4.96%	23276	162051	14.36%	6273	27677	22.67%
2005	85109	1465786	5.81%	27381	162051	16.90%	7770	27677	28.07%
2006	91756	1726674	5.31%	36681	219655	16.70%	9433	36247	26.02%
2007	95052	1995944	4.76%	42101	270375	15.57%	10658	41464	25.70%
2008	102631	2256783	4.55%	44748	301066	14.86%	11298	43759	25.82%

Source: China Statistical Yearbook, Beijing Statistical Yearbook, 2005-2009

According to the major distribution of these graduates from Beijing, 35% of the graduates held the master' degree of engineering, followed by science, the number of graduates with master's degree of these two majors account for 56% of total master graduates in 2008; while among graduates holding the doctoral degree, 39% were in the major of engineering, followed by business management, the number of graduates with doctoral degree of these two majors account for 53% of total doctoral graduates in the same year (see Figure 22). From which we can see that the major distribution of senior talents training in Beijing are consistent with the development of its key industries.

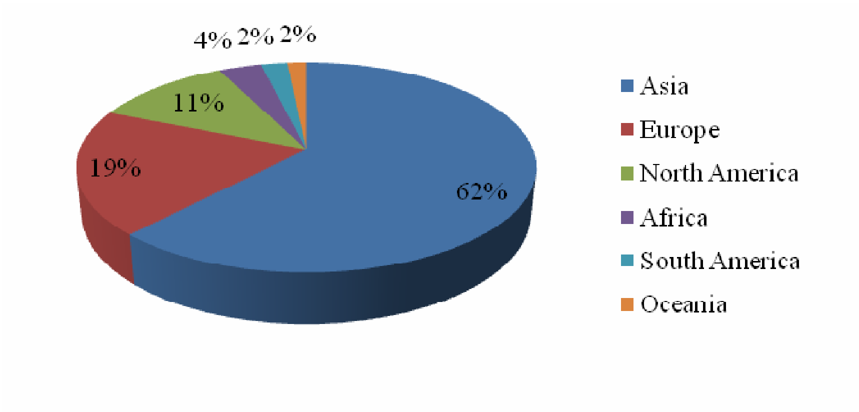
Figure 22: Major distributions of graduates with Master and Doctoral degrees in Beijing, 2008 (%)



Source: Beijing Statistical Yearbook, 2009.

Currently, more and more foreign students would like to study in Beijing. In recent years, the number of new enrolment of foreign students of Beijing has maintained at 23,000 per year, among which 62% comes from Asia, 19% from European countries, 11% come from North America, 4% come from Africa, and 2% each from South America and Oceania (see Figure 23). Since 2008, Beijing has planned to provide no less than 35 million yuan of government scholarship per year to attract foreign students to study in universities in Beijing, and no less than 15 million yuan for Chinese language promotion per year (Beijing Municipal Commission of Education, 2008).

Figure 23: Country distribution of new enrolment of foreign students in Beijing, 2008 (%)



Source: Beijing Statistical Yearbook, 2009.

3.2.2 Research Infrastructure

As an important innovation centre in China, Beijing brings together a large number of research personnel and research resources compared with other cities in China. In the past ten years, about 33% of research institute R&D spending and 15% of university R&D spending of the whole country have taken place in Beijing (see Table 7). Take research facilities as an example, there are 58 State Key Laboratories in Beijing currently, accounting for 26.36% of the total number of China. 14Taking research talents as another example, by 2007, there were 719 academicians in Beijing, accounting for 50% of the total number of China, among which 405 were affiliated to Chinese Academy of Sciences, and 314 were affiliated to Chinese Academy of Engineering. Based on such strong research facilities and human capitals, many research projects of Beijing received funding from the country. In 2007, Beijing obtained a funding of 1.18 billion yuan from "973 Program", and 1.62 billion yuan from "863 Program", 9.38 billion yuan from "Science and Technology Support Program", accounting for 47.0%, 22.8%, and 55.3% of the total number of China respectively.

Table 7: The percentage of research institute R&D spending and university R&D spending of Beijing in China, 2000-2008 (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Research institute R&D spending	33.33	31.56	33.39	34.61	35.94	35.47	33.43	34.57	32.13
University R&D spending	22.74	20.37	18.06	15.66	14.29	15.09	13.46	15.14	14.31

Source: China Statistical Yearbook on Science and Technology, 2001- 2009.

Beijing is home to more research institutes than any other cities in China. By 2008, here were 266 research institutes (RIs) in Beijing, among which 38 were affiliated to Chinese Academy of Sciences (CAS), 36 affiliated to Chinese Academy of Social Sciences (CASS), 151 affiliated to the ministries of State Council, and 41 were local RIs of Beijing. Of all these RIs, 178 were natural science-based. In RIs of Beijing, 70,000 persons were engaged in scientific and technological activities, and the average funding for science and technology per capita reached 436,000 yuan in 2008.

From the 1950s to the 1980s, RIs was established at different administrative levels in China with various goals and orientations. The most important of these were at the national level, such as the Chinese Academy of Sciences (CAS), which was founded in 1949, and is the largest research institution in the world. Most basic scientific research was done by CAS and some large research universities such as Tsinghua University and Peking University. There were also hundreds of industrial research institutes under a wide range of industrial ministries in different regions, focusing on applied research and developmental tasks. Thus, there are two types of RIs in Beijing: first is basic research oriented, such as CAS. CAS has 12

[14] In 1984, China launched the program of "State Key Laboratory", up to now, there are 220 State Key Laboratories distributing in 22 provinces across the country.

branches and more than 100 RIs throughout China, but many of the 38 RIs which locate in Beijing are the largest and most prestigious ones. Currently, CAS employed approximately 50,000 scientists and engineers, as well as 35,000 graduate students. It was China's leading research institution in terms of publications and patents. The second type is applied research and development oriented including those affiliated to ministries and local RIs.

However, since the beginning of China's economic reforms, the innovation system has undergone significant changes, in terms of the relative importance of key actors and the mechanisms that drive the development of the innovation system. The government driven by a desire to lower the cost of supporting RIs drastically cut their funding, including the RIs in Beijing. As shown in Table 8, the share of R&D expenditure by RIs in the total R&D expenditure nationwide has gradually decreased from 42.60% in 1998 to 17.58% in 2008, while the corresponding share for enterprises has increased from 44.80% to 73.26% in the same period. This change is driven by a combination of the restructuring of research institutes, the expansion of the higher education sector and the strengthening of innovation capacity of enterprises. Same changes have also happened with Beijing, however, the R&D expenditure by RIs still accounted for more than 40% of the total, and the percentage of enterprises has increased very limitedly, only from 8.10% in 1998 to 12.89% in 2008. This further manifested the functional characteristics and key research position of Beijing.

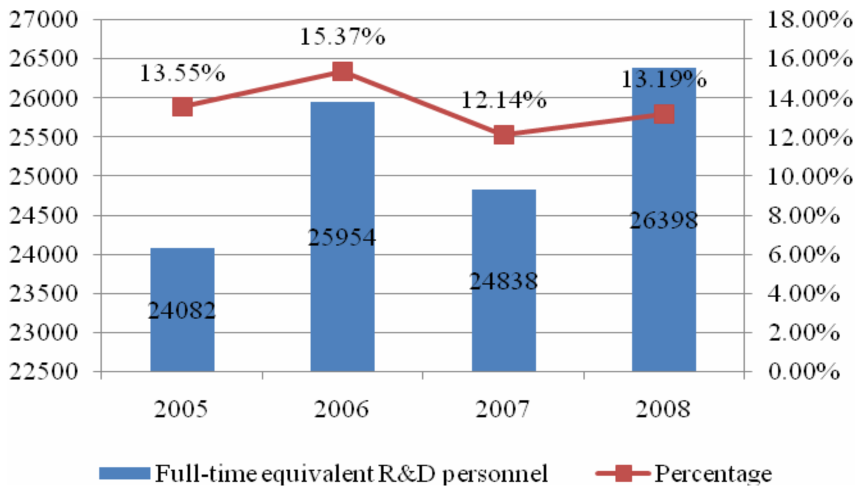
Table 8: The relative importance of key actors in R&D expenditure (%)

Year	**Research institutes**		**HEIs**		**Enterprises**		**Others**	
	Beijing	China	Beijing	China	Beijing	China	Beijing	China
1998	80.96	42.60	10.94	10.40	8.10	44.80	-	2.20
1999	80.94	38.50	9.65	9.30	6.08	49.60	-	2.60
2000	55.30	28.84	11.21	8.57	10.07	60.29	-	2.30
2001	53.18	27.67	12.18	9.82	12.33	60.41	-	2.10
2002	53.43	27.28	10.73	10.13	12.97	61.19	-	1.40
2003	53.89	25.91	9.92	10.54	14.03	62.40	-	1.15
2004	48.97	21.95	8.93	10.22	40.88	66.83	1.23	1.00
2005	43.20	20.94	9.42	9.89	46.23	68.32	1.15	0.85
2006	43.80	18.89	8.60	9.22	46.19	71.08	1.41	0.82
2007	45.11	18.54	9.04	8.48	44.20	72.28	1.64	0.69
2008	42.04	17.58	8.98	8.45	47.10	73.26	1.88	0.71

Source: China S&T Data Book, Beijing Statistical Yearbook, 1999- 2009.

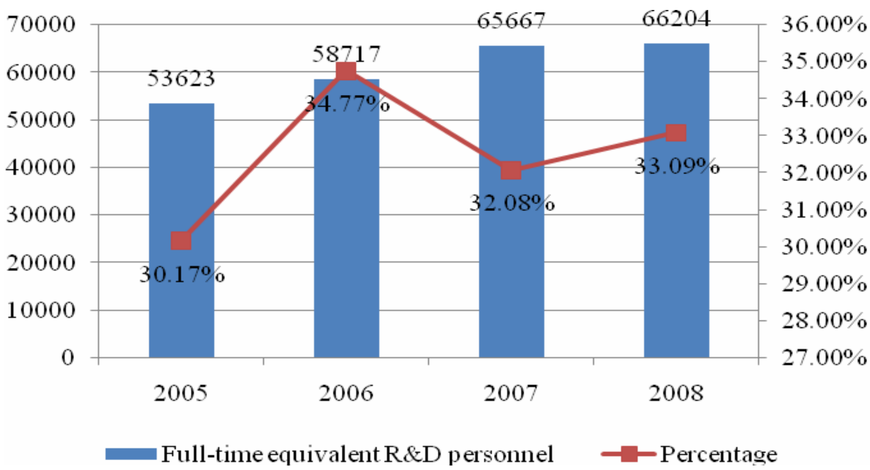
In recent years, the number of full-time equivalent R&D personnel in HEIs has flattering at the level of 25,000, and the percentage of which in total full-time equivalent R&D personnel of Beijing was around at 13% (see Figure 24). While the number of full-time equivalent R&D personnel in RIs has increased slowly and reached 66,204 by 2008 (see Figure 25), the proportion of which was around 33%. Nevertheless, the proportions of full-time equivalent R&D personnel in HEIs and RIs were far less that of enterprises. This phenomenon can only indicate the changing role of enterprises as the key actor of innovation, but not deny the status of HEIs and RIs in research, especially basic research, which we will make a further explanation in the latter.

Figure 24: Full-time equivalent R&D personnel in HEIs of Beijing, 2005-2008 (person year, %)



Source: Beijing Statistical Yearbook, 2006-2009.

Figure 25: Full-time equivalent R&D personnel in RIs of Beijing, 2005-2008 (person year, %)



Ssource: Beijing Statistical Yearbook, 2006-2009.

The funding for science and technology activities in HEIs of Beijing has increased rapidly from 2.96 billion yuan in 2000 to 12.38 billion yuan in 2008, accounting for 16.90% of the whole country. Among the total funding, the percentages of government funding and enterprise funding have been flattering at the level of 60% and 30% respectively (see Table 9). This shows a close relationship between HEIs and enterprises. The research component of

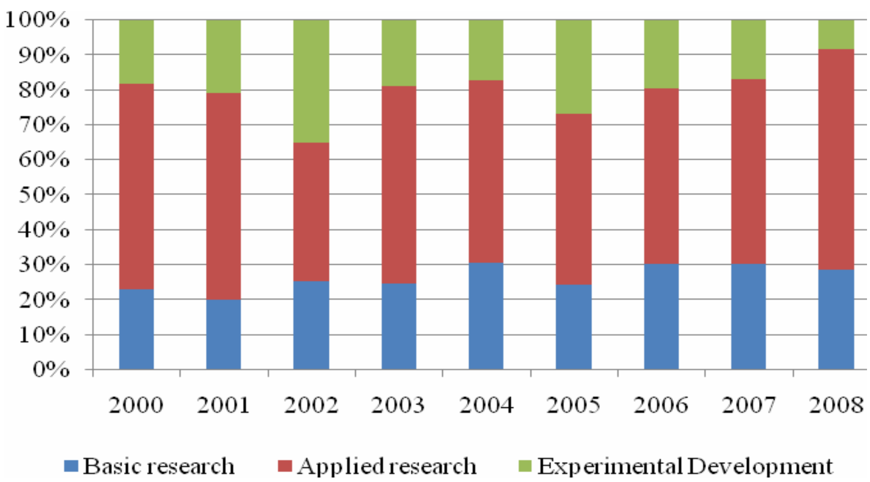
HEIs has increased steadily in recent years, by 2008, 90% of R&D expenditure were performed on basic research (30%) and applied research (60%) (see Figure 26). This means that HEIs play a very important role in the basic research of Beijing.

Table 9: Source of funding for science and technology activities in HEIs in Beijing, 2000-2008 (10,000 yuan, %)

Year	Total Funding for S&T Activities	Funds from government		Funds from enterprises	
		Number	Percentage	Number	Percentage
2000	296048	182685	61.71	85041	28.73
2001	339386	205146	60.45	92008	27.11
2002	404572	243627	60.22	131430	32.49
2003	508181	272864	53.69	170492	33.55
2004	623810	365077	58.52	205146	32.89
2005	807147	462760	57.33	291558	36.12
2006	902442	529601	58.69	311960	34.57
2007	1055869	630362	59.70	336845	31.90
2008	1238167	775320	62.62	376630	30.42

Source: China Statistical Yearbook on Science and Technology, 2001- 2009.

Figure 26: The structure of R&D expenditure of HEIs in Beijing, 2000-2008 (%)



Source: China Statistical Yearbook on Science and Technology, 2001-2009.

The funding for science and technology activities in RIs of Beijing has increased from 20.35 billion yuan in 2001 to 43.14 billion yuan in 2008, accounting for 30.88% of the whole country. Among the total funding, the percentage of government funding increased from

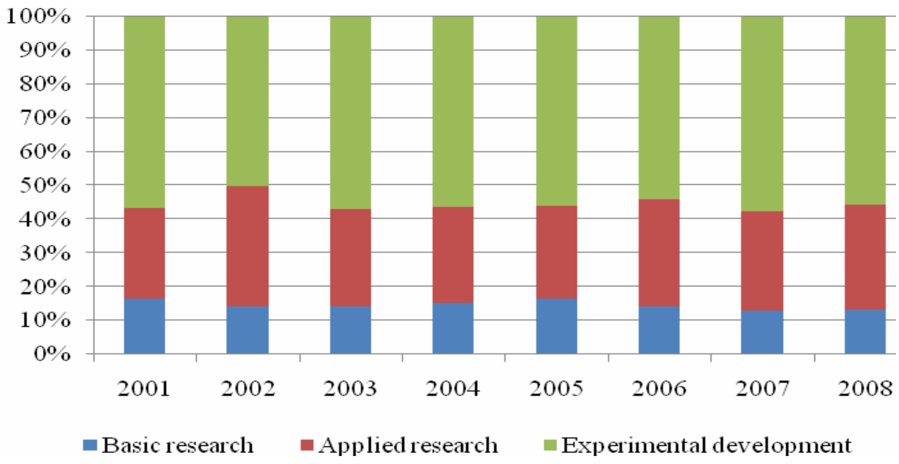
64.80% in 2001 to 85.11% in 2008, in absolute terms it was two times greater in 2008 than it was in 2001 (see Table 10), which indicates that RIs are still heavily relying on direct funding from government. However, the structure of R&D expenditures on basic research, applied research and experimental development didn't change correspondingly, maintaining at the level of 15% on basic research, 30% on applied research, and 55% on experimental development (see Figure 27). Compared with HEIs, RIs are more experimental development oriented, because (1) nearly 60% of research institutes in Beijing are affiliated to ministries and have a close relationship with industrial development; and (2) the corporatization of many RIs led to their reorientation and pursuing commercial goals.

Table 10: Source of funding for science and technology activities in RIs in Beijing, 2001-2008 (10,000 yuan, %)

year	total	funds from government		funds from enterprises		loans from finance institutions	
		number	percentage	number	percentage	number	percentage
2001	2035332	1318853	64.80	66032	3.24	1356	0.07
2002	2200331	1655904	75.26	56806	2.58	5396	0.25
2003	2392915	1654259	69.13	157100	6.57	13706	0.57
2004	2584592	2058865	79.66	141950	5.49	10500	0.41
2005	3018144	2471024	81.87	137015	4.54	30424	1.01
2006	3240896	2752569	84.93	133421	4.12	9391	0.29
2007	4065610	3450365	84.87	107894	2.65	13117	0.32
2008	4313966	3671576	85.11	102870	2.38	20083	0.47

Source: China Statistical Yearbook on Science and Technology, 2002- 2009.

Figure 27: The Structure of R&D expenditure of RIs in Beijing, 2001-2008 (%)



Source: China Statistical Yearbook on Science and Technology, 2002-2009.

In 2008, 48076 scientific publications of Beijing were cited by SCI, EI, and ISTP, ranking 1st and accounting for 17.75% of the total number of China. The distribution of these cited scientific publications were shown in Table 11, from which we can see that 67.78% of cited scientific publications of Beijing were from HEIs, and 29.45% were from RIs.

Table 11: Scientific publications cited by SCI, EI, and ISTP of Beijing, 2008

	Total	**HEIs**	**RIs**	**Enterprises**	**Hospitals**	**Others**
Number	48076	32588	14158	700	525	105
Percentage	100%	67.78%	29.45%	1.46%	1.09%	0.22%

Source: Chinese S&T Papers Statistics and Analysis, 2008.

3.2.3 University and Research Institutes Spin-offs

There is substantial evidence that universities around the world are adopting a policy of encouraging entrepreneurship (Goldfarb and Henrekson, 2003; Shane, 2004; Rappert et al., 1999), and Beijing is one of such example. The universities and research institutes in Beijing not only function as human capital and knowledge providers, but also generated spin-offs and established science parks to commercialize their research and technologies.

Currently, there are 14 university science parks in Beijing, among which 13 are national-level science parks. By the end of 2004, there were 417 spin-offs from 45 universities in Beijing with more than 36,000 persons, the total assets of which reached 55.9 billion yuan. In 2006, the revenue created by university spin-offs in Beijing were 61.55 billion yuan, accounting for 52.73% of total number of China; the profit were 3.14 billion yuan, accounting for 52.81% of total number of China. The share of revenues created by spin-offs from Peking University (31.40 billion yuan) and Tsinghua University (22.91 billion yuan) in total number of China were 46.53%., among which the revenue of Founder Group from Peking University were 29.83 billion yuan, and Tongfang from Tsinghua University were 12.32 billion yuan (Ministry of Education, 2007).

In the late 1980s, universities and research institutes in China were allowed and encouraged to set up their own spin-offs with three fundamental purposes: first, universities and research institutes could commercialize their technology and research results directly through spin-offs, during which they could be more integrated in economic activities; second, spin-offs would provide universities and research institutes with some financial resources, which could compensate for budget cuts from the government; third, spin-offs are platforms to promote linkages among industry, education and research. For example, the close organizational tie between the university and the spin-offs integrates postgraduate education into industrial R&D (Lazonick, 2004), and the spin-offs would provide internship opportunities to students at the university, many of whom are hired directly after graduation.

After more than twenty years' development, spin-offs have become an important economic force competing with other types enterprises in China, which promoted the development of high-tech industries, and this policy also gave birth to many successful high-tech companies, such as Lenovo (from CAS) and Founder (from Peking University), Tongfang (from Tsinghua University), which are now leading enterprises in China's ICT industry. Many biotechnology companies are also spin-offs, such as Beijing Shuanglu Pharmaceutical Co. Ltd., which was founded by former researchers from research institutes (Liu and Lundin, 2006). Many spin-offs have published.

8.3. Government

During the era of central planning for R&D activities, the Chinese government had ultimate oversight and control over R&D plans and resource allocation under the highly centralized planning system modeled on that of the former Soviet Union. Having embarked on reform in early 1980s, the Chinese government began to address a series of measures to encourage innovation activities with a shift towards a less interventionist role, allowing greater decision-making at the local level. Since then the local government of Beijing developed a number of policies in encouraging knowledge intensive activities in order to improve regional innovation capabilities, which also lay a foundation for Beijing to become a global knowledge hub. We illustrate how these policies facilitate Beijing to become such a hub from the following four aspects.

3.3.1. Creating an innovation friendly business environment

The local government mainly took the following measures to create an innovation friendly business environment: first is patent protection. For example, in October 2005, Beijing Municipal People's Congress Standing Committee issued the "Regulations on Patent Protection and Promotion of Beijing". Second is to promote the development of scientific and technological intermediaries. In January 2007, the "Opinions on Promoting the Development of Science and Technology Intermediaries" was issued, in which many ways to promote the development of science and technology intermediaries were proposed, such as the establishment of special fund to provide free financing to science and technology intermediaries, the special fund to support local venture capital companies, setting up various associations for science and technology intermediaries, and so on. Third is construction of technology market. In July 2002, the "Beijing Technology Market Ordinance" was issued by Beijing Municipal People's Congress Standing Committee in order to improve technology market services, promote technical trading, maintain technology market order, and protect the legitimate rights and interests of actors in technology transactions. Fourth is talents policy. For example, in April 2005, Beijing introduced the "Regulations on Award to Attracting Top Talents", and top talents meeting the following requirements all have changes to be rewarded: (1) employed by multinational local headquarters with registered capital of 10 million US dollars (or more), or the companies invested by Fortune Top 500 multinationals in Beijing, or accounting companies established by world-renowned accounting companies in Beijing, as vice president or equivalent positions for 2 consecutive years or more; (2) employed by software or IC companies for more than 2 consecutive years with the annual salary of more than 100,000 yuan (inclusive) as senior management talents and professional technical talents; (3) employed by science and technology research and development institutions in Beijing as director or equivalent position for more than 2 consecutive years with the annual salary of more than 100,000 yuan (inclusive); (4) employed by companies invested in Beijing as executive vice president (or above) and chief accountant, chief engineer chief economist for more than 2 consecutive years; (5) employed by financial companies invested in Beijing as vice president (or above) or equivalent positions for more than 2 consecutive years; (6) national and international cultural and artistic celebrities, famous and national experts in traditional arts, sports stars, outstanding coaches and outstanding cultural arts, sports industry management talents in Beijing.

3.3.2. Promoting the development of high-tech industries

In order to promote the development of high-tech industries, the local government of Beijing introduced the following main polices:

In May 1988, Beijing Municipal Government issued the “Interim Ordinance Concerning the Experimental Area for Developing New Technology Industries”, planning to zone out an area of about 100 square kilometers in Haidian District centering on Zhongguancun to establish an extraverted and open New Technology Industry Development Experimental Zone. This ordinance included 18 clauses concerning about preferential treatment such as in taxation and foreign exchange. For example, enterprises in this zone could enjoy the following tax reduction or exemption: (1) the income tax rate is reduced to 15%, and if the export value reached more than 40% of total output value, the income tax could be reduced to 10%; (2) from the start date, new technology enterprises could enjoy income tax exemption for 3 years, and from the fourth year to the eighth year, they could enjoy 50% reduction of income tax rate; (3) exempted from export duties; (4) if any equipment and facilities were imported for new technology enterprises to develop new technologies, while they could not be purchased in domestic, they could be exempted from import tariffs for 5 years; (5) any foreign investment enterprises in the Experimental Zone could also enjoy the above tax reduction or exemption if they met the criteria of new technology enterprises.

In May 1997, Beijing Municipal Government introduced the “A Number of Provisions on Encouraging Foreign Investment in High-Tech Industries of Beijing” in order to support high-tech industries by means of encouraging foreign investment into these areas. Foreign investment into high-tech industries could enjoy many preferential treatments such as simplification of investment procedures, reduction of land premium, taxation reduction or exemption, etc.

In April 1999, Beijing Municipal Government introduced the “A Number of Policies to Further Promoting the Development of High-Tech Industries of Beijing”, proposing that high-tech industries are core elements and new economic growth point of Beijing’s economic development. This policy regarded electronic information, optical and electrical integration, biology engineering and new medicine, new materials, and environment protection as key supporting high-tech industries and tried to promote the development of high-tech industries from the following four aspects: (1) attract high-quality creative and entrepreneurial talent pool; (2) raise funds from carious channels and increase financial support for high-tech industries; (3) facilitate the transformation of high-tech achievements; (4) support and foster the sustainable development of high-tech enterprises. Since January 1st 2002, a newly-introduced policy “A Number of Provisions to Further Promoting the Development of High-Tech Industries of Beijing”, replaced the original policy, and proposed more concrete and feasible measures to promote the development of high-tech industries than before. It was more focused on the transformation of high-tech achievements. In line with the new policy, both the financial department and taxation departments of Beijing announced their corresponding policies, for example, Finance Bureau of Beijing introduced the "Implementation Approach of Financial Special Fund on Supporting the Transformation of High-Tech Achievements of Beijing", and Beijing Local Taxation Bureau and Beijing Municipal Office of State Administration of Taxation jointly introduced the "Implementation Measures of Tax Policy on Supporting the Transformation of High-Tech Achievements of Beijing".

In 2000, the State Council of China issued the "A Number of Policies on Encouraging the Development of Software and IC Industry". To further promote the development of Beijing's software and IC industries, combining with the actual situation of Beijing, Beijing Municipal Government introduced the "Suggestions on Implementing the State Council's Policy on Encouraging the Development of Software and IC Industries" in February 2001, proposing very concrete development initiatives for the development of software IC industries of Beijing.

3.3.3. Encouraging indigenous innovation

In November 2008, Beijing Municipal government issued "Suggestions on Pilot Experimentation of Government Procurement of Indigenous Innovation Products in Zhongguancun Science Park". Based on this policy, the "Measures on Identification of Indigenous Innovation Products (Amendment)" was introduced correspondingly in February 2009, which regarded the products in the fields of electronic information, biology and medicine, new material, modern manufacturing, energy and environment protection, agricultural technology, and high-tech services as key supporting areas. The introduction of these two policies indicated that the local government used public procurement as an instrument to promote indigenous innovation in key high-tech fields. For example, in 2009, the government procurement of indigenous innovation products in Zhongguancun amounted to 3.3 billion yuan, which boosted the investment of 890 million yuan, which covered many fields, such as rail transportation, water treatment, garbage disposal, new energy, environmental protection, advanced manufacturing and information technology.

Second, patent applications are encouraged, especially in key areas. For example, in January 2007, the "Beijing Interim Measures on Grant of Patent Applications" was introduced, and projects in key areas, high-tech projects and invention patents are all given priority to be funded. Another special policy to encourage invention patent was also issued in the same year, named "Measures on Rewarding Invention Patents of Beijing", which set rewards ranging from 50,000 yuan to 1,000,000 yuan to important invention patents in Beijing.

Third, technology standard setting is also encouraged. For example, the "Measures on Special Subsidies of Technology Standard Setting or Amendment" was issued by the local government in 2006, providing different subsidy levels to those approved to be international standard, national standard, industrial standard, and local standard directly.

3.3.4. Stimulating collaborations among innovation actors

In December 2006, "Implementation Measures on Promoting the Development of Industrial Technology Alliances in Zhongguancun Science Park" was issued, with the aim of promoting industry-academia cooperation, improving enterprises' indigenous innovation capability, and enhancing competitive advantages of specific industries of Beijing. With the promotion of this policy, more than 100 industrial alliances involving more than 5000 members (2/3 are enterprises members) have been set up in various key industries of Beijing up to now, such as software alliance, IGRS (Intelligent Grouping and Resource Sharing) Industrial Alliance, TD-SCDMA Industrial Alliance, New Energy Technology Alliance, New Medicine Alliance, newly-established Zhongguancun Cloud Computing Industry Alliance in July 2010, and so on. Take IGRS Industrial Alliance as an example, it was initially established by five leading ICT companies in China (Lenovo, TCL, Konka, Hisense and Changhong), and now has 118 members, which also includes some foreign companies such as Sumsang, STMicroelectronics, Philips. IGRS has developed the world first international standard in the field of 3C. Another example, Changfeng Open Standards Platform Software Alliance, has 69 members, including software and information service enterprises, research institutes, universities, customers and third parties.

In April 2007, Beijing Municipal Government issued another document called “A Number of Suggestions on Encouraging Industry-Academia Cooperation between Enterprises with Universities and Research Institutes”, which proposed three approaches to promote industry-academia cooperation: the first approach is science and technology policies, e.g. establishing venture capital fund for SMEs to give priority to support industry-academia cooperative projects; encouraging enterprises to introduce scientific and technological resources from universities and research institutes to establish enterprise R&D institutions; public procurement for products created by industry-academia cooperative projects; business tax concessions for their technology transfer activities. The second approach is scientific and technological plans or R&D subsidies to industry-academia cooperative projects. The third approach is improving innovation environment, e.g. encouraging the co-establishment of science and technology platform, scientific and technological business incubators, technology transfer centre, as well as joint training of creative talents by enterprises, universities and research institutes. For example, with the promotion of relevant policies, Beijing Municipal Government and 12 organizations such as CAS, Tsinghua University, Peking University, Research Institute of China Building Materials, Academy of Military Medical Sciences co-established “R&D Experimental Service Base of Capital Science and Technology Platform” in order to provide technology services to enterprises, especially small and medium-sized enterprises, during which they integrated 264 national and regional-level key laboratories, as well as 13,000 equipments with the total value of 7.63 billion yuan. Up to now, this service base have provided R&D experimental services to more than 4100 enterprises with the contract value of 450 million yuan, which facilitated the resource-sharing between enterprises with universities and research institutes.

3.4. Intermediate organizations

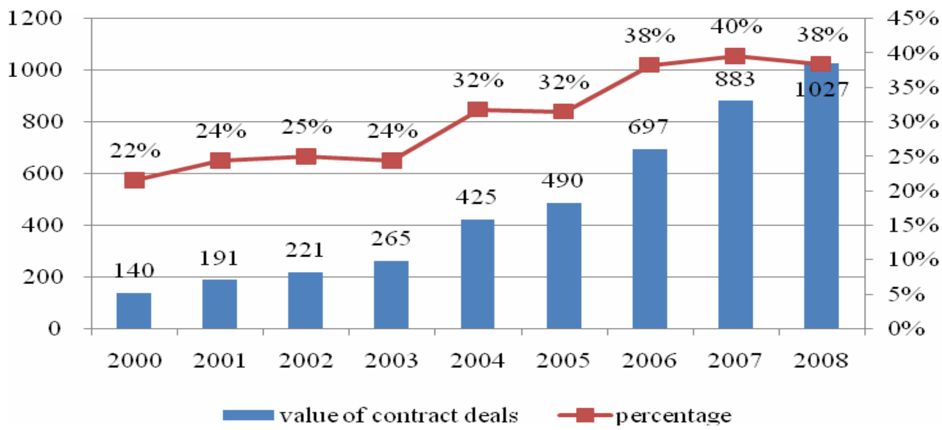
Intermediaries refer to professional organizations that provide enterprises with supporting services in areas such as technology services (e.g. business incubation, technology commercialization and brokering), accounting and finance, talent search, law, IPR. Saxenian (1990) argued that by sharing costs and risks and pooling technical expertise intermediaries allow Silicon Valley’s specialist firms to continue to innovate and react flexible. Bahrami and Evans (1995) pointed out that in technology clusters intermediaries, together with private firms, universities and research institutes, and venture capitalists, form an industrial ecology that facilitates and disciplines the development of technology firms. On the one hand, in today’s business environment characterized by globalization and rapid technology change, no company is smart enough to know what to do with every new opportunity it finds, and no company has enough resources to pursue all the opportunities it might execute. On the other hand, intermediaries sit at the intersection of many firms, organizations and industries, so they can facilitate the exchange of information about innovation among firms (Wolpert, 2002).

With the improvement of regional innovation system, intermediate organizations in Beijing have developed fast in the past twenty years. Up to now, the number of intermediate organizations of Beijing has reached more than 9000 with 180,000 employees. These intermediate organizations comprise more than 10 types such as technological innovation service centres, productivity promotion centres, technology transfer centres, technology markets, consulting services, human resources headhunters, and regional scientific societies. Nearly 100 intermediate organizations' annual service revenues were over 50 million yuan, and 10 intermediaries were over 100 million yuan.

By 2009, there were 81 scientific and technological business incubators in Beijing with a total area of more than 1.36 million square meters, among which more than 30 are locating in Zhongguancun Science Park. The number of enterprises which have been incubated was 8500, and currently 4,000 enterprises are still in these incubators. These incubators are owned by multi-agent such as government, university, or private companies.

In order to promote and manage the development of the technology transaction market, a technology transaction service centre was established in Zhongguancun Science Park in 1988 when it was founded. Its function was to offer a series of commercial frameworks to support emerging technology markets and to establish strong legal measures to protect the rights of different parties. Currently, more than 100 technology transfer centres or markets have been established in Beijing. Figure 28 shows the growth of contract deals value in Beijing technology market and its proportion in the whole country. In 2008, the value of contract deals in technology market of Beijing was 102.7 billion yuan, accounting for 38.47% of the total value of China.

Figure 28: Value of contract deals in technology market of Beijing and its proportion of China (100 million yuan, %)



Source: China Statistical Yearbook on Science and Technology, 2001-2009.

Headhunting has taken off with a growing number of firms placing young, well-educated and experienced professionals with Chinese companies. For example, among the 120 human resources intermediary agencies now certified in Zhongguancun Science Park, several dozen are headhunting firms.

There are over 100 national and regional scientific and industrial societies in Zhongguancun Science Parks, such as Beijing Association of High-Tech Entrepreneurs (established in 1987), Zhongguancun Association of Foreign Investment Enterprises (established in 1990), Zhongguancun Association of High-Tech Enterprises (established in 1991), Beijing Association of Intellectual Property Protection (established in 2006), and so on. These peer-group professionals associations provide opportunities for networking at conferences, lectures and joint projects, promoting communication across administrative boundaries and disseminating scientific knowledge and technology, as well as providing refresher training for technicians and engineers, and consultancy for SMEs and end-users.

3.5. Innovation financing system

Beijing is one of the earliest cities in China to explore and improve innovation financing system. Three kinds of funding sources provide capital for innovative firms in different stages. The innovation fund invests a firm in the earliest stage - seed stage, during which the entrepreneurs may only have an idea or new technology that still hasn't been applied prevalently. Most firms in this stage spend much more than revenues and thus negative profit, which need sufficient capital support. Venture capital invests firms in the second stage - start-up stage, when firms show growth potential of market and have positive cash flow. Venture capital helps firms to expand more rapidly and shorten time for technology transfer. The majority of bank financing, however, was available only at the expansion and later stages of a venture's development, with local governments acting as guarantors. As risk aversion institutions, banks were the main financers of new venture expansion, but essentially absent as financers at the seed capital and start-up stages of these ventures. This sector will illustrate the functions of these funding sources in the innovation financing system of Beijing.

3.5.1. Innovation fund for technology based small and medium sized firms

In 1999, Ministry of Science and Technology and Ministry of Finance launched national innovation fund for technology based small and medium sized firms, with the intention of supporting and guiding scientific and technological innovation activities of SMEs, accelerating the transfer and commercialization of scientific and technological achievements, and promoting the development of high-tech industries. Up to now, 1843 projects from Beijing were approved by this fund, accounting for 9.08% of total number of projects approved in China. These approved projects of Beijing received a funding of 1.22 billion yuan, accounting for 10.03% of the total in China (see Table 12). Since 2001, Beijing Municipal Science and Technology Commission started to provide a matching funding with the share of 50% to those projects that have received the funding for free from the national innovation fund.

Table 12: Projects approved by the "National Innovation Fund for Technology Based Small and Medium-Sized Firms" of Beijing, 1999-2009

	Number of projects	**Percentage (%)**	**Amount of funding (10,000 yuan)**	**Percentage (%)**
1999	151	13.87	11921	14.60
2000	97	11.12	8870	13.45
2001	135	13.39	10894	13.91
2002	114	14.62	7799	14.44
2003	180	15.04	10575	15.93
2004	176	12.02	11118	13.44
2005	183	11.79	11674	11.81
2006	125	6.56	6149	7.30
2007	143	6.77	8549	6.81
2008	172	6.96	10380	7.10
2009	367	6.28	24221	7.27
Total	1843	9.08	122150	10.03

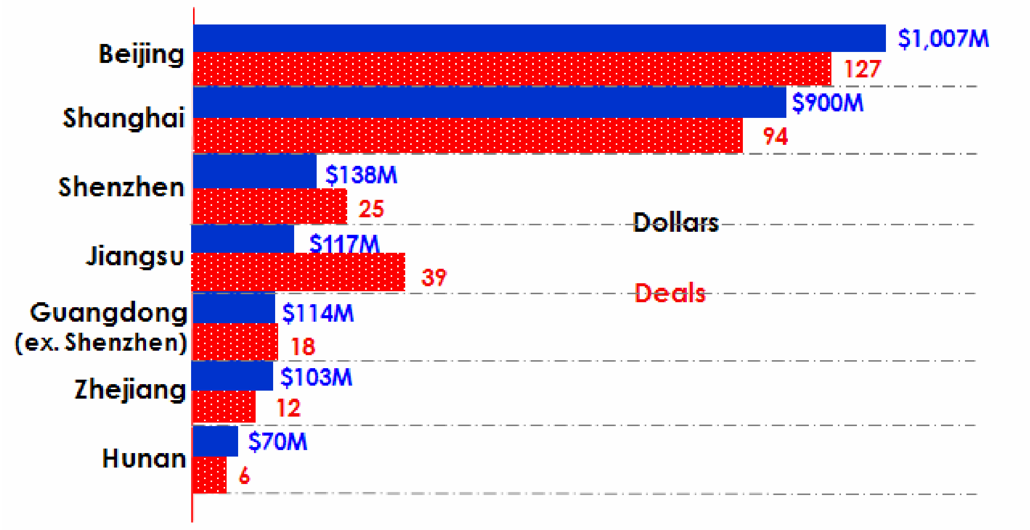
Source: http://www.innofund.gov.cn/index.asp

Since 2006, Beijing Municipal Science and Technology Commission set up local innovation fund for technology based small and medium sized firm. Among the total 1843 projects approved by the national innovation fund, 898 have also been funded by the local innovation fund with the amount of 0.59 billion yuan. This means that many projects were firstly selected and funded by the local innovation fund, and then were recommended to the national innovation fund. Applicant qualifications for innovation fund are: (1) technology based firm involving in high-tech R&D, production or services, the share of scientific and technological personnel in total employees is more than 30%, the share of R&D personnel in total employees is more than 10%, and the share of R&D expenditure in sales is more than 5%; (2) small and medium sized firms with less than 500 employees, but firms whose Chinese equity is less than 50% are not included; (3) firms that have novel technology or intellectual property, and with strong market competitiveness and potential profitability. The innovation fund, both national and local, lays the foundation for industrial expansion and introduction of commercial funds, and invests a firm in its earliest stage suffering high risk, which means that the innovation fund targets at "market failure" where government support is needed.

3.5.2. Venture capital

Beijing is one of the most developed cities in the field of venture capital. In 2007, the venture capital investment of Beijing amounts to 1.01 billion US dollars, and the number of deals reached 127, both of which ranked 1st of China (see Figure 29).

Figure 29: Geographical distributions of venture capital in China, 2007



Source: China VC 2007 Annual Report (PPT Version), Zero2IPO Group

With regulatory changes in the 1990s; however, venture capital firms entered the system as a new organizational form and now account for most of the activities related to pooling funds, identifying investments, channelling and monitoring funds and gain appropriate returns to invested funds. Among the approximately 200 registered venture capital firms, four distinct categories VC firms can be identified.

The first type of specialized venture capital firms to appear in China was the government VC firms (GVCFs). Although the first such venture capital was established by the central government (SSTC and MOF) in 1985 and began operations in 1986, those that followed were all controlled by local governments, usually led by the local bureau of science and technology commission and supported by the finance department. Although local governments were their initial source of financing, they have diversified their funding sources over time and with changes in the regulatory environment. Indeed, they are increasingly dependent on listed and cash-rich enterprises to keep up their investment capacity.

GVCF's linkages to the local government and thereby new venture developments in those zones represent preferential access to information and investment opportunities. This can also be a weakness; however, because they are then susceptible to local government pressure to support new ventures whose risk and return prospects are not attractive. They are also not able to attract the most experienced or capable managers, so their ability to assess, monitor and intervene in new venture management is limited. On the other hand, the GVCFs together have the most total venture capital under management of the four categories of VC firms (estimated by Wang, 2003, p. 14), and as such they are an important element of the system.

University VC firms (UVCFs) began to emerge in 2000 from the major universities in China that have strong R&D bases, such as Tsinghua, Shanghai Jiao tong, Fu Dan, Harbin Institute of Technology and Zhejiang University. They benefit tremendously from their university ties, giving them privileged access to new venture investment opportunities, as well as intimate information about the ventures. On the other hand, they also suffer from some of the same weaknesses as the GVCFs. Specifically, their investment opportunities are in practice limited to those that emerge from the university, and they do not have the managerial expertise related to venture capital investing. Another weakness is that the universities usually are not cash-rich, so they depend more and more on other sources of investment capital; as in the case of GVCFs, publicly listed and cash-rich enterprises have become their primary backers. Although there are examples of research institutes founding VC firms (e.g., CAS is a major investor in Shanghai New Margin Ventures (Shanghai Lianchuan Touzi)), they are too few to represent a major category of VC firms. They do, however, share the same advantages and disadvantages of UVCFs.

A wave of corporate VC firms (CVCFs) was founded in response to the No. 1 Proposal of 1998, and they now represent the majority of VC firms operating in China. Beijing High-Tech Venture Capital Ltd. was the first CVCFs, founded in October 1998. Their strong government backing, however, causes many to perceive them as firms under the Beijing government’s commercial holding company. From early 1999, there was a wave of true corporate-backed CVCFs, although they still sought local government support. Their managers typically come from securities firms, banks or industry.

CVCFs and their backers, however, had invested in ventures with the expectation that the investees would list quickly. They generally have not proven themselves to be interested in long-term development of the new ventures. As the government has postponed establishing a second board, however, their timeframe for realizing a return on their investments is becoming unexpectedly longer and longer. A number of these CVCFs have suffered heavy losses, pushing some into bankruptcy.

Finally, foreign VC firms (FVCFs) have entered China and become a major source of new venture financing. As of 2001, 8 of the top 10 VC investors in China were foreign firms and 14 of the top 20 (Table 4). Like the domestic CVCFs, most of the FVCFs are backed by multiple investors, although a few (e.g., Intel Capital) are the investment arms of single firms. More recently, domestic venture capital funds have been raising funds from outside China. New Margin, for example, recently received funds from Alcatel and Motorola, and Tsinghua’s UVCF has raised US$10 million from Hong Kong for its China Environment Fund 2002. Some observers expect that the process of raising funds internationally and interacting with those investors will be a learning opportunity for these domestic venture capital firms, especially regarding their internal structure, and act as an incentive to recruiting more experienced venture capital managers.

The founding of domestic VC firms began with the establishment of local government-financed venture capital firms (GVCFs), first in 1991–1993 in Guangdong, Jiangsu, Zhejiang and Shanghai, and in other provinces by the late 1990s and early 2000. Next came university-backed VC firms (UVCFs). Although foreign venture capital and private equity firms had already been allowed to register as commercial enterprises in China in the 1980s, their investment activities were extremely limited by the lack of suitable investment projects.

China’s venture capital system has developed rapidly, but this development is not even across activities, nor is the system matures in terms of regulatory and related institutions. Currently, domestic and foreign funds are being effectively pooled by the different types of venture capital firms. These firms are also taking over the primary role of identifying and evaluating investment targets, a role previously played by bureaucracies within the central and local governments. On the other hand, these venture capital firms (especially domestic firms) are biased towards late-stage investment projects, and are not acting as a channel of funds to true start-ups to the extent desired by the government.

4. Functioning of the RIS: empirical evidence of ICT industry

From the analysis of section 3, we can say that the region plays an important role in the provision of skilled talent pool, innovation infrastructure, knowledge to support R&D and other innovation activities, as well as an innovation friendly business environment. In addition, we actually found the role of regions in supporting the emergence and development of GINs, especially developing local and international linkages, and attracting or retaining knowledge intensive activities.

We conducted survey through phone call interview during March and April of 2010. The survey aims to collect data from firms in ICT industry in Beijing. 8692 firms were contacted, among which 208 participated fully the interview, and the response rate is 2.39%. Figure 30 and Figure 31 show the size and sub-sector distributions of the sample respectively.

Figure 30: Size distribution of ICT firms in Beijing

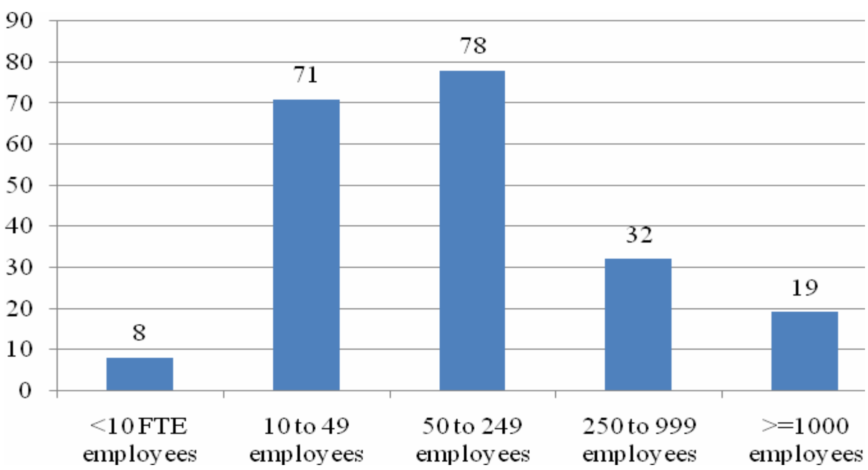
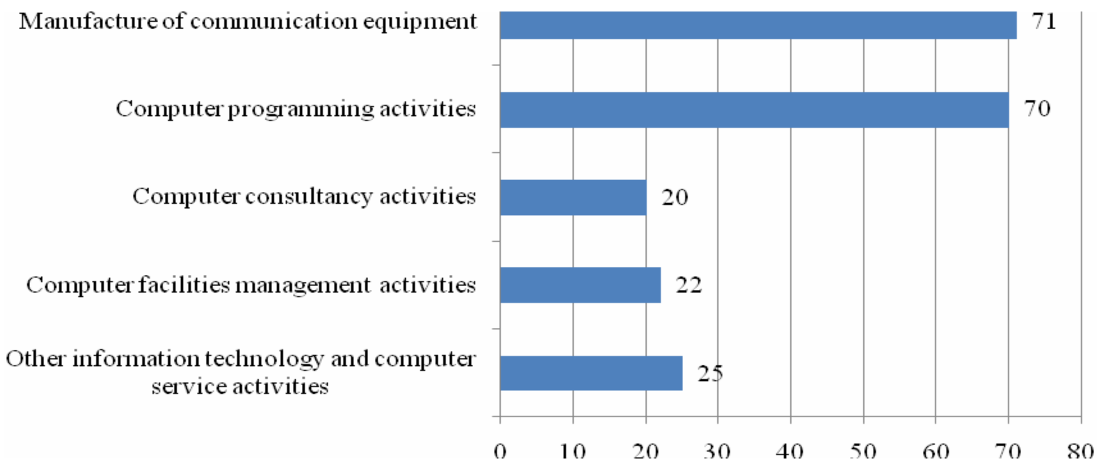
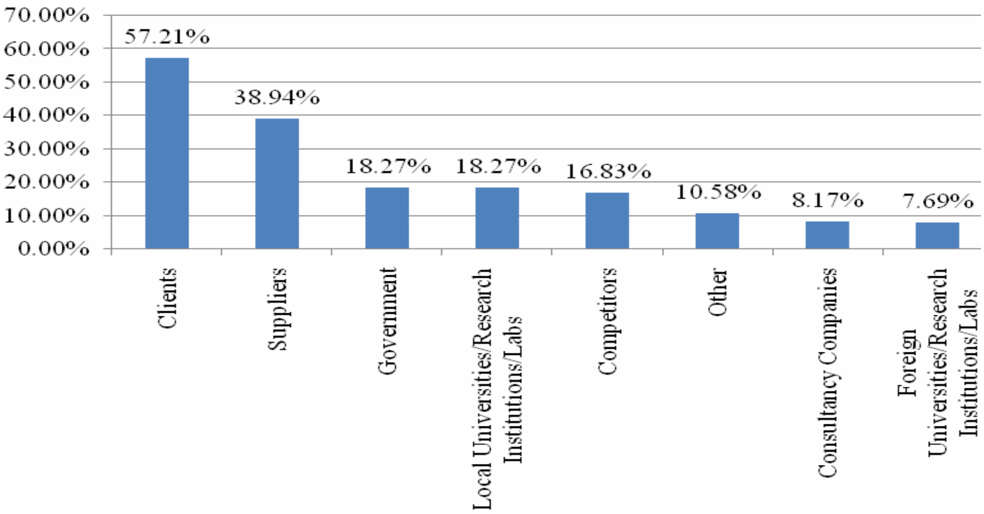


Figure 31: Sub-sector distribution of ICT firms in Beijing



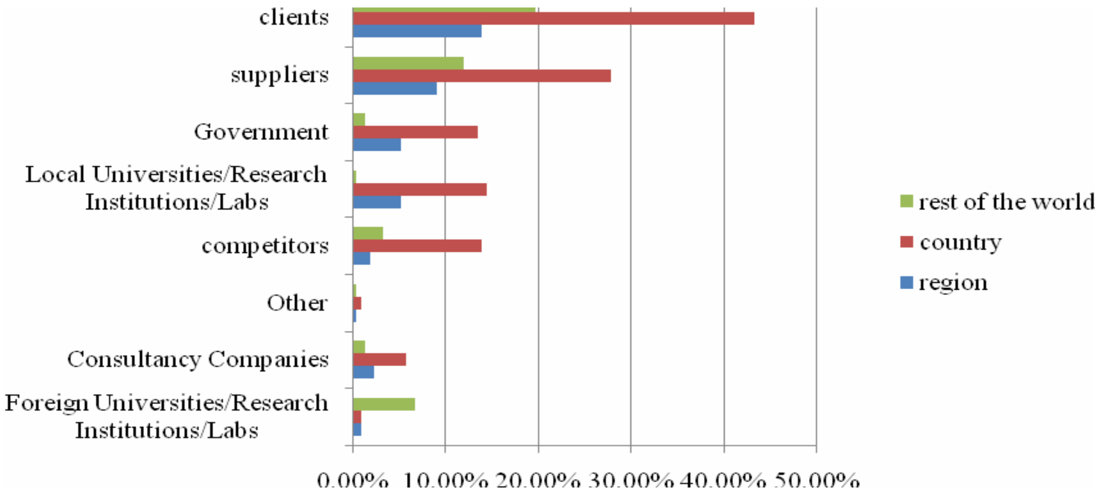
The first function of regional innovation system to support the emergence and development of GINs is to develop local and international linkages. Not only linkages among enterprises with local clients, suppliers, competitors, business service firms, government, universities and research institutes, but also linkages with foreign organizations are important. In our survey for ICT industry, we asked the respondents whom they actively collaborated with regarding the development of the most important innovation in the last three years, and the geographical location of these organizations. The results indicate that 57.21% of respondents actively collaborated with clients in their most innovation, followed by suppliers with the percentage of 38.94%, while foreign universities/research institutes/labs was listed as the last (see Figure 32).

Figure 32: Collaboration partner in the most important innovation of respondents in Beijing



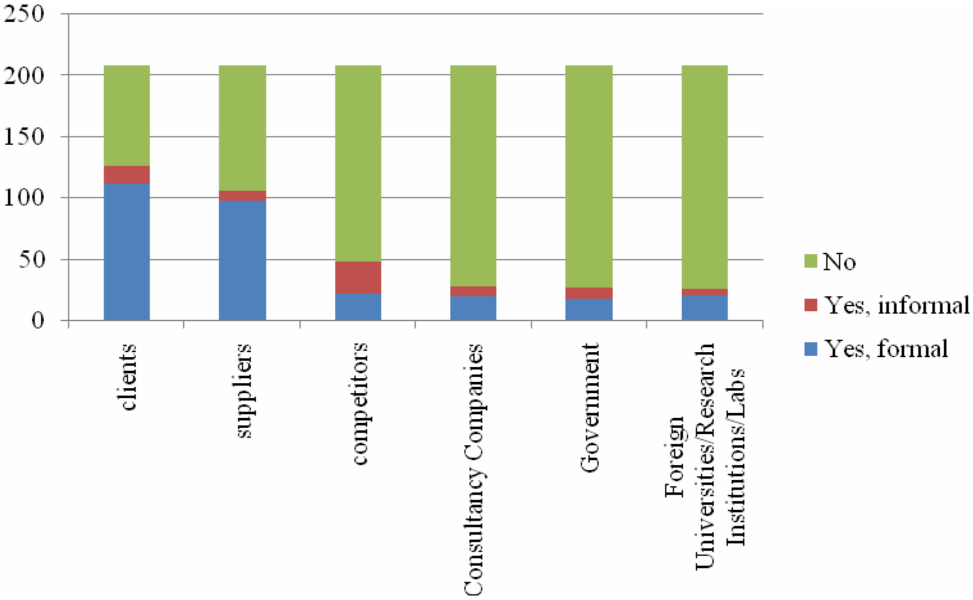
The geographic locations of organizations that the respondents actively collaborated with are shown in Figure 33, from which we can see that domestic linkages of the respondents are more active than international linkages and regional linkages, one of the main reason is that China's huge market lays a good foundation for collaborations between enterprises with other organizations, such as clients and suppliers.

Figure 33: Geographic distributions of organizations that the respondents actively collaborated with



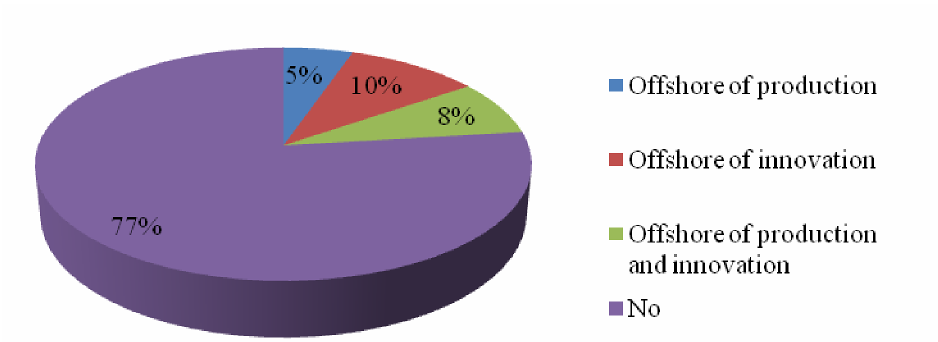
From Figure 34, we can see that linkages between enterprises and foreign clients are most closed, and more than 60% of enterprises have established formal or informal linkages with foreign clients, followed by foreign suppliers.

Figure 34: Formal or informal linkages with foreign organizations by respondents in Beijing



The second function of regional innovation system to support the emergence and development of GINs is to attract and retain knowledge intensive activities. From the above analysis, we can see that the local government of Beijing not only encouraged domestic firms to engage in indigenous innovation, but also took measures to attract foreign multinationals coming into Beijing, especially in high-tech industries and business service sectors In our survey for ICT industry, we asked respondents about their offshore of production and innovation activities, as well as the motivation to locate such activities in a particular region. The results indicate that 5% of respondents offshore their production activities, 10% offshore their innovation activities, 8% offshore both their production and innovation activities, and 77% had no such activities (see Figure 35).

Figure 35: Offshore of production and innovation activities of respondents in Beijing



In the 27 enterprises which have offshore their production, 70.37% of enterprises regarded "opportunity to sell existing products and achieve greater access into new market" as an important factor to this decision; followed by "access to knowledge infrastructure and services in the host region", and "efficient financial market", which means market access, knowledge infrastructure and financial environment are the most important factors for Beijing to attract production activities (see Table 13).

Table 13: Regional factors for enterprises to offshore production activities

	Number	Percentage
Opportunity to sell existing products and achieve greater access into new markets	19	70.37%
Access to knowledge infrastructure and services in the host region	14	51.85%
Efficient financial markets	12	44.44%
Availability of specialized knowledge in the host region	11	40.74%
The level of ethical standards and trust	11	40.74%
Access to other infrastructure, cheaper production resources and services	10	37.04%
The enforcement of intellectual property rights	10	37.04%
Availability of qualified human capital at a lower cost than in your own country	8	29.63%
Following clients who are outsourcing	8	29.63%
Incentives for the location of activities in the host region	6	22.22%
Other	1	3.70%

In the 37 enterprises which have offshore their innovation, still most enterprises regarded "opportunity to sell existing products and achieve greater access into new market" as an important factor to this decision; and followed by "access to knowledge infrastructure and services in the host region"; but the third factor is "the enforcement of intellectual property rights", which is different from that of production offshore (see Table 14). This means market access, knowledge infrastructure and IPR environment are the most important factors for Beijing to attract innovation activities.

Table 14: Regional factors for enterprises to offshore innovation activities

	Number	Percentage
Opportunity to sell existing products and achieve greater access into new markets	27	72.97%
Access to knowledge infrastructure and services in the host region	26	70.27%
The enforcement of intellectual property rights	23	62.16%
Availability of specialized knowledge in the host region	18	48.65%
The level of ethical standards and trust	17	45.95%
Efficient financial markets	13	35.14%
Availability of qualified human capital at a lower cost than in your own country	10	27.03%
Following clients who are outsourcing	10	27.03%
Incentives for the location of activities in the host region	9	24.32%

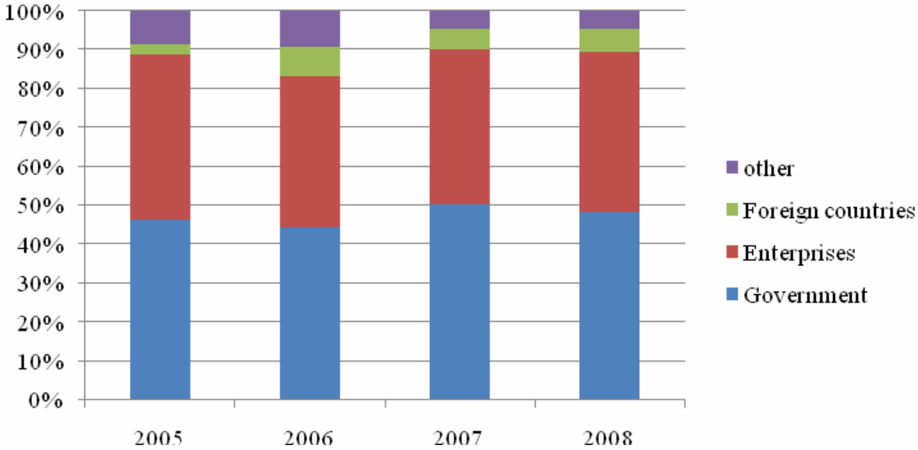
Access to other infrastructure, cheaper production resources and services	8	21.62%
Other	1	2.70%

5. Challenges of the RIS

First, The R&D system of multinationals in Beijing is still mainly a closed one, and has so little linkage with regional innovation system. A recent report by Office of Technology Market Management (OTMM), which subordinated to Commission of Science and Technology of Beijing, shows that the spillover effect of the multinationals in Beijing is very low. From 2001-2006, about 88.32% of the technology contract value sold by multinationals with R&D centers in Beijing flowed outside China, among which 99.84% is bought by their headquarters. Only 1.88% of the technology contract value sold by these multinationals flowed into Beijing, and 9.80% flowed into other provinces in China. From the above data, on the one hand, we can see that many multinationals take good advantage of excellent science and technology resources, as well as low cost qualified human capitals in Beijing by means of establishing localized R&D centers. On the other hand, the R&D system of multinationals in China is still mainly a closed one, and even in Beijing it has so little linkage with regional innovation system (OTTB, 2007). In addition, the technology contract value sold by multinationals with R&D centers in Beijing from 2001 to 2006 focused on two fields of electronic & information and modern manufacturing (such as 3G mobile communication technology, computer network, software development technology, new generation of human-computer interaction technology, new generation of network multimedia, new generation wireless internet technology, semiconductor device and process simulation, system-on-chip integration, and so on), the proportion of the former was 76.87%, and the latter was 10.51%. From the above analysis, we can see that the multinationals compete in talents of key industries with local firms, while they create so little spillover of core technology.

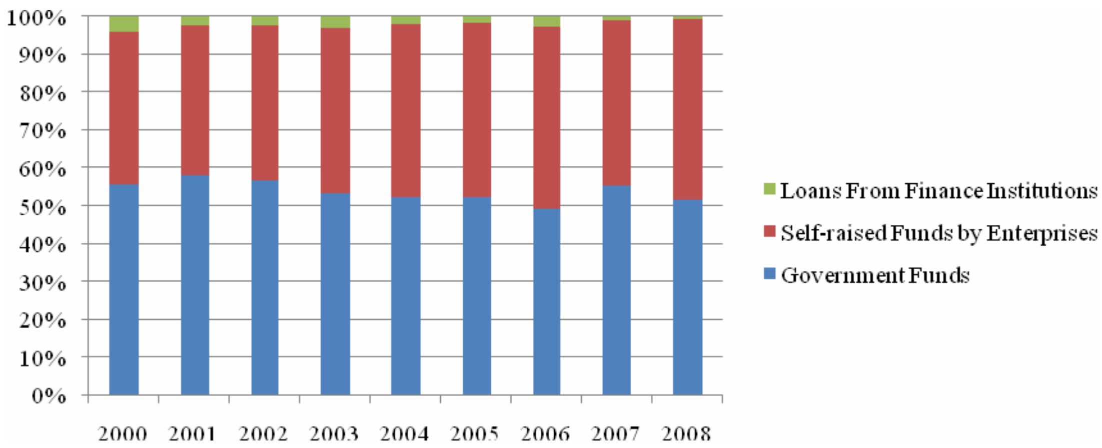
Second, the pattern of government-led R&D resources allocation would constraint the sustainability of innovation input of Beijing. In recent years, nearly 50% of R&D expenditure of Beijing comes from the government, 40% comes from enterprises, and 10% comes from foreign countries and other channels (see Figure 36), which means that the government plays a leading role in supporting R&D expenditure.. The same situation is with the funding structure for science and technology activities of Beijing. For a long time, the funding from the government has maintained a large proportion of more than 50%. However, the government funding didn't play a leverage role in driving the social investment, for example, the loans from finance institutions account for less than 1% of the total funding (see Figure 37).

Figure 36: Source of R&D expenditure of Beijing, 2005-2008



Source: Beijing Statistical Yearbook, 2006-2009

Figure 37: Funding for science and technology activities of Beijing, 2000-2008

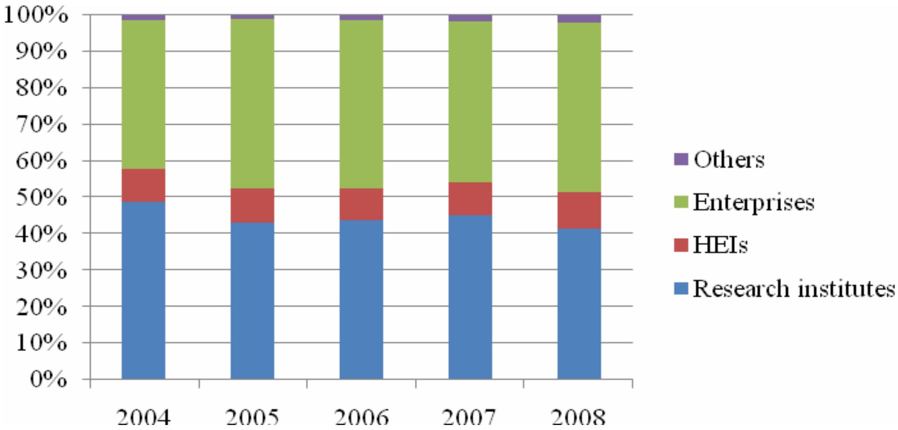


Source: China Statistical Year Book on Science and Technology, 2001-2009

The pattern of government-led R&D resources allocation would promote innovation effectively in the short term, but has limited potential in enlarging R&D resources input and would not be helpful to improve its effective use, which will impact the sustainability of Beijing's innovation capability.

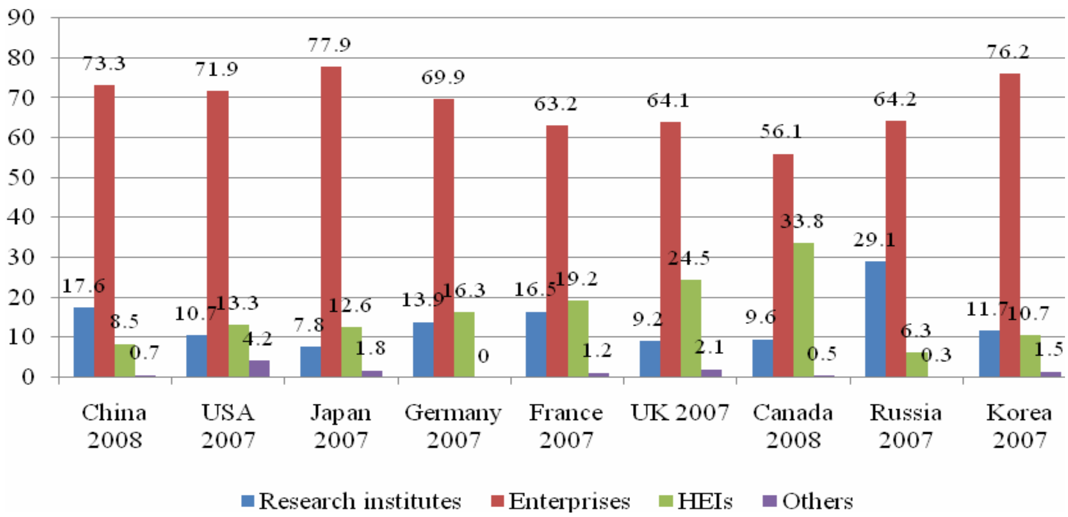
Third, the structure of R&D expenditure and the distribution of R&D human resources would impede the improvement of enterprises' innovation capability. In recent years, Beijing's R&D expenditure performed by enterprises has stabilized at the proportion of 45% of total R&D expenditure; and the similar proportion was with the R&D expenditure performed by research institutes (see Figure 38). While in most OECD countries, the R&D expenditure are mainly performed by enterprises, the proportion of which are about 70%; followed by HEIs, with the proportion of 20%; and only about 10% are performed by research institutes. Figure 39 shows these data of selected countries, from which we can see that Canada has the lowest proportion (56.1%) of R&D expenditure performed by enterprises, even so, this proportion is much higher than that of Beijing. Furthermore, the proportion of R&D expenditure performed by research institutes of Beijing has maintained at the level of more than 40% in recent years, which is obviously higher than that of OECD countries, while the proportion of HEIs of Beijing is similar with that of OECD countries, both of which are around 10%.

Figure 38: Beijing's R&D expenditure by sector of performance, 2004-2008



Source: Beijing Statistical Yearbook, 2005-2009.

Figure 39: R&D expenditure in selected countries by sector of performance (%)

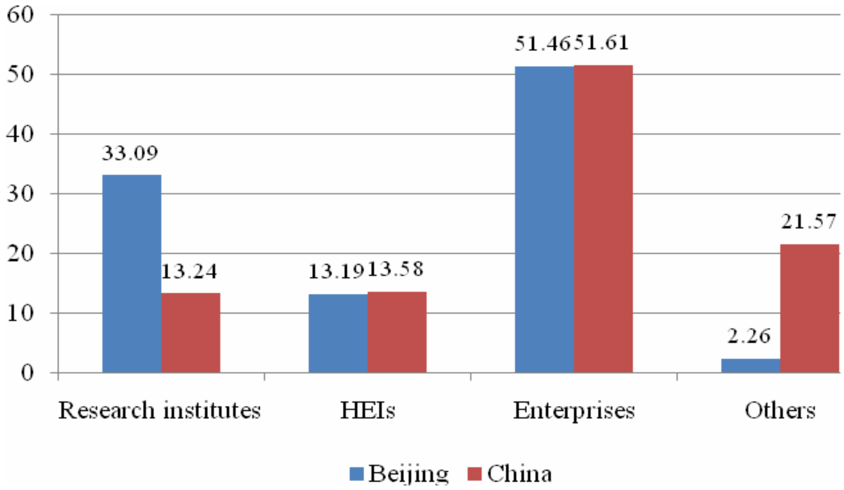


Source:MOST; Main Science and Technology Indicators 2009/1 (OECD).

The pattern of high proportion of R&D expenditure performed by research institutes and low proportion of R&D expenditure performed by enterprise led directly to a small proportion of applied R&D results which are closely relevant to the market needs in the total number of scientific and technological results from Beijing. This phenomenon can be explained in two ways: on the one hand, without enough input to engage in applied research and experimental development, it is difficult for enterprises to bring their superiority into full play, transforming scientific and technological results into final product; on the other hand, research institutes which spend a large number of resources on applied research and experimental development could not grasp market needs accurately and timely, and are usually lack of effective sales channels and strong operational capabilities for new product, which also makes it difficult for scientific and technological results to be transformed into marketable commodities. Therefore, the efficiency of applied research and experimental development of Beijing have not been improved, though many good scientific and technological achievement emerged from Beijing, in fact they haven’t played a full role in promoting Beijing’s economic and social development.

The distribution of R&D human resources in Beijing also exacerbated this problem. Although the amount of R&D personnel of Beijing ranked top in the whole country, the percentages of R&D personnel in business and HEIs are both lower than the average level of the whole country. In Figure 40, the percentage of business R&D personnel in Beijing was 51.46% in 2008, 0.15% lower than the national average; the percentage of HEIs R&D personnel was 13.19% in 2008, 0.39% lower than the national average. However, the R&D personnel in research institutes account for 33.09% of total R&D personnel in Beijing, which is more than twice of the national average. This means that even now, the R&D activities of businesses are still not an attractive place for talents, which will impede the improvement of Beijing’s innovation capability.

Figure 40: The distribution of R&D personnel in Beijing and China (%)



Source: Beijing Statistical Yearbook, China Statistical Year Book on Science and Technology, 2009

6. Conclusions

There is evidence of GINs in the Beijing region. Particularly, Beijing aims to be a global science and technology center and world city in the recent two years. It shows global activity, not only attracting numerous MNEs to conduct R&D, production and sales activities and becoming a cluster of headquarters of MNEs, but also cultivating a group of outstanding local enterprises to go abroad. It also shows innovation activity. As a Chinese city most endowed with top-quality universities and research institutes, Beijing has well-established innovation infrastructure, and most important it has developed a rich scientific and technological talent pool, especially in the ICT field. Because Beijing is a knowledge creation center, coupled with the huge Chinese market opportunity, more and more MNEs put R&D activities rather than production activities into Beijing in order to capture the local demand and take good advantage of qualified but low-cost of talents. Enterprises in Beijing are more or less networked, and clients, suppliers and local universities/research institutions/labs play the most important roles in the enterprises’ innovation. However, the linkages between local firms and multinationals are still limited. For most multinationals in ICT industries, they are strongly feeling the great threat from Chinese local enterprise, and the latter are catching up so quickly. In certain industrial fields that the gap between local enterprises and MNEs are small, these two types of enterprises have begun to collaborate in R&D and other activities, such as many MNEs (including Siemens) have joined in the TD-SCDMA alliance. Therefore, Beijing has accumulated abundant resources and manifested many unique advantages to play an increasingly important role or to be an important hub in GINs.

The RIS of Beijing facilitates the emergence and development of GINs. RIS not only plays an important role in the provision of skilled talent pool, innovation infrastructure, knowledge to support R&D and other innovation activities, and an innovation friendly business environment, but also develop local and international linkages, and attract or retain knowledge intensive activities. Both the elements that constitute RIS and the interaction among these elements facilitate the emergence and development of GINs. As for Beijing, the education and research infrastructure, and the established innovation friendly environment including government policy are very important elements up to now to make Beijing to be a hub of GINs, especially for the ICT industry. However, the government investment-oriented pattern may have negative effect on the sustainability of GINs, so it’s a long way to go to find a sustainable way of RIS to promote the development of GINs.

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ANNEX 2 - Intermediate report – the role of regions supporting the emergence and development of GINs: the case of Bangalore

Authors: Balaji Parthasarathy (pbalaji@iiitb.ac.in) and V Ranganathan (ranga@iiitb.ac.in)

Participant no.8: International Institute of Information Technology, Bangalore (IIIT-B)

1. Introduction

Addressing the Bangalore Municipal Corporation on 17 April 1962, former Indian Prime Minister Jawaharlal Nehru stated:

> "Now Bangalore, ... is unlike the other great cities of India. Most of the other cities remind one certainly of the present, … but essentially of the past. But, Bangalore, … is on a picture of India of the future, more specially because of the concentration of science, technology and industries in the public sector here."

Nehru's words were fitting, not least because independent India's first public sector enterprise (PSE), Indian Telephone Industries (ITI), was established in Bangalore in 1948. During the 1950s, three others, Bharat Electronics Limited (BEL), a defense-electronics firm, Hindustan Aeronautics Limited (HAL)15, and Hindustan Machine Tools (HMT) were also established in Bangalore. As related laboratories and related research followed, Bangalore was no longer the sleepy cantonment town it used to be in 1947.16

[15] Hindustan Aeronautics was not established anew. It emerged from the nationalization of a private firm established during World War II to service British combat aircraft.

[16] By 2000, besides ITI (which was under the Department of Telecommunications), the public sector included BEL, HAL and Bharat Earth Movers Limited under the Ministry of Defence, and HMT and Bharat Heavy Electricals Limited under the Ministry of Heavy Industry and Public Enterprises. Nine of forty-nine Defence Research and Development Organization's laboratories were in Bangalore. These included the Aeronautical Development Agency, Centre for Air Borne Systems, Centre for Artificial Intelligence and Robotics, Centre for Aeronautical Systems Studies and Analysis, Defence Avionics Research Establishment, Defence Bio-Engineering and Electro Medical Laboratory, Gas Turbine Research Establishment, Electronics and Radar Development Establishment, and the Microwave Tube R&D Centre. A location of the Centre for Development of Advanced Computing under the Department of Information Technology, and the Centre for Development of Telematics of the Department of Telecommunications is in the city. Bangalore is home to the Council of Scientific and Industrial Research's National Aerospace Laboratories and the Centre for Mathematical Modeling and Computer Simulation. Finally, the Indian Space Research Organization, of the Department of Space, is also located in Bangalore.

Table 1: **Electronics Production in Karnataka**
(as a percentage of national production and rank among states)

Year	Consumer Electronics	Industrial Electronics	Computers	Telecom	Defense Electronics	Components	FTZs	Total
1971	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		50.36%
								1
1981	1.86%	20.82%	1.02%	45.25%	41.02%	20.87%	0.00%	20.09%
	8	2	7	1	1	3		2
1990	11.02%	20.39%	27.52%	29.15%	31.63%	17.75%	0.00%	19.13%
	4	2	1	2	1	2		1
1994	14.43%	16.25%	32.23%	24.11%	32.83%	16.17%	0.00%	18.51%
	3	2	1	2	2	3		2

Source: Data Bank and Information Division, Department of Electronics, Government of India.

Table 2: **Relative importance of economic activity in Karnataka**
(by location quotient and percentage share of national GDP)

	1999-2000	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Forestry and Fishing	1.23	1.02	1.04	0.89	0.87	0.93
Mining and Quarrying	0.23	0.43	0.45	0.52	0.56	0.60
Manufacturing	0.94	1.20	1.09	1.10	1.16	1.11
Construction	1.21	0.84	1.14	1.19	1.18	1.21
Electricity, Gas, Water Supply	1.01	1.07	1.12	1.05	1.07	0.71
Trade, Hotels, Transport and Communication	0.77	0.85	0.84	0.87	0.86	0.86
Finance, Banking, Insurance, Real Estate (FIRE)	1.20	1.36	1.35	1.39	1.30	1.28
Community, Social and Personal Services	0.86	0.83	0.77	0.82	0.85	0.85
Karnataka's share of national GDP	5.67%	5.26%	5.40%	5.22%	5.29%	5.18%

Note: Location quotient computed using Gross Domestic Product at factor cost at current prices
Source: Computed from data provided by Directorate of Economics and Statistics, Government of Karnataka
(at: http://des.kar.nic.in) and *Handbook of Statistics on Indian Economy 2009-10* , Reserve Bank of India (at: http://www.rbi.org.in)

With the concentration of these PSEs in its capital city, by 1971, the state of Karnataka became the leading centre for research and production in the electronics industry (Table 1).[17] Karnataka's dominance of the electronics industry has since declined and, in the past decade, its economic growth and structure has not very dissimilar to the national economy (Table 2). Among the activities more critical to Karnataka than to the national economy are manufacturing, construction and FIRE. However, none of this data for state adequately captures the transformation of the economy in Bangalore: nearly half a century after Nehru's reference, the idea of Bangalore as representing the future has endured. In recent years, the city has been described by terms such as "India's Silicon Valley" (IDG 2004) to suggest that it is leading the country into a world of information and communication technologies (ICTs) that lie at the heart of a third industrial revolution. But, while science and technology, especially ICTs, persists as the lietmotif in these visions, the handmaiden to the future is no

[17] Ideally, the data should be for Bangalore district or the metropolitan area. Unfortunately, reliable disaggregated data is unavailable. But, at least in the case of the electronics industry, this is not an issue as most of the industry in Karnataka is concentrated around Bangalore.

longer the PSE occupying the ‘commanding heights of the economy’; instead, it is internationally mobile capital.

This essay will trace the trajectory of this shift and Bangalore’s emergence from the confines of an autarkic economy to its integration into production networks and, subsequently, into innovation networks of the global informational economy. To this end, the following section will describe the technological changes, especially the pivotal role that software has come to play in contemporary ICTs, which have facilitated Bangalore’s emergence. Section 3 will examine the changes in public policies since the 1980s that have enabled India, especially Bangalore, to capitalize on the growing importance of software. Section 4 details the components of the regional innovation system that emerged to address the opportunities offered by technological change and a more liberal policy environment. Section 4.1 identifies the means by which the educational and institutional infrastructure was created to reinforce Bangalore’s regional advantage with skills and infrastructure. Section 4.2 discusses the evolution of a historically specific organization of production in the software industry in Bangalore, including the local and international linkages that were developed for production and innovation. This discussion is pursued in Section 4.3 where new approaches to innovation are being pursued by firms as they seek to draw on local resources in Bangalore to address national and international markets. The paper closes with a discussion of the implications of the Bangalore region for our understanding of global innovation networks.

2. Technological change and the origins of the Regional Innovation System

Over the half-century, technological changes have accompanied the institutional shifts. When ITI was established in Krishnarajapuram, on the eastern edge of Bangalore, the underlying technology for the communication equipment, including telephone exchanges or switches, ITI’s main product, was electromechanical.18 But just before ITI was established, the transistor was invented at the Bell Laboratories of American Telephone and Telegraph (AT&T) in 1947 the US. Mass manufacture of the transistor came in 1951 and, in 1957, the first integrated circuit (IC) was developed at Texas Instruments and Fairchild Semiconductor. Integration techniques improved rapidly and, in 1971, Intel embedded enough logic functions and data handling capabilities to produce the first microprocessor, or a monolithic “system on a chip”. Since then, thanks to architecture and circuit improvements, the development trajectory of the microprocessor has been defined by Moore’s law, a rule of thumb which predicts a doubling in the performance to price ratio every 18 months.

The impact of increasingly powerful and inexpensive microprocessors would probably not be very revolutionary but for the fact that they can be instructed and modified to do a wide range of tasks. This ability comes from the concept of stored program control (SPC), first enunciated by John von Neumann in the mid-1940s. SPC proposed entering and storing programs as numbers and laid the foundations for the development of computer software. In

[18] ITI started off making stronger exchanges in 1948 with technological collaboration with Automatic Telephone and Electric of England. In 1964, Bell Telephone Manufacturing (BTM), Belgium, agreed to provide ITI with the technology to manufacture and maintain the pentaconta crossbar switches.

other words, it provided the basis for a common digital language in which information in any form, spoken, written or visual, can be processed and conveyed by microprocessor-based devices. The functional versatility that software gives general purpose, programmable hardware has led to the technological convergence of previously distinct information processing and communications devices, such as computers and telephone exchanges/ switches, and the application of ICTs in domains ranging from agriculture to medicine. Consequently, it is software that imparts the revolutionary character to contemporary ICTs.

Over the years, however, the technological convergence has been accompanied by a divergence. While design and manufacturing technologies have enabled the mass production of increasingly more reliable hardware, in highly automated, capital-intensive operations, software production, in contrast, software production is a relatively craft-like, labor-intensive operation relying more on trial and error to achieve its goals (Brooks 1995). The result is that software development is prone to defects, or bugs, delays and cost overruns.

To overcome this ‘software bottleneck’, there has evolved a discipline of software engineering, along the lines of industrial engineering, to simultaneously automate and rationalize software development (Cusumano 2004). While the adoption of engineering practices has improved the overall productivity and quality of software projects, there remain wide variations in programmer productivity and quality. In short, quality and productivity improvements delivered by software engineering have thus far been limited, supporting Brooks’ (1995) contention that there is no ‘silver bullet’ for the bottleneck. Thus, overcoming the bottleneck has required the deployment of more software professionals. The inability of software producers in North America, Europe and Japan to deploy enough professionals triggered the globalization of production, especially to countries with the appropriate skills at relatively low costs (Parthasarathy 2000).19

[19] Although the question of the skills shortage is controversial, in the United States at least, there is agreement that there was a shortage of people with specific skills, such as the ability to maintain older code for mainframe computers (Koch 1998).

Table 3: **India's Software and Service Revenues and Exports, 1985-86 to 2008-09**

Year	Revenues in Millions of US$	Exports: as % of Revenues	Exports: % Share of STPs	Exports: as % of all Exports
1985-86	81	29.63		
1986-87	108	36.11		
1987-88	130	40.00		
1988-89	160	41.88		
1989-90	197	50.76		
1990-91	243	52.78		
1991-92	304	53.95		
1992-93	388	57.99	8.0	
1993-94	560	58.93	12.0	
1994-95	787	62.13	16.0	1.9
1995-96	1253	60.18	29.0	2.4
1996-97	1841	59.75	46.0	3.2
1997-98	3011	58.42	54.0	4.9
1998-99	4069	63.90	58.0	7.6
1999-00	5611	70.61	68.0	10.6
2000-01	8386	74.14	70.7	13.8
2001-02	10073	76.79	80.9	17.0
2002-03	12324	79.29	80.7	18.0
2003-04	16700	77.25	88.4	20.2
2004-05	22500	78.67	92.3	21.2
2005-06	30300	77.89	97.0	22.9
2006-07	39300	79.13		24.6
2007-08	52000	77.69		
2008-09	58700	78.88		

Source: www.nasscom.org; National Association of Software and Service Companies (NASSCOM), Indian Software Directory, 1993-94. NASSCOM; National Association of Software and Service Companies (NASSCOM). 1992. Indian Software Directory, 1992. NASSCOM; STP data from www.stpi.in.

Table 4: **Software firms in Karnataka and their share of national software exports**
(firms registered with the Software Technology Parks of India)

	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Number of firms	1,521	1,721	1,885	2,001	2,085
as a % of national number	22.97%	22.39%	21.33%	20.59%	20.23%
Exports as a % national exports	37.29%	37.24%	33.77%	33.02%	33.70%

Source: Software Technology Parks of India, Bangalore (at: http://www.soft.net/perfanalysis.htm) and Software Technology Parks of India (at: http://www.stpi.in/)

Table 5: **Software Exports - Sectoral Contribution, 2001-02 to 2006-07**

Year	ITES-BPO exports as a % total Software & Services exports	R&D Service exports as a % total Software & Services exports	Embedded Systems exports as a % of R&D Service exports
2001-02	19.3	15.7	76.6
2002-03	23.7	16.4	68.7
2003-04	24.0	19.3	64.0
2004-05	25.9	17.5	70.9
2005-06	26.9	16.6	
2006-07	26.8	15.7	

Source: NASSCOM (www.nasscom.in)

India was among the countries that capitalized on this opportunity and, as Table 3 indicates, the revenues of the Indian software and services industry grew from US$81 million in 1985-86 to US$58.7 billion in 2008-09. With more than three-fourths of those revenues coming from exports, India became the world's largest exporter of ICT services (World Bank 2009). About a third of these exports came from Karnataka, mostly from Bangalore (Table 4). In addition to the quantitative expansion, the industry has also undergone qualitative shifts: from being a provider of low-wage, even if high skill services, to a source of innovation. By 2008-09, a fifth of the exports came from software products and engineering services (Table 5).

3. The policy context for the globalization of ICT production

The mere availability of the necessary skill-cost advantage, however, cannot guarantee the profitable exploitation of a global opportunity without a supportive socio-economic environment for firms. Thus, for instance, the globalization of the semiconductor industry since the 1960s bypassed India (Henderson 1989), reflecting the extent to which the Nehruvian model of a PSE-driven import-substitution-led industrialization (ISI) model had discouraged entrepreneurship and foreign investment, and had proven inimical to innovation (Ahluwalia 1985). Indeed, until the 1980s, the highlight of the Indian computing industry was forcing the wholly-owned local subsidiary of IBM, then the world's largest computing firm, to cease operations after it refused to comply with foreign investment regulations. Another highlight was the failure of the Hyderabad-based PSE, Electronics Corporation of India, to develop a commercially viable computer despite a domestic monopoly. Similarly, India's ramshackle telecommunication infrastructure was thanks, in part, to the obsolete technologies and manufacturing capabilities in ITI, a monopoly producer of communication equipment.

In the 1980s, cautious efforts were made to liberalize the policy regime and to move away from the Nehruvian model. As part of the effort, the government took the initiative to improve communications technologies by establishing the Center for Development of Telematics (C-DoT) in 1984. Based in Bangalore and in New Delhi, C-DoT was to develop state-of-the-art digital telephone exchanges suited for Indian conditions. C-DoT developed many small exchanges, such as the 128 Rural Automatic Exchange (RAX), as steps towards achieving its mandate of developing a 40,000 line Main Automatic Exchange. In what marked the beginning of the end for ITI's monopoly, C-DoT liberally licensed its technologies to entrepreneurs.[20] Stifled by political and bureaucratic interference, which made it difficult to either import technology quickly enough, or to develop commercially viable options in-house, ITI also became a C-DoT licensee.

New policies for the software industry were more explicit in rejecting ISI and the ideology of self-reliance. Two key initiatives of the 1980s were the Computer Policy of November 1984, and the Computer Software Export, Development and Training Policy of December 1986 (Subramanian 1992). The 1984 policy recognized software as an "industry", and made software exports a priority. The 1986 policy aimed at increasing India's share of world software production. The means to do this was the 'flood in, flood out' feature: firms in India were provided liberal access to global technologies to encourage "thousands of small software companies in the country and thereby increasing export as well as local development" (Dataquest 1987:87). Industry was to be independent, with the government stepping in to provide only promotional and infrastructure support.

Despite the initiatives, exporting in this phase typically involved little more than bodyshopping, which had its advantages and limitations. On one hand, it meant 'input-less exports'', requiring only a contact overseas, some finance, and local programmers who could be sent on-site (Heeks 1996). The drawback, however, was an underutilization of the skills of well-trained professionals, many of whom tended to quit seeking technically more challenging and better paying jobs once sent overseas. The high turnover only reinforced the tendency of Indian firms to compete on the basis of low costs rather than being able to fall back on a repository of technical and managerial expertise acquired from previous projects.

Although bodyshopping seems a quick-buck strategy, there were not too many options for firms from a country that had hitherto not merited any attention as a source of ICT products. A study by Banerjee and Duflo (2000), of 230 projects across 125 firms in India, shows that reputation matters in software contracting, even after controlling for project, firm and client characteristics. There is also agreement within the industry that there was no alternative to on-site services to gain the confidence of global customers in the 1980s (Parthasarathy 2000). Further, while Indian engineers had the necessary technical skills, they had trained in a closed economy. On-site services provided exposure to market trends, management processes, and socially specific communication protocols in addition to emerging technologies.

The official encouragement given to bodyshopping reflected a limited understanding of the industry among policymakers: software was widely perceived as being "hi-tech" without adequate distinction made between the different stages of production or the corresponding value added, and amidst the euphoria following the growth in software exports in the 1980s, ignorance and arrogance combined to encourage the opinion that the software industry did not need much by way of policy support (Sen, 1994).

[20] For more on C-DoT's history and strategies, see Meemamsi (1993) and Pitroda (1993).

Paving the way for a better understanding of the industry, and policy support, was a shift in approach to policymaking. Whereas until the 1980s, it was concentrated within a closed bureaucratic apparatus, since then the state has increasingly attempted to draw on industry feedback to make policies (Evans 1995). Based on inputs from the industry, which in 1988 formed the National Association of Software and Services Companies (NASSCOM), subsequent policy measures tried to promote the industry more proactively. The clearest instance of this was the establishment, in 1990, of the Software Technology Parks (STPs). As export zones dedicated to the software industry, the STPs offered data communication facilities which firms that use to offer offshore services, i.e. service provision from India, instead of having to work at customer sites overseas.[21] The popularity of STPs within industry is reflected in the growth of STP centres from 3 to 48 between 1990 and 2007; and the share of software exports passing through STPs increased from 8.0% in 1992-1993 to 97% in 2006-2007 (Table 3).

In 1991, the year after the STPs were established, a balance of payments crisis induced a major shift in economic policies, including devaluation of the Rupee by 18% against the US Dollar, trade liberalization and duty rationalization, openness to foreign investment, and a new industrial policy that removed entry barriers for new firms, a process that is still underway.[22] Even as these economy-wide changes have benefited the software industry, many sector-specific policy changes also emerged from constant state-industry interaction, with NASSCOM represented on various committees at the Department of Information Technology, the Department of Telecommunications, the Ministries of Commerce, Finance, Human Resources Development and Labor. Examples include income tax exemption on profits from service exports in 1992; elimination of import duties on software by 1997; and permission to grant ADR (American Depository Receipts)/GDR (Global Depository Receipts) linked employee stock options in 1998.

The shift to offshore services in a more liberal economic environment marked the beginning of a new relationship between the Indian software industry and global markets. According to Sen's (1994) analysis of quarterly export growth, between 1987 and 1992-1993, a linear equation provides the best fit for the growth. From 1992-1993 until 1994, however, an exponential equation provides a better fit. Although Sen had insufficient data to determine if it was a long-term trend, he projected that if exports maintained the exponential trajectory, they would reach $630 million by 1997. Since actual exports in 1996-1997 were $1.1 billion (Table 3), there was clearly a change in the growth characteristics of Indian software exports.[23] The next section will explain the geographical specificity of these characteristics in Bangalore.

[21] For details of all the benefits offered by STPs, visit www.stpi.soft.net.
[22] For details of these policy changes, see Acharya (2002) and the essays in Oman (1996).
[23] The share of software in Indian exports grew from 1.9% in 1994-1995 to 24.6% in 2006-2007 (see Table 1). Rising software exports also helped increase India's share of world exports from 0.5% to 1.1% between 1985 and 2005. See http://indiabudget.nic.in/es2007-08/chapt2008/tab75.pdf

4. The functioning of the Regional Innovation System

4.1 Local institutional infrastructure and skills availability

Bangalore was among the first three locations where STPs were established in 1990. Within Bangalore, the STP was based in Electronics City (EC). EC was established on 136 hectares of land in 1977 by the Karnataka State Electronics Development Corporation (KEONICS), a Government of Karnataka (GoK) agency, to attract export-oriented firms in the electronics industry. Phase II of EC was developed in the late 1990s on 114 hectares, and, later, a third phase was developed on an additional 98 hectares. As home to the International Institute of Information Technology (IIIT)-Bangalore (see later), and as a location for campuses of firms such as Hewlett Packard, Infosys, Siemens and Wipro, EC is now a prominent hub for the ICT industry in the southern outskirts of Bangalore.

The availability of infrastructure in the form of STPs, in an increasingly liberal economic climate, reinforced the availability of another crucial input that ICT firms sought: skilled labour. Despite widespread illiteracy, Indian education policies managed to create a large pool of skilled labour that, in a relatively slow-growing economy, suffered from underemployment if not unemployment, thus offering a ready resource. The annual output of graduates with a Bachelor’s degree in engineering grew from 247 at the time of independence in 1947 to 237,000 in 2006 (Banerjee and Muley 2008:9). The figure for the US in 2006 was 104,200 (*ibid.*:31). Within India, Bangalore was not only home to the first STP, but it also had access to a deep labour market. Since the 1980s, the early trickle of MNCs to India and prominent domestic firms, such as Infosys, located in Bangalore attracted by the concentration of skilled labour in the public sector in the region. This labour pool was subsequently replenished by the products of the engineering colleges of the states of Karnataka, and bordering Andhra Pradesh, Kerala, Maharashtra, Tamil Nadu, which collectively account for more than 60% of the nation’s institutions authorized engineering degree granting institutions sanctioned intake of engineering graduates (Table 6).[24]

[24] The expansion of engineering education in these states has to with local politics. In the case of Karnataka, Kaul (1993) describes how rich rural peasantry forced the state to permit the establishment of professional colleges to channel agrarian surplus and to ensure the mobility of non-Brahmins into lucrative urban professions. Since the colleges have a political and economic purpose, the quality of education they offer often leaves much to be desired. Nevertheless, the availability of engineering graduates from these institutions has undoubtedly increased the size of the labor pool from which the ICT industry in Bangalore can draw.

Table 6: **Distribution of select technical programs**
(by approved institutions and intake, as on 31 March 2007))

	Undergraduate Engineering (a)		Master of Computer Applications (MCA) (b)		Diploma in Engineering ©	
State	Institutions	Intake	Institutions	Intake	Institutions	Intake
Karnataka	8.58%	9.72%	6.43%	6.41%	14.75%	13.83%
Tamil Nadu	16.43%	18.28%	20.98%	20.44%	16.93%	23.40%
Andhra Pradesh	18.76%	19.91%	27.31%	28.80%	7.76%	6.92%
Maharashtra	11.38%	10.13%	5.22%	5.18%	12.73%	14.84%
Kerala	6.25%	5.08%	3.31%	2.96%	4.58%	3.95%
India	1503	583333	996	53092	1288	300501

Note: (a) Refers to a 4 year professional degree after high school
(b) MCA is a 3 year degree after a 3 year first degree in the sciences
(c) the diploma is a 3 year post high-school vocational certificate
Source: AICTE (2007:97, 99-100)

While the colonial legacy also meant that this labour was mostly educated in English, India's most pointed advantage came, however, not merely from the low-cost, English-speaking labor but from the skills embodied in it. Following IBM's departure in the 1970s, and the unsuccessful local efforts to build a commercially viable computer system, users had to rely on imports. Since high duties were a disincentive to import, the few that were imported were of various vintages and sources (Harding 1989). The experience gained by working on a variety of platforms in the 1970s, helped the Indians win labour-intensive contracts to maintain older systems in the 1980s and 1990s.[25] Further, with the growth in computer manufacture and usage in the 1980s, Unix became the operating system of choice.

As the government undertook limited computerization of some of its activities, it played a role in encouraging the use of Unix, especially in public sector bank automation. This opportunity led to many innovations in the design of Unix-based systems (Heeks 1996). It is impossible to overemphasize the importance of familiarity with Unix. It was developed initially at AT&T's Bell Labs in 1969, as a multi-user operating system to provide a comfortable programming environment. Its use spread rapidly as AT&T's liberal licensing to universities led to the collaborative development of a truly open system, various versions of which were widely adopted by the world's leading computer vendors. As Unix had a profound impact on almost every commercial operating system, Indian software professionals entered the 1990s in a position of special advantage (Udell 1993).

As the global demand for software was sustained by the proliferation of personal computers since the 1970s, the unleashing of networking technologies in the 1980s, and the commercialization of the internet in the 1990s, the skills of Indian software professionals

[25] Examples of such contracts were those requiring the reconciliation of formats, such as those involving dates, of which the Y2K problem received the widest publicity. Jones (1998) points to other format problems with older software that manifest themselves in the 1990s. One date problem had to do with resetting the counters of global positioning system (GPS) satellites used for global fund transfers. The shift to the Euro, replacing 12 European currencies, from 1 January 1999, posed a different kind of format problem.

were also in demand across the world. Just one indicator of the phenomenon is that Indians became the largest beneficiaries of H1B admissions (and, later, L1 too) to the US (Table 6).[26]

The emergence of global opportunities for the Indian professional did manifest itself in terms of wage and skill pressures in the local labour market in the 1990s. However, following the cyclical downturn in the world economy in 2001, and the "dotcom bust", India's share of H1-B admissions declined along with the decline in spending on ICTs.[27] NASSCOM estimated that approximately 35,000 professionals returned to India, mostly from the US (Singh 2003). Of the returnees, an estimated 70% were H1-B visa-holders, while another 10%-15% had been abroad for at least 10 years. Since Bangalore was the first choice for Indians returning home, it further deepened the skills available in the domestic and local labour market.

To build on these skill advantages, Karnataka took the initiative in 1997 to become the first Indian state to have its own information technology policy.[28] A key outcome was the establishment of IIIT-B, in partnership with industry, to offer postgraduate programs in information technology. Along with the century old Indian Institute of Science, widely regarded as the finest research institution for the physical sciences and engineering in the country, IIIT-B has become a critical source of researchers and research inputs for the industry. The GoK also announced a Semiconductor Policy in 2010 which, besides fiscal incentives for the industry, also included a grant to IIIT-B to establish a research centre for the industry.[29]

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[26] The H1B classification enables employment up to six years in a specialty occupation which requires the theoretical and practical application of specialized knowledge requiring completion of a specific course of higher education. The L classification applies to intra-firm transferees who, within the three preceding years, were employed abroad continuously for one year, and who will be employed by a branch, parent, affiliate, or subsidiary of that same employer in the U.S. in a managerial, executive, or specialized knowledge capacity for up to seven years.

[27] For instance, in the US, spending on IT, after growing by 16% in 2000, fell by 6% in 2001 (*Economist* 2002) and, in aggregate terms, technology spending declined from nearly 5% of GDP in 2000 to about 4% by 2003 (*Economist* 2003).

[28] The full text of this policy is available at http://www.bangaloreitbt.in/worddocument/ITpolicy.pdf

[29] The full text of the Semiconductor Policy is available at http://www.bangaloreitbt.in/worddocument/pdf/semiconductor%20brochure.pdf

Table 7: **Comparing regional factors in Bangalore with other regions motivating offshoring of production/innovation**

Factors	Regions	Number of firms undertaking Production	Number of firms undertaking Innovation	As a % of firms that offshore Production	As a % of firms that offshore Innovation
Availability of specialised knowledge	Bangalore	15	12	68.2	54.5
	All other regions	101	86	66.9	57.0
Availability of qualified, low cost, human capital	Bangalore	17	11	77.3	50.0
	All other regions	92	79	60.9	52.3
Access to knowledge infrastructure and services (R&D infrastructure, technical support services etc.)	Bangalore	13	19	59.1	86.4
	All other regions	89	83	58.9	55.0
Access to other inexpensive infrastructure, production resources and services (land, unskilled labour, ICTs, electricity, roads, airports, ports etc.)	Bangalore	18	14	81.8	63.6
	All other regions	77	69	51.0	45.7
Opportunity to sell existing products and achieve greater access into new markets	Bangalore	16	16	72.7	72.7
	All other regions	79	69	52.3	45.7
Regional incentives (e.g. favourable regulations, special tax regimes, testing facilities etc.)	Bangalore	16	10	72.7	45.5
	All other regions	70	59	46.4	39.1
Efficient financial markets (including Venture Capital)	Bangalore	20	15	90.9	68.2
	All other regions	79	67	52.3	44.4
Following clients who are outsourcing i.e. 'follow sourcing'	Bangalore	16	14	72.7	63.6
	All other regions	81	69	53.6	45.7

Source: Responses to INGINEUS Survey Question 9

On the infrastructure front, Karnataka Industrial Areas Development Board (KIADB), a GoK agency, established the Export Promotion Industrial Park (EPIP) in Whitefield, East of Krishnarajapuram.[30] A showpiece within EPIP is the International Technology Park Bangalore (ITPB). ITPB is a partnership between Ascendas of Singapore, the Tata conglomerate, and the KIADB (which provided land as equity). Set in a 28 hectare campus that is a "self-contained city….set amidst a refreshing and aesthetically appealing lush landscape" the park claims to offer an "international business lifestyle second to none". ITPB is now home to 145 firms and 24,000 employees.[31] Like EC, Whitefield is a hub for the ICT industry in Bangalore.

How firms evaluate the significance of the outcomes of these institutional initiatives is reflected in the responses to a survey (Table 7). Firms in Bangalore perceive local physical infrastructure to have played a greater role in determining their choice of location for offshore production and innovative activity than firms in other regions of the country. A much higher percentage (86.4%) of firms that have innovation activity in Bangalore consider the access to R&D infrastructure and services from regional institutions to have determined their location than similar firms in other regions of the country (55%). Although more firms in Bangalore consider regional financial and regulatory incentives to have influenced them, the incentives are more significant for firms undertaking production than innovation. A rather surprising revelation in Table 7 is that there is little difference between the percentage of firms in Bangalore and in other regions for whom the availability of specialized regional knowledge was a draw. There is also little difference in the perceived impact of the presence of low cost human capital for innovation, although it is a bigger draw for firms from Bangalore undertaking production activities. A possible explanation to this finding is that once locate in Bangalore on the basis of other advantages, drawing labour to the region is easy.

4.2 The development of local and international linkages

Thus, by the 1990s, Bangalore became the dominant centre of production for the software industry, and invited comparisons with Silicon Valley, arguably *the* leading centre of innovation for the ICT industry. But the moniker concealed as much as it revealed. On one hand, after a presence of nearly half a century in the ICT industry as a profitable entity in a protected economy, ITI suffered its first losses in 1994-95.[32] Unable to compete with new entrants in an increasingly open market, the PSE shed 30% of its employees in Bangalore between 1988-89 and 1994-95 as they were ill-equipped for the demands of the new technologies for communication equipment. Indeed, the tragic irony of this decline was that 75% of the cost of digital exchanges, ITI's main product line, was software – which was providing the basis for an emergent global industry in the neighbourhood.

The comparisons with the Valley were perhaps appropriate in describing organizational and process innovations that software industry embraced in the 1990s. Capitalizing on the policy

[30] In 1984, the GoK acquired 159 hectares of land for an export zone in Whitefield. When the GoI proposed EPIP in 1994, KIADB acquired another 114 hectares.
[31] For details of ITPB, see http://www.itpbangalore.com/home.html
[32] For details of ITI's decline, see Parthasarathy (2000).

changes since the 1980s, and the availability of the necessary skills and data communication facilities, firms began to pioneer a Global Offshore Delivery Model using offshore development centers (ODCs). The ODCs replicated the infrastructure, technologies, and quality processes of the customer workplace, and brought professionals under one roof, instead of having them scattered at customer sites across the world. For instance, Indian firms focused on adopting industry-wide certification norms, such as the ISO-9001/9000-3 standards prescribed by the International Standards Organization, and the Software Engineering Institute's five-level Capability Maturity Model (SEI-CMM), to codify quality procedures in the development process. By June 2002, 85 firms were certified at Level 5, the highest level of the SEI-CMM, compared with 42 in the rest of the world, with Polaris Software being the first company in the world to obtain CMMi Level 5 certification.33

Arora and Asundi (1999) identify two reasons why Indian firms seek quality certification. First, it is a marketing device, to signal to potential customers that the firm follows a well-defined and documented development process. Second, a well-defined process improves the ability of firms to estimate and manage the time and resources required for a project, helping them bid for larger projects, thereby expanding business. Although Arora and Asundi conclude that the relationship between certification and better rates is not very robust, they add that for firms with an on-going commitment to quality, getting bigger projects is a route to obtaining turnkey contracts that are more profitable.

Obtaining turnkey contracts forces firms to develop substantial management skills, as they have to coordinate a much wider range of tasks than just programming, and take responsibility for the overall project schedule, quality and productivity, in contrast to bodyshopping, which is little more than resume selling. Not only did some Indian firms get better work at better rates, they also began to move away from competing on hour-based productivity to intellectual property rights based productivity, by converting knowledge gained from development projects, in specific application areas, such as banking, retailing or telecommunications, to a customizable generic product for clients with similar needs.

In the following decade, there were signs of technological innovation. Despite the global downturn in 2001-02, as Table 3 shows, the Indian software and services industry continued to grow. This growth can be understood in terms of the efforts by firms worldwide to control costs by outsourcing, not just software but everything from high value-added research and development (R&D) services at one end of the skill spectrum to business processes such as voice-based customer support centers (call-centers) at the other (Srinivas and Jayashankar 2002). Central to the growth of R&D services in India is the ability to design embedded systems.[34] The Indian embedded systems industry is centered on Bangalore, and just one

[33] www.nasscom.org/artdisplay.asp?cat_id=205. Although SEI upgraded the CMM model to CMMi (Capability Maturity Model Integration) in 2000, the broad philosophy of the five-stage model remains the same. For details, see www.sei.cmu.edu/cmm/cmm.html.

[34] An embedded system is any computer that is a component in larger systems (Wolf 2002). In these systems, which can range from consumer goods to transport equipment to industrial process controls, embedded systems not only take over what mechanical and dedicated electronic components used to do, but they increasingly connect to the Internet. It is the ability to digitally capture and simulate various mechanical or other functions that makes the globalization of R&D in various domains technologically feasible. Thus, for instance, automobile firms such as General Motors and Mercedes-Benz have established R&D facilities in Bangalore. Embedded systems design is about adapting software abstractions to meet real-time constraints, power requirements and

indicator of this phenomenon was the formation of the Bangalore-based India Semiconductor Association (ISA) in October 2004 to meet the specific needs of the emerging sub-sector.35 The ISA is distinct from the New Delhi-based NASSCOM, which caters to a more broadly defined software and services industry.

Although the data indicates that embedded systems design did not take off in India until the late-1990s, the origins of the industry can be traced to the pool of circuit designers employed by Bangalore-based PSEs.36 It was this pool of skills that Texas Instruments (TI) drew on when it became the first MNC to establish itself in Bangalore in 1984. The subsequent evolution of the ODC provides an insight into the emergence of embedded systems production in India. Despite the availability of skills, TI did not immediately plunge into design. Instead, the Bangalore centre started off doing maintenance and application work and it was not until the early 1990s that TI developed a design strategy in India. A design center for digital signal processors (DSPs), TI's main line of business, was established in 1995, and the first commercial DSP developed in India was launched in 1998. Since then, the center has developed many new DSPs and obtained numerous patents.

With the growing complexity of embedded systems and the rapid proliferation in their use, chip vendors such as TI do not develop their products in isolation. Thus, while TI retains DSP development, in 2004, it had more than 600 independent DSP partners globally from whom it either sought design services or intellectual property (IP). Forty nine of its partners were Indian, thirty one of which were Bangalore-based. While TI's partners in India include firms that offer contract design services, which is not unlike providing software services, there is another category of partners that was non-existent in the 1990s. This category includes start-ups that generate IP in niche areas and derive revenue from license fees or recurring royalty payments.

Start-ups include such firms as Bangalore-based Ittiam Systems, which was named the most preferred *global* supplier of DSP-based IP by the international DSP Professionals Survey of 2004 (Krishnadas 2004). The emergence of a firm like Ittiam is not merely because of new market opportunities. It is also the availability of the right kind of people which is encouraging entrepreneurs to take risks. Thus, the founders of Ittiam are former TI employees who ventured on their own. In many cases, the entrepreneurs are those returning home not only with years of design experience but also vital exposure to sales and marketing in the global arena. The lack of such experience previously inhibited homegrown startups and the interest of venture capitalists (Krishnadas 2003).

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safety considerations in various domains while interacting with the physical world through sensors and actuators (Lee 2000). Designing embedded systems often requires engineers who are classically trained in the domain of application rather than commodity programmers.

[35] For more on the Indian Semiconductor Association, see http://www.isaonline.org/

[36] This was in part due to the timing of legislation enacted by the GoI to encourage work on embedded systems. In addition to training a pool of skilled labor at PSEs, the GoI passed the Semiconductor Integrated Circuits Layout-Design Act 2000 (http://www.mit.gov.in/sites/upload_files/dit/files/SICLDA.pdf), which provides for the registration and protection of the design and layouts of integrated circuits for a 10-year period. While software patents are not permitted in India, the GoI issued an ordinance to modify the Patent Act "to provide for patents when software has technical applications in industry in combination with hardware," i.e. embedded systems, effective 1 January 2005. For the modified Patent Act, see http://ipindia.nic.in/ipr/patent/patent_2005.pdf

Table 8: **Collaborators for innovation in the past 3 years**
(by % of firms)

	Your Region		India		North America		South America		Western Europe		Central/Eastern Europe		Africa		Japan & Australasia		Rest of Asia	
	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions	Bangalore	Other regions
Clients	55.1	33.1	34.7	37.8	34.7	38.9	10.2	28.0	6.1	14.9	10.2	13.1	4.1	9.8	4.1	16.0	8.2	20.4
Suppliers	59.2	23.3	34.7	28.0	18.4	24.0	8.2	20.7	10.2	9.5	6.1	4.7	0.0	4.7	2.0	8.4	4.1	8.0
Competitors	59.2	17.1	36.7	35.3	22.4	23.6	10.2	17.1	8.2	6.2	6.1	4.7	4.1	3.3	8.2	8.7	6.1	7.6
Consultants	51.0	15.3	44.9	29.8	20.4	21.5	6.1	15.3	6.1	4.7	4.1	3.6	0.0	1.5	4.1	6.5	6.1	6.5
Government	46.9	14.9	34.7	33.5	6.1	8.7	6.1	5.1	4.1	2.9	4.1	2.9	0.0	1.8	4.1	4.4	0.0	2.2
Local universities	53.1	13.8	40.8	26.5	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
Foreign universities	0.0	0.4	0.0	1.5	24.5	10.2	4.1	10.5	6.1	5.8	6.1	4.7	0.0	1.1	4.1	2.9	6.1	2.2
Other	0.0	0.7	2.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Number of firms surveyed in Bangalore = 49; in other regions = 275

The emergence of a dense local network of production and innovation in Bangalore is reflected in the responses to a question to identify the key collaborators for innovation in the past three years (Table 8). Bangalore stands out as a much higher percentage of firms have worked with every type of regional collaborator than firms in other regions. The only exception is the category of Foreign Universities and Others – but the numbers are trivial to non-existent whether for firms anywhere in the country. When considering collaborations within the country, or with North America, which is the largest export market, there is little difference in the percentages. However, a much higher percentage of firms in Bangalore collaborate with universities and consultants within the country and with universities in North America. This suggests that firms in Bangalore have a greater research focus, or a need of specific skills, than firms from other regions. When compared to firms from Bangalore, firms from other regions have had greater interaction with clients in various parts of the world barring North America. This not only suggests that firms from other regions have more diverse markets, but it also raises the question of the relative value of interacting with clients in the region versus those who are afar. The importance of interacting with local clients is brought out by the discussion in the next section.

4.3 The attraction of Bangalore to innovative firms

After years of focusing on export markets, firms have taken another approach to innovation – this time based on interactions with local users who are typically poorer and less literate. With markets in industrial economies maturing, other markets, especially the estimated four billion consumers with the lowest incomes at the 'bottom-of-the-pyramid' (BoP), are becoming attractive (Prahalad 2006).[37] The BoP is a potentially vast and yet largely untapped market, as the majority owns few consumer products. But there are challenges when entering the unfamiliar operating conditions this market as infrastructural inadequacies, socio-cultural diversity, and affordability, mean that existing metrics for 'lead' users do not work. It is against this backdrop that India is attractive. First, India's inadequate infrastructure demands identification of needs and technological solutions which are difficult to conceive of, and turn into product ideas, for researchers in the affluent world. Second, India's vast, poor but socially and culturally diverse environment serves as a laboratory of similar challenges faced in many other countries. Third, the product and service applications generated by the BoP

[37] Facilitating these efforts were also policy initiatives by the GoI and the GoK. For instance, the National Task Force on IT and Software Development was established in 1998 to recommend ways of transforming India into an 'IT superpower'. The Task Force recommended improving telecommunications infrastructure and expanding IT usage to ensure 'IT for all by 2008'. For details of the Task Force constitution and its recommendations, see http://it-taskforce.nic.in/ The Broadband Policy (http://www.dot.gov.in/ntp/broadbandpolicy2004.htm) was approved in 2004 to ensure broadband services for enhancing quality of life through applications such tele-education and tele-medicine. On the demand side, the National e-Governance Plan (http://www.mit.gov.in/default.aspx?id=837) was approved on 18 May 2006 to deliver government services in an efficient and transparent manner, at affordable costs, through common service delivery outlets. In Karnataka too, the state IT policy called for the reduction of poverty and unemployment using technology. Specific initiatives included projects such as Bhoomi (http://www.bhoomi.karnataka.gov.in/) to digitize all the records of Rights, Tenancy and Crops of agricultural land in the state.

market in India, combined with the availability of technical skill, make India a unique location for R&D. Thus, firms such as HP, Microsoft, Motorola and Siemens established research centres in Bangalore to specifically address the BoP market.

An instance of their work is HP's involvement with the 'i-community' in Kuppam district in the state of Andhra Pradesh from 2002-06, where half the population of 300,000 lives in poverty. HP became involved with the project to create "public-private partnerships to accelerate economic development through the application of technology while simultaneously opening new markets and developing new products and services" (Dunn and Yamashita 2003:48). For HP, whose products such as personal computers, scanners and printers remain unaffordable to most Indians, Kuppam was a 'learning lab' to "divine the needs of customers by probing at underlying problems and transferring that understanding to the innovation process" (ibid.:50). In Kuppam, HP developed an easy to carry solar powered digital camera with a small printer. This was given to women in self-help groups to help them generate income by taking photographs at social events or wherever there was a need. HP saw the Kuppam effort as a 'lighthouse account' to guide subsequent product development for India and elsewhere.

Interest in accessing the BoP goes beyond simply serving an untapped market. Indeed, a segment of innovation and product development introduced as responses to the needs of the BoP market is exportable, and has helped some firms to identify new markets in the affluent world. The examples include an affordable X-ray system with outstanding diagnostic precision developed by GE for the poor; ATM machines that use a thumbprint recognition system by Citibank originally intended for illiterate, slum-dwellers; low cost cell phones, with longer battery life, developed by Motorola; and PCs developed by HP in India that run on car batteries to combat power outages.38 Thus, policy initiatives to extend the reach of ICTs to the poor, and to transform their economic and social activities, not only created domestic market opportunities but also offered a platform to export innovative products.

5. Conclusions

Bangalore has long been envisioned as India's future, and ICTs have played a dominant role in that imagination. But the public sector, which was once seen as the vehicle to realize the vision, has given way to the internationally mobile capital. This shift was driven by global changes in technology and public policy, which, in turn, allowed a regional innovation system in Bangalore to adapt and insert itself into the global production networks (GPNs) and, subsequently, global innovation networks (GINs) of the ICT industry.

The emergence of software as a common digital language in which information in any form, spoken, written or visual, can be represented and processed was a technological revolution. The functional versatility that software gives general purpose, programmable hardware has led to the technological convergence of previously distinct information processing and communications devices, and the application of ICTs in domains ranging from agriculture to medicine. The decline in hardware prices since the 1970s led to the widespread demand for

[38] For expanded discussions of these examples, see Nilekani, (2006) and Giridharadas (2007).

software and, since the production of software is labour intensive, the industry sought locations that could provide the labour at a competitive skill to cost ratio.

It was against the backdrop of these technological changes, that the Indian state began to abandon a PSE-dominated, ISI economic model in favour or a model that was more supportive of the private sector and foreign investment. New policies for the software industry in the 1980s were particularly explicit in rejecting ISI and the ideology of self-reliance as manifest in the 1980s were the Computer Policy of November 1984, and the Computer Software Export, Development and Training Policy of December 1986

Within India, Bangalore was able to capitalize on these changes in technology and public policy more quickly and effectively than other regions thanks to a regional innovation system that was nurtured since the 1950s by the public sector. Critical to this innovation system was the concentration of a skilled but relatively low-cost labour pool, initially in the PSEs and subsequently replenished by the products of the engineering colleges of Karnataka and those from bordering states. The provision of skilled labour was reinforced by the provision of the necessary infrastructure. This was manifest in the development of EC and ITPL as the infrastructure to support local production while the establishment of the first STP in Bangalore offered the means to address global markets. Subsequently, to build on these skill advantages, Karnataka took the initiative in 1997 to become the first Indian state to have its own information technology policy and, later, a policy for the semiconductor industry.

The availability of institutional support in the region could not prevent the decline of ITI although a significant proportion of the cost of digital exchanges, ITI's main product line, was software. In contrast, the emergent independent software industry in the neighbourhood was able to thrive by adapting itself to changing global needs. After initially relying on labour arbitrage, the industry pioneered pioneer a Global Offshore Delivery Model using ODCs that replicated the infrastructure, technologies, and quality processes of the customer workplace. The focus on quality, in particular, allowed firms in India to obtain turnkey contracts which forced them to develop substantial management skills and to move away from competing on hour-based productivity to intellectual property rights based productivity in various application areas. One such area was embedded systems where the industry inserted into the GIN as a provider of R&D services by seizing the opportunities provided by a disintegration of the vertically structured division of labour in the semiconductor industry and a labour market that was deepening with Indians with years of international exposure returning home to seek opportunities for innovation. This, in turn, led to ODCs being supplemented by R&D centres, and the evolution of a R&D infrastructure with a network of clients, customers and other supporting actors that is denser than in other region of India.

During the course of the past decade, the opportunities for innovation are no longer limited to the international arena, as firms have "discovered" a BoP domestic market. This market is characterized by poverty and illiteracy, in an environment that does not provide reliable infrastructure for the use of technology. Since it is unlike anything that most firms have experienced, understanding and catering to its needs demands proximity to users and has triggered the establishment of another wave of R&D centres, mostly in Bangalore. There is also policy support for initiatives in this regard as the government has realized the importance of using ICTs to transform various social and economic activities, while firms realize that lessons in India can potentially be used to address the needs of similar markets globally.

As technological and policy changes combined to make India the world's largest exporter of software services, Bangalore became the dominant hub in this historical conjuncture, inviting comparisons with Silicon Valley. This paper shows how that moniker is applicable to Bangalore. The region's insertion into an emergent GPN and, subsequently, GIN of the software industry was a consequence of a regional innovation system that provided suitable skills and necessary physical infrastructure. This allowed firms devise strategies that have led to organizational and process innovations, followed by technological innovations and, more recently, product innovations that draw from interactions with hitherto ignored sections of society. In other words, the paper shows how a territorially distinct hub for GINs has been shaped by historically specific forces in ways that Nehru could not have envisaged.

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ANNEX 3 - Intermediate report – the role of regions supporting the emergence and development of GINs: the case of the Cape Town region

Authors: Jo Lorentzen and Luke Muller (lmuller@hsrc.ac.za)

Participant no. 11: Human Sciences Research Council, South Africa (HSRC)

1 Introduction

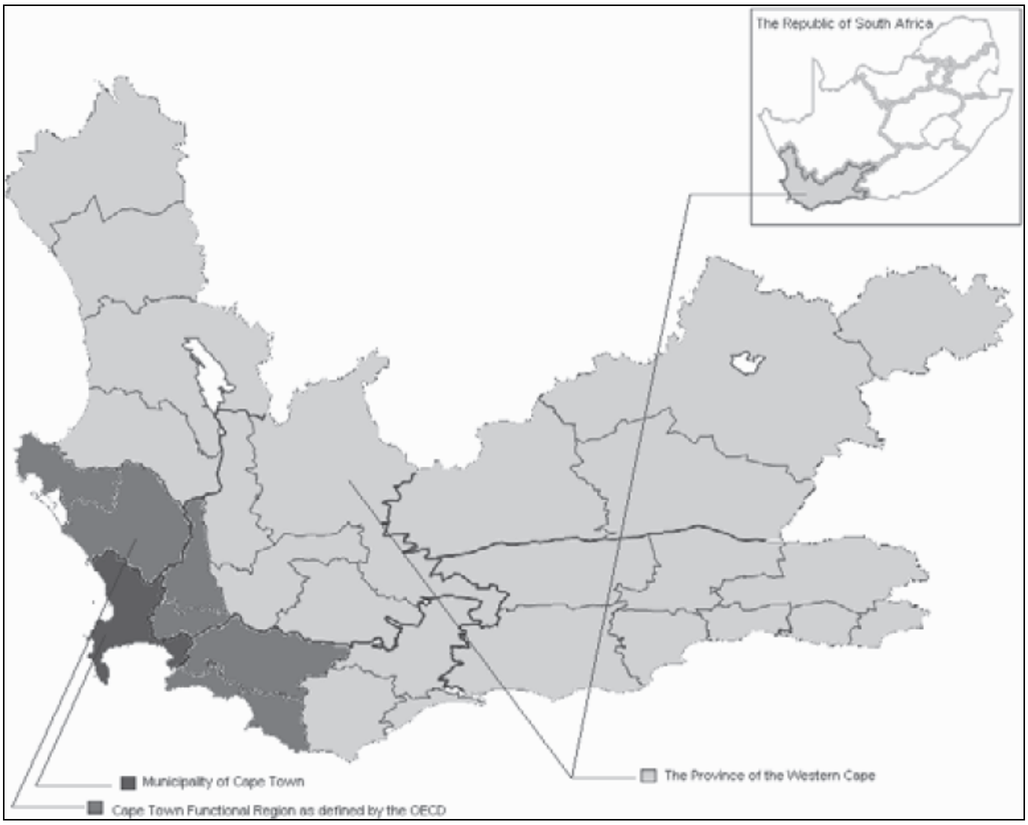
This report focuses on the role of the regional innovation system (RIS) in attracting and supporting knowledge intensive activities that in turn may lead to the emergence and development of global innovation networks (GINs). It is important to point out that this is only one, albeit important role of the RIS. South Africa is the world's most unequal society, and Cape Town is no exception. One out of five members of the labour force is unemployed, and a third of the population lives in poverty. Innovation, whether it takes place in GINs or otherwise, can help address this problem, but it can also exacerbate it by widening the existing divides in society. South Africa is already an economy where an excess demand for (highly) skilled labour is paired with an excess supply of unskilled labour, partly due to a highly dysfunctional education system that will continue to produce young people that are of no interest to GINs whatsoever.

So a comprehensive assessment of the Cape RIS must pose the cui-bono question, namely whether processes associated with GINs involve opportunities for social and economic upgrading or lead to further marginalization of large parts of the population. In fact, "inclusive growth" is a key objective of both the provincial and the city government. But this question is not pursued here.

Cape Town is the second largest metropolitan area in South Africa, with some four million inhabitants, similar to Rome or Athens, and covering an area half the size of Belgium. Historically it played an important role primarily in port logistics and trans-shipment, due to its position along major global trading routes. But today its economy is highly diversified and spans activities in the primary, secondary, and tertiary sectors. Its per capita GDP is comparable to that of Mexico City and Naples. The city is the administrative capital of one of South Africa's nine provinces, the Western Cape. Cape Town and its immediate surroundings account for about 90 per cent of provincial income and population. The region's principal knowledge producers are also located here. The focus of this report is therefore on the urban agglomeration around Cape Town, rather than on the entire province, or what the OECD terms a "city-region" (OECD 2008, see Figure 1).

The Cape Town region has grown faster than the national average or the Gauteng region in the past decade, increasing its share of national income. It is also a less poor and unequal region than all other metropolitan areas in the country, but the region's score on both counts is still very high. At the same time it has a more highly educated population. On the whole, economic activity in the Cape Town region has become markedly more knowledge intensive over time. The economy is largely service based, yet agriculture and manufacturing also matter. In fact, although agricultural activities account for only some three per cent of provincial GDP, products such as fruit and wine are still among the largest exports and are linked into manufacturing (esp. agro-processing) and services (tourism). The Cape Town region is on the whole rather open, with a trade-to-GDP ratio of 0.61. The EU and China are its most important trading partners. Foreign direct investment primarily targets service sector activities, followed by manufacturing and resource-based activities (OECD 2008).

Figure 1: The Cape Town region



Source: OECD (2008, Figure 1.8)

Agro-processing, tourism and hospitality, wholesale and retail, construction and housing, financial and business services, creative industries, and logistics are the most dynamic activities in the Cape Town region (OECD 2008). Lead local firms and subsidiaries of MNEs in each of these sectors are linked to global knowledge flows and there is evidence of localised knowledge spillovers (Lorentzen et al. 2010b). In addition, some firms produce at the global technological frontier (Lorentzen et al. 2010a).

2 History of the RIS

2.1 RIS research in South Africa

South Africa’s national innovation system (NIS) is fairly well documented, although not necessarily well understood (Lorentzen 2009a). The OECD (2007) undertook a comprehensive review in 2006, based on a background report by the National Advisory Council on Innovation (2006). Neither the background report nor the review itself included any consideration of innovation dynamics at a higher than national level of disaggregation. It was not mandated to do that, of course, but even if it had been, the result would not have been much different. The reason is that research on regional innovation systems has been few and far between in South Africa, and consequently the relevant literature is rather thin.

Early research was mainly concerned with indicators and rankings. The Foundation for Research Development (1995) looked at physical endowments, human resources, economic strengths, and scientific and technological resources in each of the nine provinces of the country. It described each dimension on the basis of a handful of factors and thus arrived at four composite indices according to which provinces were ranked, with the Western Cape coming out on top. By the authors’ own admission, the procedure was not objective. The report also did not probe causal links between the various dimensions and factors within them.

Ten years later the Unit for Local Innovation of the Department for Science and Technology made an attempt to understand the role of the provinces in South Africa’s technological achievements (DST 2005). It made use of the technology achievement index (TAI), developed by UNDP (2001) for the Human Development Report. Again Gauteng, Western Cape, and KwaZulu-Natal came out tops (DST 2005, 28), thus mirroring the results of the earlier study by the Foundation for Research Development (1995), even though the two analyses measure two different, albeit not entirely unrelated sets of economic indicators.

Much of the relevant literature is unpublished. Examples include Cartwright et al (2009) on Limpopo. Between 2007 and 2009 the Finnish government provided technical assistance to the South African government, focusing specifically on regional innovation systems. But some studies commissioned through this project were of such poor quality that they do not even figure on the project website (www.dst.gov.za/links/cofisa).

A notable exception to the generally thin and poor state of research on regional innovations in South Africa is research on the wine sector which -- since it is primarily based in the Western Cape -- often includes the spatial aspects of regional analysis (e.g. Giuliani and Rabellotti 2010, Lorentzen 2010, Ponte and Ewert 2009). The first comprehensive analysis of regional innovation systems in South Africa concluded that regional or local innovation systems exist, if at all, only in Gauteng and Western Cape, and possibly in KZN, but nowhere else. To be sure, innovative activities occur elsewhere, but at least on the basis of the data reviewed here they do not appear to result from any systemic interactions at the local or provincial level, if only because in most cases there is no activity to interact with. In other words, provinces such as Limpopo and Northern Cape would rely on outside knowledge sources, while Gauteng exploits diversified knowledge industries, and Western Cape appears to be the province where regional and sectoral dynamics are especially important (Lorentzen 2009b, 224).

2.2 RIS research in the Cape Town region

Between 2004 and 2009 the Department of Economic Development and Tourism of the Western Cape Provincial Government elaborated a microeconomic development strategy (MEDS) for the region. This was in response to an attempt at national level in 2003 to formulate a growth and development strategy for the country. The MEDS was evidence-based and emerged in multiple iterations between officials in the department, commissioned researchers, and an academic oversight committee. Although this was primarily an exercise in industrial and not in innovation policy, the role of knowledge in regional economic development was given due consideration (Kaplan et al 2010, Chapter 7).

In fact, the MEDS was

> principally concerned with ensuring that there is an alignment between (provincial) government, markets and networks of firms and individuals. Consequently, key emphases of policy implementation focus on institutional capacities and relationships; the creation of new institutions to address non-existing entities; and the monitoring and evaluation frameworks necessary to ensure that these institutions improve the responsiveness of provincial government to the challenges facing enterprises (Kaplan et al 2010, 11).

The implementation of the MEDS hinged on public-private partnerships in the form of so-called special purpose vehicles (SPVs) which are in effect development councils for the sectors they represent and which involve both industry and government representatives. The principle of enlisting industry participation in the identification of coordination and other failures as well as in the search for appropriate solutions is undoubtedly among the more important features of the regional innovation system in the Cape Town region. Although the MEDS was discontinued in 2009 -- mainly for political reasons and despite a very favourable international peer review -- the intelligence it provided about the economic dynamics of the region continues to influence policy discussions and it may well re-emerge. The MEDS dwelled at length on the increasing importance of knowledge-intensive activities in the province and generally supported a focus on human capital to alleviate constraints on higher growth.

The Provincial Treasury (2005) also contributed to economic intelligence. Starting in 2005 it published an annual Provincial Economic Review & Outlook in which experts described and analysed regional economic trends in the context of relevant global dynamics. In this sense the Western Cape is the best documented and most analysed provincial economy in South Africa.

The best study of the Western Cape to come out of the Cooperation Framework on Innovation Systems between Finland & South Africa (COFISA) mapped triple helix innovation networks in the regional economy. It concluded that the region has a number of assets and capabilities that can support innovation networks, such as both small and large innovative firms, competent universities and public research institutions, and a government alert to the challenges of competition in the global knowledge economy. It further described existing networks in agro-food, the creative sector, retail specifically aimed at poor people, and the electronic and medical equipment industries, and suggested that innovation networks may be incipient in biomedical, drug discovery, and pharmaceutical activities, as well as in ICT. Constraints to networking include a lack of trust, information and coordination failures, mismatch and divergent expectations across competences, as well as high costs associated with setting up and running networks. Constraints not specific to the region include IP legislation, skills shortages, and funding (Kaiser Associates 2009).

In 2009 the City of Cape Town commissioned a study on its future competitiveness in the global knowledge economy. A background paper focusing on the institutional environment in the city and based on extensive interviews with private and public sector representatives concluded that the city's competitive positioning is hampered by a lack of vision of its future over the next 20 years; governance structures that are not aligned with existing partnerships and networks; the absence of a transparent planning framework; shortcomings in hard (transport, power, and telecommunications) and soft (institutions in support of learning and problem solving in the private sector) infrastructure; and a lack of leadership. But the research also showed the many functioning and incipient, albeit often narrowly focused networks that are functional and productive (Boulle, Hadingham, and Harrison 2010).

Fieldwork undertaken for this research and presented below supports the nuanced finding that the Cape Town region does not have a comprehensive innovation system, but a series of smaller, often sectorally-based, collaborative innovation activities that are successful in pursuing relatively narrow agendas.

3 Composition of the RIS

3.1 Industrial structure

The regional economy is heavily oriented towards services. Three quarters of gross value add are generated in the tertiary sector, especially wholesale and retail trade, transport and communication, and financial, insurance, and business services. Manufacturing accounts for just under a fifth of economic activity, with concentrations in agro-food, petroleum products, and construction. Agriculture and fishing contribute five per cent (see Table 1).

Small and medium-sized firms dominate the regional economy (Kaplan et al. 2010). 50 predominantly large firms listed on the Johannesburg Stock Exchange have headquarters in Cape Town. Half of them are in financial services, property, business services, and retail. The products of more than 40 innovative small, micro, and medium-sized firms in software, biotech, pharmaceuticals, boatbuilding, automotive, and agro-processing have won national or international awards. In a survey under the auspices of the Global Entrepreneurship Monitor (GEM) more than a third of start-up businesses in the Western Cape felt that the product or service they were offering would be considered new or unfamiliar to most clients, and more than half felt that they had few competitors, although only 12 per cent used technologies that had been around for less than a year. A related GEM report concluded in 2008 that Cape Town is South Africa's most entrepreneurial city (Kaiser Associates 2009).

Since most firms are SMEs, even those that innovate do not necessarily have R&D labs. But there is no doubt that leading firms are involved in frontier activities in agro-processing, ICT, and financial services. By contrast the OECD (2008), commenting on Cape Town's alleged innovation deficit relative to Johannesburg, notes that Cape Town's manufacturing base lacks specialisation in high-value added activities which are more active in innovation. This may be true in general. But that "[i]nnovation in Cape Town does not occur in the key value-chains of the economy" (OECD 2008, 104) is nonsense.

But there are differences across sectors in how technological upgrading comes about. For example, subsidiaries of oil and gas groups and business process outsourcing firms access knowledge through their group, and business tourism operators absorb relevant technology from outside. In construction and retail, even lead firms operate at a distance to the frontier, mainly because of a lack of demand for more sophisticated solutions (Lorentzen et al 2010a). Relevant examples are reported with the field work.

Table 1: The regional economy (Western Cape) around Cape Town, 2008

Sector	GVA, R mil	GVA, %	Employ-ment	Employ-ment, %	Exports, R mil	Exports, %
Agriculture, forestry, fishing, food, beverages and tobacco.	31 653	10.61	177 281	10.23	25 711	42.98
Construction	12 887	4.32	131 395	7.58	N/A	N/A
Creative and design	N/A	N/A	47545*	2.74	N/A	N/A
Wholesale and retail trade	38 580	12.93	320 350	18.49	N/A	N/A
Catering and accommoda-tion services	3 613	1.21	53 590	3.09	N/A	N/A
Manufactu-ring (incl. oil and gas; minus food, beverages and tobacco).	45 041	15.10	211 475	12.20	32 505	54.34
Finance, insurance and business services	95 945	32.16	324 011	18.70	N/A	N/A
Government	29 966	10.05	211 919	12.23	N/A	N/A
Other	39 897	13.62	299 293	14.73	1602	2.68

Note: GVA = gross value added. Employment includes informal sector. * = 2005.

Source: Quantec EasyData (2008), van Graan (2005)

3.2 Educational infrastructure

Four universities are in the Cape Town region, namely the Cape Peninsula University of Technology (CPUT), Stellenbosch University (SU), University of Cape Town (UCT), and University of the Western Cape (UWC). UCT is among the top 200 universities in the world and the highest ranked university in Africa. SU has some world-class competences. UWC also has incipient strengths through which it is active in international knowledge networks. Some 2,200 research staff work at these universities. Cape Town also has half a dozen Further Education and Training (FET) schools, and there are yet more in the region at large (Kaplan et al 2010). However, the FET sector in South Africa is generally in crisis and the number of schools says little about the quality of human capital it produces.

3.3 Research infrastructure

Apart from the universities, the region also hosts the regional offices of so-called science councils or public research organisations. They include, inter alia, the Agricultural Research Council (ARC), the Council for Scientific and Industrial Research (CSIR), the Human Sciences Research Council (HSRC), and the Medical Research Council (MRC), employing some 1,800 researchers. In addition, there are 11 private testing labs that undertake chemical analysis, physical testing, civil engineering testing, and microbiological analysis (Kaiser Associates 2009).

The Cape Town region hosts a number of business parks and incubators not all of which are aimed at -- or have been successful in promoting -- innovative firms. They include the Capricorn Business & Industrial Park which started out with an innovation and ICT focus but ended up as a commercial property development. The Stellenbosch Technopark close to SU also has largely a commercial function. In the IT field, the Bandwidth Barn and the Cape IT Initiative (CITI) provide a mix of business acceleration and incubation and pre-start-up services, some of which on a subsidised basis. The Cape Biotech Trust, including Acorn Technologies, is funded by the national Department of Science & Technology in support of emerging biotechnology activities in the region. Initiatives planned for the future include the Bellville Science Park which would focus on life sciences, ICT, alternative energy, as well as engineering and materials science. The initiative is being coordinated by an umbrella body representing all local universities, the Cape Higher Education Consortium (CHEC). The East City Design Precinct, close to the centre of Cape Town, is an emerging initiative that aims to exploit the co-location of upstream and downstream activities in design-related sectors to facilitate agglomeration benefits (Kaiser Associates 2009).

Quantitative evidence for the specialisation and the quality of research undertaken at the local universities has mostly been assembled relative to the rest of the country as opposed to the rest of the world. Specialisations derived from scientific articles exist in life sciences related fields (biology, clinical sciences, medicine, human movement and sports science, public health and health services, medical biochemistry and clinical chemistry, medical microbiology, immunology), engineering (mechanical and industrial engineering, civil engineering, chemical and process engineering, electrical and electronic engineering), earth sciences, and industrial biotechnology and food sciences (Lorentzen 2007a).

The National Research Foundation (NRF) rates researchers according to their output. "Leading international" and "internationally acclaimed researcher" are the two top rankings that provide some measure of global weight of locally produced research. A third of the national researchers rated by the NRF are based at universities in the Cape Town region, principally at UCT and SU. A third of those, in turn, are rated A or B, of whom UCT has more than half. NRF-rated researchers focus on the specialisations identified by Lorentzen (2007) reported above which strengthens this finding. A-rated researchers cover a relatively broad spectrum in the natural sciences (biology, mathematics, earth sciences, chemistry, physics), life sciences (medical and health sciences, agriculture and veterinary sciences), engineering, and social sciences and humanities (law; language, communication and culture; philosophy and religious studies; commerce, management, tourism and services, political science; education) (Kaiser Associates 2009).

3.4 Network infrastructure[39]

The Cape Town region boasts many entities whose remit includes the support of networks between and within the private sector, government, and higher education institutions. Figure 2 provides an overview of 32 entities plus all spheres of government.40 Entities at the base of the triangle mediate the business environment and include statutory as well as private sector organisations, such as national and provincial government departments, Cape Town Partnership (CTP), an initiative to regenerate the inner city, and Accelerate Cape Town (ACT) and Cape Town Activa, forums representing large firms, including MNEs, and SMEs in Cape Town. It also includes the Cape Town Regional Chamber of Commerce and Industry, which represents medium and smaller firms in the city. The universities, represented by the Cape Higher Education Council (CHEC) are close to but outside this area reflecting the generally relatively poor development of university-industry linkages in the Cape Town region.

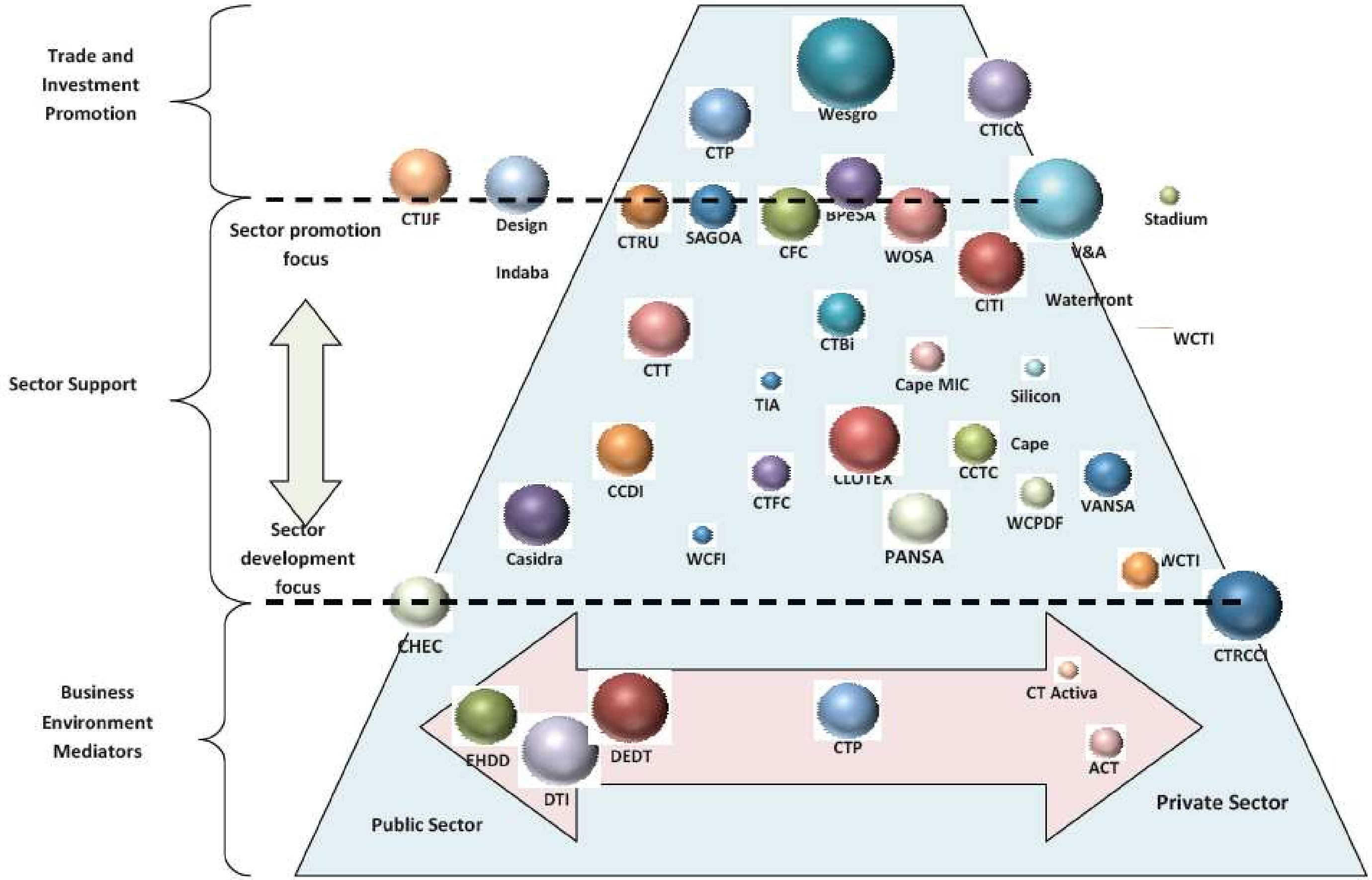
The majority of entities supporting networking activities, located in the centre of the triangle, are dedicated to specific sectors. Prominent among them are the so-called special purpose vehicles (SPVs), established to develop and promote targeted sectors which were a key constituent of the MEDS industrial policy architecture outlined in Section 2.2, as well as a few private sector-initiated clusters and sector associations. Entities located closer to the top include trade and investment promotion activities whereas those closer to the bottom focus more on internal sector development. There are currently 15 such SPVs, supported either by the city and provincial government, or both. Cluster initiatives driven by the private sector include the Silicon Cape (for IT industry promotion), the Western Cape Property Development Forum and the Wine Organisation of South Africa.

Entities at the top of the triangle, also supported by local and provincial government, are involved in trade and investment promotion. Wesgro focuses more on business development, whereas Cape Town Routes Unlimited markets the region mainly as a leisure

[39] This section draws heavily on Boulle, Hadingham and Harrison (2010).
[40] In the current version, the size of the bubble is determined by the age of the institution. The final version will rather depict whether the entity is a weak or strong network actor.

destination. The Cape Town International Convention Centre, rated the top convention centre in Africa and the Middle East, plays a role in attracting business people, events and, indirectly, investment into the city.

Figure 2: Cape Town entities



Source: Boulle et al. 2010

KEY
ACT – Accelerate Cape Town
BPeSA-WC – Business Process enabling South Africa Western Cape (formerly Calling the Cape)
Cape MIC – Cape Music Industry Commission
Casidra – Cape Agency for Sustainable Integrated Development in Rural Areas
CCDI – Cape Craft and Design Institute
CCTC – Cape Clothing and Textile Cluster
CFC – Cape Film Commission
CHEC – Cape Higher Education Consortium
CITI – Cape Information Technology Initiative
CLOTEX – Western Cape Clothing and Textile Services Centre
CT Activa - Cape Town Activa
CTBi – Cape Town Boatbuilding and Technology Initiative
CTFC - Cape Town Fashion Council
CTICC – Cape Town International Convention Centre
CTIJF – Cape Town International Jazz festival
CTP – Cape Town Partnership
CTRCCI – Cape Town Regional Chamber of Commerce and Industry
CTRU - Cape Town Routes Unlimited
CTT - Cape Town Tourism
Design Indaba – Key Event
DEDT – Western Cape Department of Economic Development and Tourism
DTI – Department of Trade and Industry
EHDD – City of Cape Town: Economic and Human Development Department
PANSA – Performing Arts Network of South Africa
Stadium – & Sail de France
SAGOA – South African Oil and Gas Alliance
Silicon Cape – ICT private sector body
TIA – Technology Innovation Agency (formerly Cape Biotech Trust)
VANSA – Visual Arts Network of South Africa
V&A Waterfront – Key location
WCFi – Western Cape Furniture Initiative
WCPDF – Western Cape Property Development Forum
WCTi – Western Cape Tooling Initiative
Wesgro - Western Cape Investment and Trade Promotion Agency
WOSA – Wine Organisation of South Africa

In sum, Figure 2 illustrates that the Cape Town region has a complex set of entities that make up its network infrastructure. There is no shortage of structure, but this does not necessarily equal a regional innovation system, understood as an interaction of productive activities in which networks improve or increase economic or other outcomes. Nominally, there are hundreds of instances of university-industry-government, university-industry, or university-government collaborations (Kaiser Associates 2009). Yet there is also evidence that in practice such collaborations work sub-optimally, and key firms report that their interactions with local knowledge producers are marginal, and with local or provincial government non-existent or not exactly positive (Lorentzen et al 2010b).

In fact, reviews of the institutional landscape have in the past pointed to a number of inefficiencies. The point is not to achieve total efficiency because that would likely impede the diversity needed for successful experimentation of ways of organising economic activity advocated by the MEDS. Perhaps worse than overlaps between institutional mandates and conflicts in project execution, is that selected key actors are not linked at all or only very little, suggesting that network infrastructure is not a sufficient condition for networks actually to function. Accordingly, the OECD commented that "[g]iven the importance of local academia and its comparative advantage in advanced fields of specialisation, the regional innovation system in Cape Town could perform better if university-industry linkages were further developed" (2008, 106). The OECD also remarked on the lack of untraded interdependencies in support of innovation, or the soft infrastructure facilitating the exchange of information and technology. This is further illustrated by the fieldwork.

3.5 Funding

South Africa does not have a strong venture capital industry. Three private equity firms are active in the Cape Town region, namely Cape Venture Partners, Bioventures, and HBD Venture Capital. National public funding is available to incentivise university-industry linkages through the THRIP programme which in 2005-2009 led to more than 400 projects at local universities and research organisations. Another national vehicle is the Innovation Fund which aims to support (pre-competitive) technological development and in 2009 gave funds to Stellenbosch University, the University of the Western Cape, and the Medical Research Council. The Department of Science and Technology, in conjunction with the National Research Foundation, supports centres of excellence at Stellenbosch University (on biomedical TB research and on invasion biology, respectively) and at UCT (on catalysis and on birds, respectively)

Provincial government has a very small budget dedicated to economic development. Much of its support was driven through the MEDS, described in Section 2.2. The administration of the City of Cape Town has traditionally not regarded economic development in the traditional sense as an important activity. The ANC administration which ran the city until 2006 focused on township activities and was not interested in interaction with established businesses. The Democratic Alliance which later took over local government promoted a hands-off approach to local government according to which minimal government intervention intent on guaranteeing basic services was sufficient, whereas the private sector would drive growth and employment creation by itself.

3.6 Government

The political economy of public innovation support in the Cape Town region is complicated. Two major fault lines exist. The first concerns cooperation between different tiers of government. In essence, the national Department of Trade and Industry (DTI) develops industrial policy without taking into account the views of provincial policymakers and stakeholders other than at the tail end of the process, that is when it announces the results of its deliberations which regularly take years to complete. This is despite the fact that provincial and national initiatives are asynchronous in the sense that the Western Cape province pioneered policy support through the MEDS since 2004 -- which DTI could have learnt from but largely ignored -- while DTI was still elaborating its National Industrial Policy Framework (NIPF) and Industrial Policy Action Plan (IPAP), introduced in 2007. Thus DTI identified sectors for promotion that have no presence in the Cape Town region which will therefore not strongly feature in national public support for industrial development (cf. Kaplan et al. 2010).

The second fault line is political. Since 2006 Cape Town has been the only metropole in South Africa governed by the opposition Democratic Alliance (DA). The provincial government was controlled by the ANC. Due to the importance of the city in the regional economy, the two spheres of government should have worked together, alas they rarely did. In 2009 the DA took control of the province which somewhat reduced conflicts between policymakers and politicians in the province and the city. Both city and provincial government have devoted some resources to understanding the region’s competitiveness and economic development better. The situation is therefore somewhat in flux, with possible new institutional configurations such as an economic development agency on the horizon (see also OECD 2008, 212-19).

4 Functioning of the RIS: Empirical illustrations

The field work for this study focused on firms and other entities in two sectors, namely IT and electronics, and in horticulture and agro-processing. The case studies illustrate

- the existence of a functioning sectoral innovation system in horticulture and agro-processing more broadly
- the presence of only very selected or the absence of any geographically proximate interactions in the electronic and IT industry
- emerging or established GINs in both activities.

4.1 Innovation in horticulture and agro-processing: sectoral dynamics[41]

4.1.1 Post-harvest innovation in deciduous fruit

Although fruit is a low-technology product, the fruit value chain is technologically very sophisticated. From the design of new cultivars to cold chain and packaging techniques, fruit production is a highly knowledge-intensive activity. Technological advances have aimed at the reduction of delivery time, the maintenance of product quality, and the cutting of shipping costs. To this end, shippers use satellite systems to track cargo and (remote) electronic systems to monitor quality. Especially fruit destined for exports must be handled so as to arrive at destination in premium condition. The market for fruit is global and highly competitive.

The Western Cape is the main production area for deciduous fruit in South Africa. Like all other agricultural activities in the country, the cultivation and sale of fruit were traditionally highly regulated and protected until the economy was liberalised in the early 1990s. In essence, farmers sold their output to marketing boards at controlled prices.

Modern fruit inspection and monitoring systems, along with handling, cooling, and storage techniques, have been around since the late 1950s. Cold stores have been in existence in fruit production areas since the 1960s. From the 1990s, the industry had a dedicated research arm (Unifruco Research Services (Pty) Ltd), funded by an industry-wide levy, which after deregulation morphed into Deciduous Fruit Producers' Trust (DFPT) Research. DFPT Research funds research at universities, science councils, and other centres. The monitoring of compliance with quality standards is undertaken through the Fresh Produce Exporters' Forum. The Perishable Products Export Control Board (PPECB) inspects and certifies fruit for export to be in compliance with international quality standards on behalf of the national Department of Agriculture (Deciduous Fruit Producers' Trust 2005).

Hence fruit used to be a highly organised sector in which statutory entities ensured coordination and regulation. Although its modus operandi was radically changed in the early 1990s, growers, processors, industry bodies and research organisations were used to intense interactions and had a history of sector-wide coordination. Post-liberalisation, industry bodies and sometimes public-private partnerships offered such coordination to the sector on a voluntary basis. This was not limited to fruit but is also well documented for the wine sector in the Western Cape, for example. The innovation system is sectoral in that it encompasses participants both small and large all along the value chain -- from small growers to multinational exporters. Since even small growers are important suppliers to larger players, the latter ensure that knowledge flows in the system -- whether it is the communication of a problem that needs solving or the technology developed to address the problem -- reach and thus, in principle, benefit all participants.

One such problem is post-harvest damage. Most deciduous fruit has an optimum handling temperature of -0.50 C. Cold chain management aims to ensure that fruit is handled, transported, and marketed so that it reaches the final customer in top quality condition. Regulations are in place to ensure that fruit destined for export has been through an

[41] This section draws heavily on Lorentzen et al (2010a).

unbroken cold chain. Upstream from the cold chain, techniques known as maturity indexing see to it that fruit is harvested at the optimum stage. This varies among cultivars, among other things depending on whether the fruit continues to ripen after picking or not. After harvesting, deciduous fruit must be pre-cooled within a few hours (grapes) or up to two days (apples and pears) and kept in well ventilated, high-humidity storage. Temperature, high ethylene concentrations, and low humidity accelerate the ripening process and must be avoided in so far as this has a direct impact on the shelf life of fruit.

The storage life of apples and pears can be extended through a technique known as controlled atmosphere (CA). CA storage reduces oxygen and increases carbon dioxide and nitrogen levels which can double storage life up to ten months. CA storage has been used in South Africa since the late 1970s. Prior to deregulation, the relevant industry body -- the South African Apple and Pear Producers’ Association -- was responsible for CA quality assurance and to this effect issued a CA label to compliant members. Since the late 1990s the Agricultural Research Council and consultants conduct inspections of CA stores upon request (Deciduous Fruit Producers’ Trust 2005). The world’s largest producer, exporter, and marketer of fresh fruit and vegetables, Dole, uses CA extensively for exports from the Southern hemisphere to North America and Europe. Firms based in the Western Cape that use CA include Capespan and TransFresh Africa (Pty) Ltd.

CA can be administered as a static or a flow-through system. Closed (static) systems re-circulate gases from the storage chamber and are the most common system used commercially. It is prevalent in South African pack houses. Open (flow through) systems do not re-circulate the gases, but have a continual supply of gases of the required composition flowing through the storage chamber (Smith et al 1997).

It is not possible to measure the technology gap between deciduous fruit exporters from the Western Cape and their competitors directly. This is because too many factors impact on the quality of the fruit when it arrives at its destination. Physiological or microbiological post-harvest disorders can affect the quality of the fruit. Even if such disorders originate in the orchard, they may only present in the cold store or during post-storage ripening. The cold storage regime itself can also initiate disorders. Even if fruit successfully passes all inspections before being shipped out and then again at its destination port, things can go wrong in the period before it reaches retail shelves, that is when it is no longer in the possession and under the control of the exporter. To mitigate this, the Fresh Produce Exporters Forum has integrated temperature and humidity measuring devices into pallets. Rejected consignments, in sum, can have many causes that would have to be determined on a case-by-case basis in order to detect where in the value chain problems appeared, and whether technological differences played any role.

Hence the technology gap can only be derived circumstantially. South Africa is the third largest deciduous fruit producer in the Southern hemisphere, after Argentina and Chile. In 2008, it was the eighth largest exporter, amounting to six per cent of the top-ten apple and seven percent of the top-ten pear exporters (FAO 2009). The volume of deciduous fruit production more than tripled between 2003 and 2008 to reach some 95m cartons. Industry insiders credit technological improvements in post-harvest handling, such as CA, for this performance (Dodd et al 2008). However, the efficiency of cold storage facilities in South Africa lies behind that found in Chile and New Zealand. The industry in New Zealand performs well in education and IT deployment. Chile, with weak human capital, enjoys modern cold storage facilities. But in an evaluation of their relative competitiveness, South Africa was given maximum points on the use of controlled atmosphere (South African Fresh Fruit Exports 2009). Hence, deciduous fruit producers based in the Western Cape are close to the technological frontier in post-harvest technology.

Further, in a comparison of production efficiency as well as infrastructure and inputs in 29 major apple producing countries, the World Apple Review (2009) ranked South Africa -- and, thus, primarily the Western Cape -- ninth worldwide. Overall, the country came in fourteenth place, due to a weak ranking of financial and market -- and hence non-technological -- factors. Similarly, the World Pear Review (2009) ranked South Africa second worldwide for production efficiency, eighth in terms of infrastructure and inputs, and twelfth overall, again due a weak performance in financial and market factors.

A benchmarking study covering South Africa, Chile, and New Zealand found that South Africa’s fresh fruit export logistics did not compare favourably. Technology-relevant weaknesses included the use of technology in transport systems and the structuring of information technology. South Africa is behind its competitors in the electronic processing of all documentation. Also, all aspects of packaging need modernization (Post-Harvest Innovation Programme II n.d., 79-80).

The industry has considerable knowledge creation potential. AgroFresh, a division of US based Dow Chemicals, recently developed a technology called SmartFresh. SmartFresh is an ethylene management system that slows down the ripening process and can be used in conjunction with CA or on its own. Experico, a research firm owned by fruit exporter Capespan, based in Stellenbosch, collaborated on research with AgroFresh and was contracted to do the commercial applications of the technology. It also conducted registration trials for certain fruit kinds, giving local growers an opportunity to use the technology.

Experico is also involved in research on packaging. Packaging is key to the maintenance of quality. For example, insufficient ventilation to fruit increases the cooling cycles and energy consumption. An important consideration for improving packaging concerns the effects of packaging on the environment. Experico researches packaging material that can be recycled, reduced, and reused. For example, preliminary studies indicate opportunities to replace the current packaging bags for more environmentally friendly biodegradable bags.

Experico’s research is part of a larger post-harvest innovation programme, steered by the Fresh Produce Exporters’ Forum in conjunction with the Department of Agriculture, Forestry and Fisheries (DAFF) and the Agricultural Research Council (ARC), funded by the Department of Science and Technology. In the first three years of its existence, the programme funded projects in the areas of integrated packaging solutions, container technology, temperature and humidity control of products, irradiation technology, non-destructive fruit quality assessment techniques, the development of an information hub, post-harvest physiology, pre-harvest disposition of post-harvest disorders, post-harvest disease control, food safety, technology transfer, mitigation technology for sanitary and phytosanitary compliance, entomology, and carbon footprint (Post-Harvest Innovation Programme n.d., Post-Harvest Innovation Programme II n.d.).

The post-harvest innovation programme is an attempt to design novel solutions to practical problems the industry is facing and that are affecting its future competitiveness. This is a knowledge-intensive process. In 2008/09, DFPT Research had 98 ongoing research projects, funded ten researchers at Stellenbosch University and three at its codling moth SIR facility, plus 48 postgraduate students. It also supported the local integration into global knowledge flows by funding the attendance of local researchers at international conferences, and of international experts to South Africa (Hortgro 2009). Although this research takes place in different parts of the country, the Cape Town region is the centre of activities. Of the 25 final projects researched in the context in the Post-Harvest Innovation Programme (Post-Harvest Innovation Programme n.d., 101-102), only one was located in KwaZulu-Natal and three in Gauteng; all others were in the Western Cape.

4.1.2 UV pasteurisation

UV radiation has been used for some 80 years to inactivate bacteria and viruses, including in clear liquids such as water. In the food industry, UV radiation has a number of advantages over other preservation methods such as heat-based pasteurization. It can kill microorganisms that are not susceptible to heat treatment. Because it is non-thermic, it does not negatively affect food whose properties are sensitive to heat. Finally, it uses much less energy than heat treatment. In principle, UV treatment can therefore improve food quality and safety, while reducing the carbon footprint of producers, for example in the dairy and fruit juice industries. Regulatory bodies such as the US Food and Drug Administration have given market approval to use UV radiation for the treatment of water and food under certain conditions (Reinemann et al 2006).

However, the practical application of this technology faces a number of challenges. In the dairy industry, for example, the solids present in milk limit the penetration of UV radiation, thereby limiting its efficacy. Also, inappropriate exposure to UV can cause oxidization and sensory defects in the product (Reinemann et al 2006).

Surepure, a company based in Cape Town and recently incorporated in Switzerland, has developed a UV purification system that addresses these shortcomings.42 Its system increases the penetration of UV throughout the liquid being treated and thus ensures a maximum coverage of individual microorganisms. The mechanism of the system is that it guides the liquid to be treated in a turbulent flow past a germicidal UV lamp housed in a quartz sleeve.

A number of universities both in the Western Cape and the US tested the technology. In dairy, the results showed a high efficacy of bacteria reduction with no noticeable effect on the taste of milk, except when UV was applied excessively. The researchers concluded that Surepure's technology could be used for the cold treatment of raw milk, reduction of bacteria not susceptible to heat treatment, psychotrophic reduction in milk refrigerated for prolonged periods of time, and in parts of the world where unreliable or costly energy supply make on-farm refrigeration unviable (Reinemann et al 2006).

[42] The incorporation in Switzerland aims to avoid the negative connotation of being based in a developing country.

Surepure used an intermediary to organise the research with the local universities. Research Solutions is a company that was founded by a graduate of Stellenbosch University who used to do applied development work for the subsidiary of a multinational agro-food in the Cape Town region. When regulatory hurdles forced Surepure to replicate all its tests at universities in the US and in Europe, Research Solutions again acted as an intermediary between the company and foreign universities, ensuring the adherence of protocols and so on.

The Innovation Center for US Dairy (2009) confirmed the relevance of UV in reducing the carbon footprint of the industry by launching a series of laboratory trials aimed at demonstrating the feasibility of substituting UV for heat pasteurization in the near future and for ultra-high-temperature (UHT) processing in the longer term, and at securing regulatory approval.

The technology has also shown good results in the treatment of fruit juices against bacteria, viruses, yeasts, and moulds, where in comparison to heat treatment it did not alter taste or colour profiles. It was recommended as a substitute for thermal treatment or antimicrobial compounds, giving consumers a preservative-free but safe product. The researchers also commented on the low energy intensity and low maintenance costs of the technology (Keyser et al 2007).

Related research (Davaux n.d., Fredericks et al n.d. a,b) suggests that the new UV technology can be used to reduce the sulfur dioxide content of wine. Its effectiveness depends on both the turbidity and the colour intensity of the wine, which means that the treatment must still be optimized. In addition, the sensory impact of the treatment is still to be evaluated comprehensively. Likewise, although hops is known to react to UV radiation by developing an "off-flavour", preliminary research shows that this effect can be contained (Mezui n.d.)

The feasibility of a technology is not synonymous with its demand. The fact that Surepure holds a worldwide patent on its technology does not demonstrate in and of itself that the new system is a frontier technology -- if nobody is interested in it, the technology will not have an impact and be relevant for technological upgrading. But Surepure is working with a number of global and local customers that either operate the technology already or are experimenting with it. Examples includes US retail group Wal-Mart which wants to increase the shelf life of its milk and reduce the frequency of delivery to retail outlets in order to cut costs. The local subsidiary of Canadian multinational McCain Foods, one of the largest producers of potato chips, uses the technology to disinfect starch-laden water used for rinsing potatoes.

A leading South African fruit juice producer based in the Western Cape, Lombardi, has been using Surepure's technology since 2007. Lombardi's main customer is Woolworth who market UV-treated juices as a greener product, due to their much lower use of energy compared to heat-treated juices. The South African operation of SAB is also experimenting with the technology. Prestigious estates such as Franschhoek based L'Ormarins in 2008 produced a small batch of Chardonnay whose sulfur content was merely 20 parts per million, some six to seven times below the industry average (No mess, no fuss 2009).

In sum, this innovation is based on a process patented by a local firm that taps into research both locally and internationally to test its system, develop it further, and prepare it for regulatory approval, mainly in the dairy industry. The firm interacts intensely with the Food Microbiology Research Group at the Department of Biotechnology of the University of the Western Cape, Department of Biochemistry and Institute for Wine Biotechnology, Department of Viticulture and Oenology, both at Stellenbosch University, Elsenburg Dairy Research Facility at the Agricultural Research Council, and Department of Food Technology, Cape Peninsula University of Technology as well as Birmingham University, California Polytechnic State University, and Milking Research and Instruction Lab, Center for Dairy Research, University of Wisconsin.

4.1.3 Recipe blending processes in the baking industry

Whereas the two examples above involve primarily locally owned companies, the next illustration includes a European multinational manufacturer of food ingredients as well as enzymes and biochemicals for detergents. The MNE has a subsidiary in South Africa and operates a blending plant in the Cape Town region. Its major activity is ingredients for the dairy and baking industry both in South Africa and the rest of the continent. It sources these ingredients from manufacturing plants of the parent, none of which are located in Africa, and blends them to the specifications of its customers.

The parent group operates an international knowledge base accessible to key personnel around the world that records and stores any relevant technological innovation, emanating from the group's more than 20 innovation and application centres around the world, as well as from collaborations with research laboratories in universities. Until recently, this system did not really pay attention to activities at the South African subsidiary because it was run by and for R&D people whom the local operation did not have, nor was local personnel really in need to tap into this knowledge base.

In 2010, this changed because the subsidiary acquired a locally owned firm which had pioneered a new way of testing flour recipes for the baking industry, reducing turnaround time -- i.e. from the receipt of a new flour to the delivery of a ready recipe -- from one month to 24 hours. The reason for the superiority of the process lies in the trade-off between scientific analysis of the flour, including several repeated trial bakes over time (which is time consuming) on the one hand, and tacit knowledge whereby experts with a lot of experience can select the most suitable blends from a portfolio of 32 batches of test bakes on the other. Criteria include, among others, softness, resilience, and crumb structure. This does not deny the role of science, but scientific analysis of flour has limitations: it cannot accurately predict how a flour will behave in a bakery. Hence blending involves a certain amount of trial and error anyway, and it is this experimenting and learning that the application of tacit knowledge can speed up.

The group now plans to make the originators of the new process visit other plants around the world to explore a possible application elsewhere. Hence there is knowledge transfer from the Cape Town region to the rest of the world, including to other developing countries.

The group as a whole is involved in GINs. It works intensely with other organizations, including some 30 universities. For example, it achieved leadership in the market for pro-biotics through its collaboration with the University of Helsinki. It also uses venture capital to buy equity in promising start-ups. Its R&D staff regularly and actively attend scientific conferences, such as the congresses of the International Union of Food Science and Technology (IUFOST).

In sum, the subsidiary is not involved in basic research but is geared up to do applied research and development with relevance for the group. Its GIN has a capital "G" (due to the global knowledge presence of the group on which the local operation can draw and to which it will contribute), a growing "i" (because it has just established an innovation-and-application unit that will work on bakery and dairy projects), and a medium-size and also growing "N" (in the sense that the emerging innovation portfolio implies that it will work more intensely outside of the group, i.e. also with external partners such as universities.

For the time being it is important that the local operation was able to develop a more ambitious subsidiary mandate because it acquired local expertise, both through take-overs and targeted headhunting of key personnel with a base in the Cape Town region. In fact, it recently acquired a small consultancy that had specialised in liaising between industry and university researchers with specific agro-food competences.

4.2 Innovation in IT and electronics

The Cape Town region does not have a strong electronics industry, but it does have a few firms that are internationally recognised for their specific capabilities. Examples include Ziton, a producer of fire detection systems that was acquired by General Electrics in 2005, and Tellumat, a group with a wide portfolio in communications, defence, and manufacturing.

Cape Town's IT industry has a much larger number of, albeit small, firms. The industry is supported by a few sector associations, notably the Cape IT Initiative (CITI), the Bandwidth Barn, and more recently the Silicon Cape.

4.2.1 DCM[43]: interaction with local universities

DCM develops high speed digital signal processing technologies for defence forces (i.e. electronic warfare) and other government agencies. Its technologies can also be utilised for sonar and radar applications. DCM's principal customer is DSM44, a South African systems engineering company based in Gauteng that markets and sells both locally and internationally and has two large European defence companies as key shareholders. The relationship between DSM and DCM has built up over some 25 years and the two partners trust each other. This is one reason why DSM does not attempt to source similar technologies elsewhere, either nationally or internationally.

DSM's competitors are typically large multinational companies, such as French-based Thales, that manufacture technologies such as those developed by DCM inhouse. Competitive drivers are mainly technological innovation, performance, and price. The technological frontier is pushed as electronics develop and new applications open up. An

[43] DCM stands for Defence Components Manufacturer. The real name of the firm is confidential.
[44] DSM = Defence Systems Manufacturer.

example of a breakthrough in the radio field engineered by DCM some ten years ago was the development of specialised radio receivers that enable users to process a wide band of the spectrum, while also focussing on a narrow part of the spectrum to identify where a transmitter was located. DCM's wide-band direction finder was a world first, with consequent high demand which pushed DSM's brand and credibility and opened up new markets.

On the supply side, DCM work with international contract assemblers to get printed circuit boards and other components up to world standards. In South Africa, they are generally not produced in the quality required but a company based in Pretoria is a preferred supplier. Sourcing from a supplier in the same country, especially for smaller volumes, obviates the need for dealing with customs procedures which can be costly. DCM test components and then give feedback to the manufacturing departments of the large multinationals supplying these specific inputs. Mechanical components are sourced from a supplier in Hong Kong.

Hence neither upstream nor downstream is DCM a firm that has many linkages in the Cape Town region. Most interactions are national and international. Its staff, however, are recruited locally. DCM recruits technicians from the Cape Peninsular University of Technology and electronic engineers from UCT and, to a lesser extent, Stellenbosch University. Their quality is high and there is no need to source human capital nationally or internationally. As one of the few high-tech companies in the region, it is easy for DCM to attract the best graduates. With UCT in particular, DCM has a close relationship; it informally interacts with lecturers and students, sponsors open-day prizes, commissions research projects, and gives the university feedback about the quality of its employees.

The main reason DCM is located in the Cape Town region is the attractive life style the city and its surroundings afford. Although it would be beneficial to have contract assemblers on site due to cost savings on testing, the past has shown that DCM can be globally competitive even without such co-location. In sum, DCM is a company that taps into and contributes to global knowledge flows which it accesses without much of a regional innovation network. Much like its suppliers, DCM could be located in other parts of the country or, for that matter, the world.

4.2.2 SEO[45]: no local interaction

SEO organizes campaign management in the context of online advertising and marketing for its clients, such as retailers. This entails the identification of relevant keywords that can drive commercial traffic to a site. On this basis it builds comprehensive campaigns which identify aims and objectives, expected returns on investment, budgets, and so on. This is client- and industry-specific. SEO also advises the client on the quality of its site.

A typical client could be a seller of i-pods who competes against many other sellers of the same product and who wants to ensure that as much traffic as possible lands on his or her site and converts into sales. Online advertisers pay the search engine for every "click" generated by a potential customer onto their link. This works on a limited inventory option

[45] SEO = Search Engine Optimisation.

basis, i.e. search engines get paid according to the value each advertiser associates with the clicks the engine yields and, thus, ultimately the expected conversion rates.

Keywords are then put onto search engines such as Google, MSN or Bing. Since potential customers are searching for information, this is known as pull advertising. Online marketing and purchasing is already very big in the US but it is also growing in SA, for example in travel which lends itself to online transactions in that it does not need to be delivered physically to the customer. Currently, delivery charges in SA are still rather high which militates against using the internet for many other kinds of products.

Although campaign management sounds simple, this is deceptive. In fact, it involves advanced mathematics and automation. Essentially the challenge is to optimize the kind and number of keywords -- each of which creates a separate but related marketing channel -- so that a specific site differentiates itself from its competitors, captures as many potential customers as it can handle, and does all of that in the context of a viable advertising budget (given that each click costs but not each click converts into a sale). For example, less obvious and trafficked keywords might generate less traffic, but this could still be substantial and would definitely be cheaper. Hence, depending on customer behaviour, pricing could be linear for one product and exponential for another. Campaign management is dynamic in the sense that monitored traffic at t1 can lead to a modification of keywords at t2 to optimize performance. Monitoring is done on an hourly or daily basis. In sum, SEO runs automated systems with dynamic optimization.

Although there are probably hundreds of thousands of firms offering campaign management, SEO only has some four or five competitors worldwide who offer a similarly knowledge-intensive service based on quantitative tools and analytical rigour. SEO has a good retention record of its clients and is particularly attractive to customers who operate only online and thus live or die by the success of their campaigns.

SEO is currently vertically integrated but this may change in the future. Due to the skills scarcity in South Africa, programming is quite expensive and could be outsourced to places like Israel or Eastern Europe. Since the development team is relatively small, outsourcing would currently entail too high management costs. But if the company grows and expands the development team to three or four times its current size, outsourcing will become an option. Outsourcing is therefore a scale issue.

The fact that the company is based in Cape Town is essentially a coincidence -- its founder is originally from Cape Town. SEO spun off a firm that's now headed by SEO's founder and is located in San Francisco where much of the development activity in this industry takes place. But while it is important to be close to clients in the acquisition phase, once the business is operative it doesn't really matter where it is. This is why SEO is still in Cape Town although the South African market isn't particularly deep. There are no clustering effects -- SEO is the only such company working at its level of complexity in the country.

SEO is a member of CITI and participates in its networking activities to keep in touch with other software engineers and the industry more generally. It also sends its staff to some of CITI's soft-skills training workshops. SEO is eager to help strengthen the IT sector in Cape Town; the more critical mass there is, the easier it becomes for individual firms to succeed. At the moment, SEO's advanced capabilities imply that it acts as a sort of training ground; it would be advantageous if it could draw on the industry as much as it contributes. For example, the recruitment of good technical people is an extremely time-consuming and lengthy process, especially because the size of the company requires that people are entrepreneurial and flexible on top of being good programmers. Finding a suitable developer can take up to seven months. This is very different from, say, Israel or the US where such skills are widely available. Not all recruits have completed degrees; a few are simply talented hackers who have a knack for programming. Most SEO staff are from SA but there are also people from Europe.

SEO stays abreast of technological developments in the industry by subscribing to the latest tweets and blogs and reading whatever else is relevant. The company attends about six industry fairs every year. What also happens is that clients voice new needs or report innovations they've heard about elsewhere. Non-proprietary information in the industry is shared quite freely. Often this happens in the context of demonstration projects where someone markets a specific solution or presents a specific capability.

SEO cannot think of any regional or national policy that has been helpful to the industry. It has tried to build research relationships with universities in the Western Cape, especially with mathematics departments. It offered sponsorships to masters students to increase the pool of potential recruits, also because most graduates with advanced mathematics skills currently end up in the financial service industry whose salaries SEO cannot match. This initiative led nowhere. In fact, neither SU nor UCT seem to have the entrepreneurial mindset required to work with industry. They would gladly accept industry funding for students, but not concede that this must be accompanied by some quid-pro-quo without which university-industry linkages make no sense to the private sector. Even personal visits to mathematics professors made no difference, until SEO eventually gave up. Business facilitation essentially seems a foreign concept in the university system, at least as far as SMEs are concerned. By contrast, UCT did set up one of the few mathematical finance programmes in the world after prodding from the industry (which is of course very sizeable in the Western Cape).

The biggest impediment to competitiveness that government could address is the unreliable, slow and expensive bandwidth. It could perhaps also incentivise commercialization centres at the universities that are open to new activities and small companies, as opposed to only big players in established activities. Past and ongoing activities such as CITI and the Bandwidth Barn are helpful. A stronger venture capital industry would also make a huge difference. One could also try to brand CT as an IT hub but this would require massively addressing the skills shortage.

5 Challenges of the RIS

Assessments of (regional) innovation systems are often morphological. Authors describe entities and interactions without determining ex ante what level or intensity of interaction between how many non-marginal actors qualifies as "systemic". In this view, almost anything can be a system, although it may be characterised as "weak" or, especially in developing countries, "immature". If terminology were employed with a greater degree of precision, one might conclude that "immature" systems are no systems at all because interactions are either totally absent or ad-hoc and haphazard, and thus by definition not "systemic". A system might then be an aspiration for the functioning of a specific socio-economic reality, rather than an immature incarnation of something that over time will necessarily grow more mature.

Empirical analyses thus suffer from an underdeveloped theoretical framework that is very permissive in terms of what constitutes a system, be it regional or national, and that has largely failed to specify the evolutionary dimension so that system trajectories are more than just arbitrarily termed and often static assessments of a specific manifestation of socioeconomic activities that are without antecedent and also of little relevance to whatever follows.

This report does not address this shortcoming. It merely posits that interactions must

1. be untradeable (i.e. not easily replicable elsewhere or with other actors)
2. generate productive outcomes, and
3. be the rule rather than the exception (i.e. involve at least the key and preferably most firms in an activity)

in order to constitute a "system". In other words, in the absence of stickiness, or in the case of interacting for interacting's sake, or if productive interactions are limited to very few entities, the resulting economic dynamics are below a threshold at which it makes sense to regard interactions as systemic. Whether they are "weak" or "immature" or simply "non-existent" can only be analysed in a longitudinal study -- it is important to avoid the implicit bias according to which systems necessarily evolve from weak to strong or from immature to mature. Also, if they do not exist, they may simply continue not to exist in which case the systems terminology should perhaps not be employed at all, because it obfuscates rather than clarifies the relevant dynamics.

The case studies undertaken for this report show that agro-food activities in the Western Cape satisfy the three criteria identified above. The interactions along the value chain, including with researchers at universities and research organisations are intense, frequent, and involve the majority of the relevant sectors. They also have a productive impact, and it would be impossible -- or at least very difficult -- to replicate them in the absence of geographic proximity that has favoured these interactions to date. This interpretation confirms findings from studies of the Western Cape wine industry which has been analysed quite widely, much more so than other areas of agro-food. It is therefore justified to speak of a regional agro-food innovation system.

The same cannot be said of the IT and electronics industry. Stickiness is much less important, and interactions are the exception rather than the rule. The firms featured here illustrate a larger picture, despite the fact that the ICT sector in the Cape Town region is supported by the aforementioned Cape Information Technology Initiative (CITI; see also Lorentzen 2007b). Hence, an IT innovation system is clearly a goal in the region, but it does not yet exist.

There are at least three differences between the two sectors. The first is that the demand for a (sectoral) innovation system is high in the agro-food sector. This is because many firms are small, and for this and other reasons do not have the capability to innovate by themselves. They need networks to identify problems, communicate them so that they can be solved, to implement the resulting solutions, and to organise the funding for this process. Large firms also need this because they are dependent on high-quality upstream inputs which presupposes that suppliers are somehow integrated in the relevant knowledge flows. It helps that agro-processing has a history of sector organisation thanks to which firms are used to cooperate. Some of the solutions created rely on tacit knowledge which in turn requires physical proximity to be absorbed and internalised.

In ICT, there is comparatively little demand for locally based networks to aid problem solving and innovation. Lead firms have high capabilities and can access knowledge around the world, and in general this industry is based on codified knowledge which is much easier to transmit and access virtually. Suppliers can thus in principle be anywhere in the world -- local proximity is convenient, but it is not strictly a prerequisite for success.

The challenge for innovation in and, more specifically, the attraction of knowledge-intensive activities to the Cape Town region is that even in areas where there is demand for coordination and systemic interactions, it does not always exist. Despite the Cape Town region being one of the better documented economic spaces in South Africa, neither firms nor universities or government entities know comprehensively what exactly is going on, whether the provision of public goods could unlock dormant or otherwise untapped innovative potential, and how this might best be done. Where sectoral innovation systems exist, they show that cooperation and coordination are possible and that they make a difference. Where they are absent but needed, the issue therefore seems to be more one of information failure than an unwillingness or inability to work together.

6 RIS and GINs

There is evidence of GINs in the Cape Town region. Each case study showed global activity, in development, technology import, or sales. It also showed innovative activity, albeit to different degrees. Some was pre-commercial, other fully in production. With one exception, companies were more or less intensely networked, but these networks were only in part locally based. In no instance did the GIN emerge out of a global production network in which producers in the Cape Town region successively occupied more demanding positions in the relevant value chain. The IT companies were born as innovative entities, and innovation also has a long history in the fresh produce industry.

The case studies discussed here suggest that systemic interaction and coordination can be instrumental in facilitating innovation in specific sectors, activities, or value chains. They are not always necessary, however. Likewise, GINs can evolve even in the absence of functioning local innovation systems. Based on this evidence, the relationship between RIS and GINs is rather simple: a regional system can support the emergence of GINs in activities where tacit knowledge, small firms, and at least in part weak capabilities militate against individual downstream firms innovating outside a geographically proximate context, by formulating the demand for innovative solutions that are commensurate with the challenges experienced in the (global) marketplace. In other words, it is more difficult for individual agro-food firms in the Cape Town region to be innovative which is why a sectoral innovation system is a prerequisite for local innovation to materialise first and then to be included in global innovation networks. It is less difficult for leading IT and electronics firms to be innovative, but in the absence of a local innovation system the IT industry at large is unlikely to be noticed by MNEs intent on offshoring or outsourcing knowledge-intensive activities. In part, therefore, a functioning RIS has a scale effect; interaction and coordination unlock innovative outcomes which in turn allow groups of firms or sectors to get involved in GINs, as opposed to only individual firms.

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ANNEX 4 - Intermediate report – the role of regions supporting the emergence and development of GINs: the case of Gauteng region

Authors: Helena Barnard (barnardh@gibs.co.za) and Tashmia Ismail (ismailt@gibs.co.za)

Participant no.12: GIBS, University of Pretoria, South Africa (UP)

1. Introduction

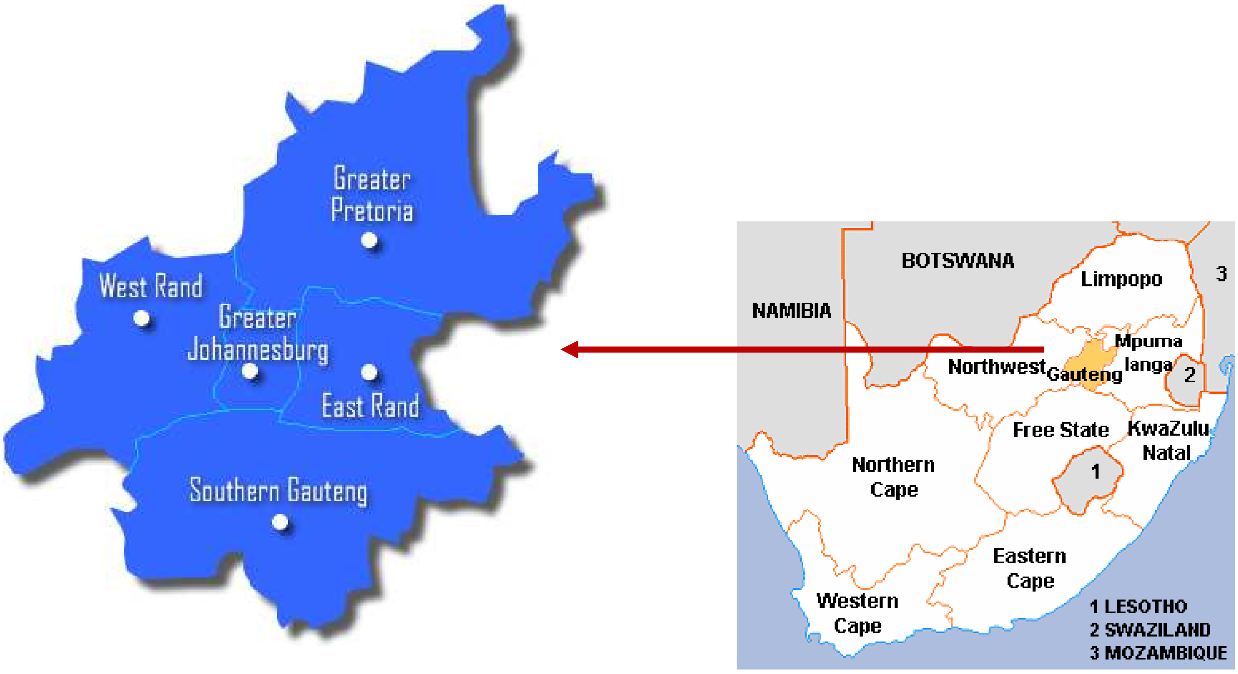
What we now refer to as Gauteng was an untouched tract of savannah up to a century ago. The discovery of gold in 1886 was to transform the landscape significantly to the hub of African economic activity it is recognised as today. Indeed, the name Gauteng, which came about in the late 1800's gold rush in Johannesburg and surrounding towns, means a place of Gold in Sesotho, one of the 11 official languages of South Africa. The diversified Gauteng economy with its highly developed urban and industrial region is now dominated by a large tertiary sector which was built on the backbone of a robust mining industry (Gauteng Treasury, 2008).

The smallest of the nine provinces in South Africa, Gauteng covers just over 17 000sq km – approximately 1, 4% of the total land surface of the entire country. Gauteng is made up of three metros, City of Johannesburg (CoJ) contributing 47.6%, the City of Tshwane (CoT) 26% and Ekurhuleni 19% to the province's GDP. Despite being the smallest by land size, Gauteng is the wealthiest and most populous province in the country.

The Provincial Economic Review and Outlook (2010) prepared by the Department of Finance reveals that Gauteng is the largest and main contributor to the national economy, at about 35% of GDP. The province's Gross Domestic product by Region (GDPR) increased from over R500 billion in 2004 to R635 billion in 2008 before declining to R624 billion in 2009. The reduced performance for 2009 was a result of the financial crisis and the recession in the country. IHS Global Insight forecasts growth to improve from R640 billion in 2010 to R750 billion in 2014.

The country's main consumer market is based in Gauteng with a purchasing power of 64% which is higher than the national average. The Gauteng economy is larger than almost every other African economy generating 10% of Africa's Gross Domestic Product (www.blueiq.co.za). Recent studies by the International Monetary Fund report that a percentage point rise in growth in South Africa is correlated with 0.5 – 0.7 percentage point in growth in the rest of Africa.

Figure 1: Map of Gauteng



2. Skills and employment

The Gauteng labour force grew from 5046 000 in the fourth quarter of 2009 to 5 063 000 in the second quarter of 2010. The province is responsible for 49, 6% of all employee remuneration in the country, 52% of all institutions' turnover and employs 20% of the country's workforce. According to the GEDA website, the skills level of the Gauteng workforce is the highest in the country and it houses 70% of South Africa's high-tech workforce (geda.co.za).

South Africa and Gauteng suffer from a skills shortage. The Provincial Economic Review and Outlook 2010 reports that the labour market is characterised by an increasing labour force "that is not adequately absorbed by available jobs on offer as a result of the skills mismatch". Unemployment in Gauteng grew by one percentage point over the 2009-2010 period, from 26% to 27%. The African population constitutes the highest number of unemployed people in the province. Whites make up the second largest percentage of population (18%) in the province but are the highest in terms of employment highlighting the inequality inherited from the apartheid legacy. Employment levels overall have however been increasing from 2004 (4.057 million) and are forecast to reach 5, 638 million by 2012. The highest percentage of employment created is in the wholesale and retail trade sub-sector, followed by the finance and business services sector, the government, social and personal services and lastly in the manufacturing sector (Fin 24, 2010).

3. Sectoral analysis

Sectoral analysis shows finance & business services to be the propeller of growth for the province, followed by government, social & personal services, and manufacturing. The metros contribute the most to the GDPR, with the City of Johannesburg (CoJ) contributing 47.6%, the City of Tshwane (CoT) 26% and Ekurhuleni 19%.

The tertiary sector is very important for South Africa as it makes the largest single contribution to the country's economy, in the first quarter of 2010 it constituted over two-thirds (67.7%) of national economic production

Table 1 provides sectoral contributions to Gross Domestic Product (GDP) and employment in Gauteng province in 2006. The table shows the economic role of the each sector within the Gauteng economy by providing a sectoral comparison of both GDP and employment contributions for 2006.

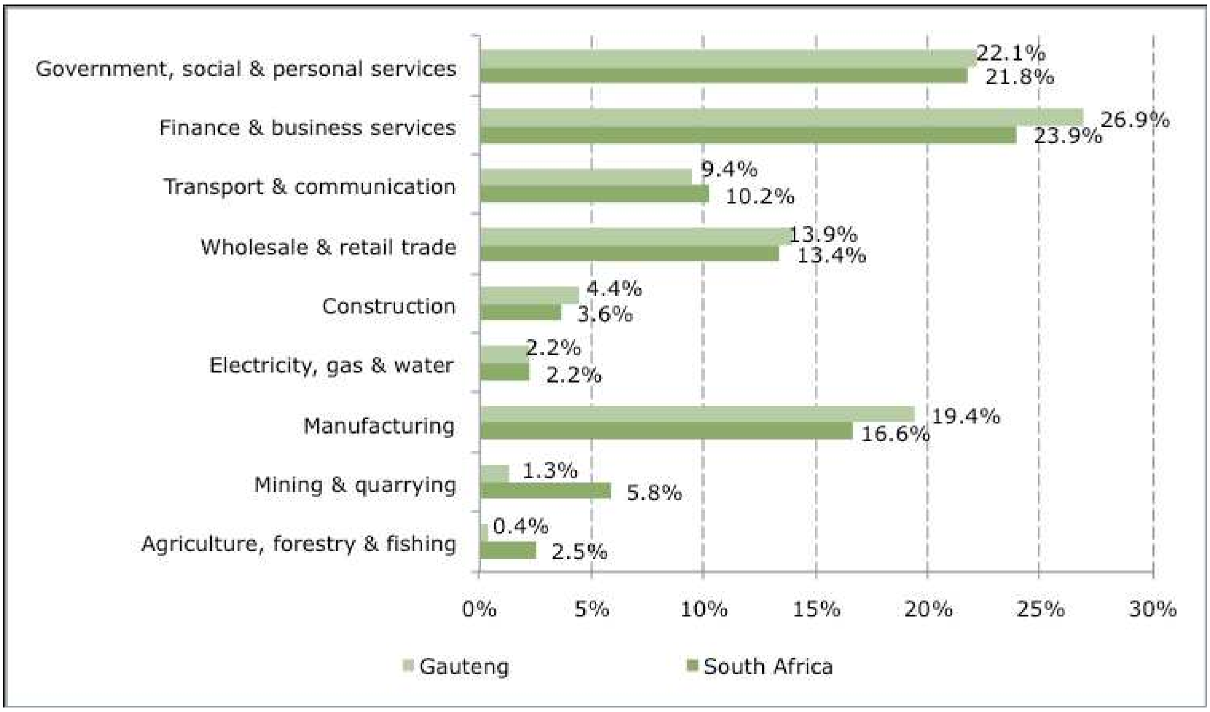
This is testament to the fact that the Gauteng economy has made the transition from historically being based on the primary sector to being based on the more knowledge-intensive secondary and tertiary industries.

Table 1: Sectoral GDP and employment contributions in Gauteng, 2006

Sectors	GDP (Constant 2000 prices, R mil)	% Share	Employment	% Share
Primary Sector	***9,336***	***2.30%***	***1,572,442***	***12.10%***
Agriculture, forestry & fishing	1,478	0.40%	1,166,859	8.90%
Mining & quarrying	7,858	1.90%	405,583	3.10%
Secondary Sector	***101,657***	***25.00%***	***2,915,185***	***22.40%***
Manufacturing	77,933	19.10%	1,757,428	13.50%
Electricity & water	8,453	2.10%	121,493	0.90%
Construction	15,270	3.70%	1,036,264	7.90%
Tertiary Sector	***260,130***	***63.90%***	***8,551,846***	***65.60%***
Wholesale & retail trade	59,556	14.60%	3,107,027	23.80%
Transport and communication	35,836	8.80%	614,512	4.70%
Finance, real estate and business serv	90,675	22.30%	1,339,772	10.30%
Community, social and other personal	15,037	3.70%	2,354,707	18.10%
General government services	59,026	14.50%	1,135,827	8.70%
GDPR at market prices and Total Employment	***407,407***	***100.00%***	***13,039,473***	***100.00%***

Source: StatsSA, 2007a and 2007b

Figure 1: Sectoral contributions to Gauteng 2009



Note: # is for estimates
Source: ihs global insight, 2010

Figure 2 shows the sectoral contributions estimates to the Gauteng and South African economies for 2009.

The finance & business services, government, social & personal services and manufacturing sub-sectors are the largest contributors to both the provincial and national economies, with the finance & business services sub-sector expected to contribute 26.9% to the province and 23.9% to the country. The province benefits from hosting the head offices of major financial institutions; this is reflected in the significant contribution made by the finance & business services. The manufacturing sub-sector is the third largest contributor in both economies and is estimated to make up 19.4% of contributions to Gauteng and 16.6% nationally. The percentage share of the primary and secondary sectors is declining, while that of the tertiary sector is growing (DTI.gov.za).

Automotive sector

The automotive parts and components industry in Gauteng is worth about R13 billion or US$ 1.4 billion per annum and contributes approximately 4.3% of the Province's output. The Gauteng automotive sector is larger than that of Ireland, Israel and Malaysia and consists of over 200 firms employing 38 000 workers.

The Motor Industry Development Programme [MIDP] has been in operation for a number of years and provides the basis for government policies toward the automotive sector. It seeks to rationalise the number of models assembled locally and to increase exports of fully assembled vehicles and components.

There are eight local producers of light motor vehicles in South Africa, of which four are located in Gauteng. There are also 11 producers of medium and heavy vehicles in the country. In total, the industry produced 787 100 vehicles in 2000.

The Automotive Industry Development Centre in Pretoria has done much to provide technical input for the development of the sector. In particular, areas of opportunity exist in light metal components for vehicles, stainless steel petrol tanks (which reduce emissions) and high-powered 42V electrical systems. It is using duty free access to the US market through AGOA as a mechanism to encourage foreign investors to set up joint ventures with local companies (http://www.geda.co.za/live/39/automotive-parts-&-components/).

Agro-processing

Food processing is a vital sector in the South African economy, and has been identified as one of the provisional sectors that can benefit the manufacturing sector and create jobs going forward.

Agriculture contributes about R36 billion (in 2007) to the national GDP; primary agriculture contributes 3% whilst the agro- processing sector contributes about 7% to GDP. The agri-food complex (inputs, primary production, processing) contributes approximately R124 billion to South Africa's GDP and employs 451 000 people in the formal sector (DTI, 2010).

The agri sector located in Gauteng is similar in size to the food processing industry in the whole of Malaysia. There are approximately 4 000 food processing companies currently operating in South Africa, of which roughly half are based in Gauteng. These companies employ around 50 000 of the estimated 183 000 people working in the sector. Table 2 below lists some of the large agro-processing firms located in Gauteng province (DTI, 2010).

Agriculture has a small share of the provincial economy and makes around R1, 4 billion of GGP. Important agricultural products include selected grain crops, certain vegetables, herbs and flowers. Processing and beverages make up around R9, 9 billion of Gauteng's geographic Product (GGP).

The competitive trade areas which are being explored include: organics, essential oils, packaging, floriculture, trade in medicinal plants, natural remedies and health foods. High value niche crops include the nutritious njugo bean, marogo and cowpeas.

Beer and Malt

Beer represented R9.3 billion of R23.7 billion beverage sector in 2001. South African breweries, the world's second largest brewer, is based in Gauteng. Gauteng Economic Development Agency (GEDA) reports that the greatest labour productivity in the province is achieved in the beverages sub- sector.

Soft drinks and carbonated waters comprise 21% of the sector. The value of the industry in South Africa is worth around US$1, 6 billion, or 3% of GDP. More than 80% of production is sold domestically; 8% is exported. South Africa is a growing market for carbonated beverages, with 4% increase in sales per annum.

Table 2: List of large agro-processing firms in SA

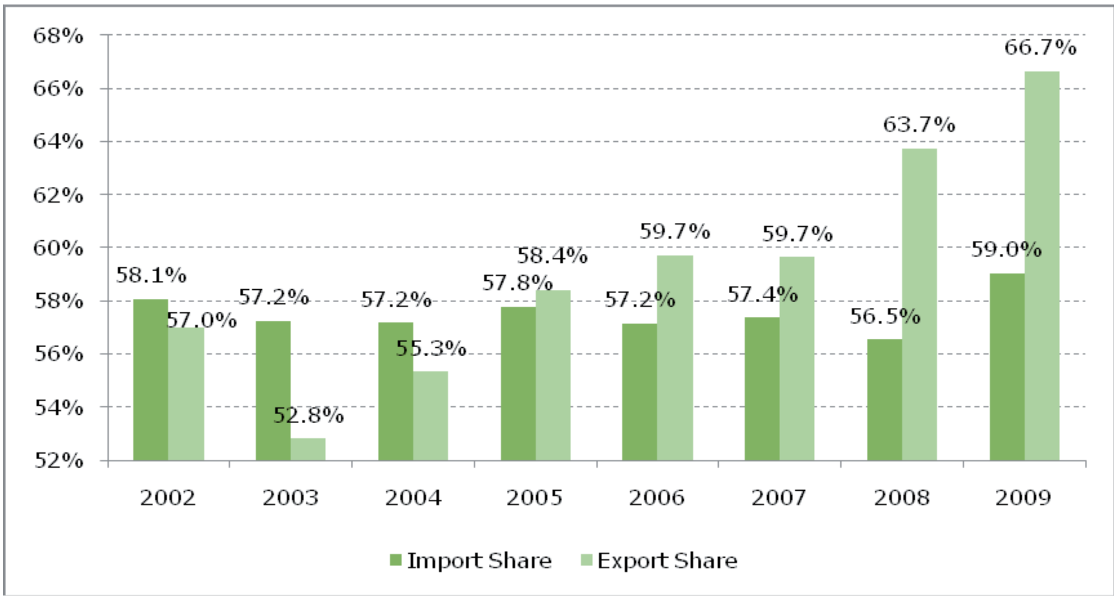
Company	Country	Industries
Unilever	Netherlands	Processed foods
Coca-Cola	USA	Beverages
Parmalat	Italy	Dairy, beverages
Nestlé	Switzerland	Processed foods
Danone	France	Dairy
Kellogg	USA	Cereals, processed foods
HJ Heinz	USA	Processed foods
Pillsbury	USA	Beverages
Virgin Cola	UK	Beverages
Cadbury-Schweppes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

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

Gauteng Imports and Exports

Figure 3 below shows the province's share of national imports and exports from 2002 to 2009. Through the period reviewed, Gauteng received 57%–59% of all imports coming into the country. The province's share of exports increased from 53% in 2003 to 67% in 2009. This could be indicative of the high economic activity in Gauteng, linking the various organisations in the value chain, infrastructure and transport facilities available in the province.

Figure 2: Gauteng share of imports & exports to South Africa, 2002-2009



Source: **Quantec Research, 2010 in Gauteng Provincial Economic Review and Outlook 2010**

Table 3: Imports and exports by sub-sectors, Gauteng, 2009

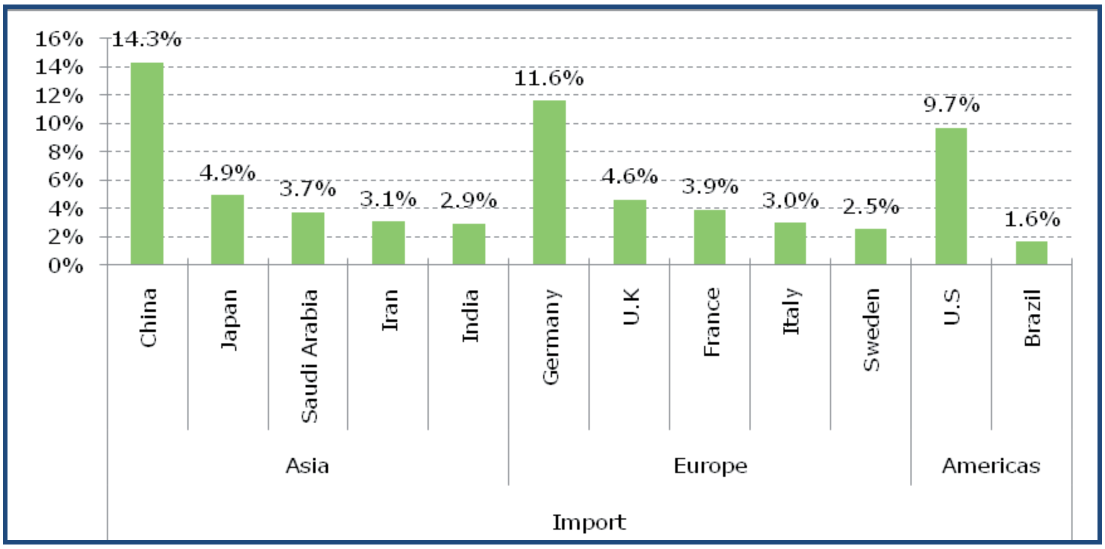
	Imports	**Exports**
Agriculture, forestry & fishing	1.10%	1.40%
Mining	11.50%	23.70%
Manufacturing	**86.80%**	**74.60%**
Electricity, gas & steam	0.60%	0.30%

Source Quantec Research, 2010

Table 3 above shows that, out of four main sub-sectors, most trading in 2009 occurred within the manufacturing subsector. Manufacturing imports and exports were the highest at 86.8% and 74.6% respectively. This indicates that manufacturing plays an important trade role for the province. It is important to note that part of manufacturing exported products are used by other sectors where goods manufactured may be used as inputs for further manufacturing processes. Mining had second higher exports at 23.7% and imports at 11.5%. This is because most of the products coming of mining such as metals are South Africa's biggest export market. Agriculture, forestry & fishing and electricity, gas & steam sub-sectors made the lowest import and export contributions.

Trading partners- Imports

Figure 3: Share of imports from major trading partners to Gauteng, 2009



Source: Quantec Research, 2010

Gauteng's total imports in 2009 amounted to R316 billion and its share of imports has remained consistent at around 58%. Europe's share of imports declined from 43.3% in 2005 to 37.2% in 2009. Asia's share, on the contrary, increased from 34.6% in 2005 to 40.6% in 2009, mainly due to increased trade between developing countries and the expansion of China.

Figure 4 above shows percentages of imports from major trading partners into Gauteng imports in 2009. About 14.3% came from China, 11.6% from Germany and 9.7% from the USA. The main import category was machinery, mechanical appliances & electrical equipment from China (56.4% of the 14.3%), Germany (32.5% of the 11.6%) and USA (38.6% of the 9.7%). The other main imports were base metals from China (9.2% of the 14.3%), and transport equipment from Germany (20% of the 11.6%) and USA (19.1% of the 9.7%). Imports from the African and Oceania regions are small and are not included in the analysis.

Trading partners-Exports

In 2009, Gauteng's exports had a total value of R337, 6 billion.

Figure 4: Share of exports from Gauteng to major trading partners, 2009

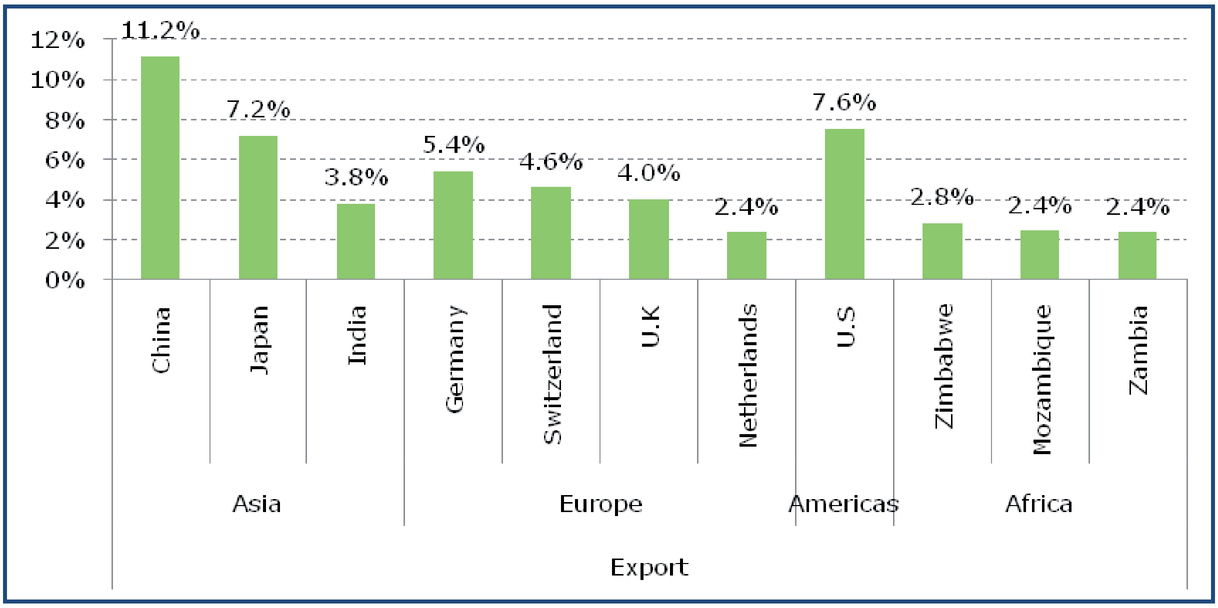


Figure 5 above describes information about the main trading partners to which Gauteng exported in 2009. The percentage going to China (11.2%) was followed by the USA (7.6%), Japan (7.2%) and Germany (5.4%). Exports to Africa were headed by Zimbabwe (2.8%), followed by Mozambique (2.5%) and Zambia (2.4%). Although not shown in the figure, the main export category was mineral products to China (67.6% of the 11.2%), precious or semi-precious stones & metals for both Germany (25.6% of 5.4%) and Japan (67.7% of 7.2%), and USA transport equipment (37.5% of 7.6%). Exports to the three African countries mentioned were mainly in the form of machinery, mechanical appliances & electrical equipment.

China trade

Gauteng had a trade surplus of R21.3 billion in 2009 with Asia. China in particular has become Gauteng's largest trading partner, surpassing Europe. China contributes 14.3% share to imports and 11.2% to exports.

Importance of manufacturing

The manufacturing sub-sector has been identified as one of the sectors to drive the economic development of the province. Manufacturing is estimated to have contributed over 16% and 19% to the economies of the country and the province respectively. Manufacturing plays a large role in Gauteng as many of the country's manufacturing firms' headquarters are based in the province. In her State of the Province address, Premier Nomvula Mokonyane stated that "GPG should work together with other spheres of government to revitalise the province's manufacturing sector". For Gauteng to address the legacy of the past, present socio economic challenges, high unemployment and poverty, expansion of the manufacturing industry is critical.

Manufacturing is divided into three sub-sectors, namely light, process and heavy manufacturing. Light manufacturing industries consist of consumer-based industries that tend to be labour intensive. Heavy manufacturing industries are capital intensive and require considerable investment. Process manufacturing consists of industries where chemical change takes place.

4. Regional Innovation System in Gauteng

Globalisation has meant that territorial production systems and not just firms must compete with each other. To this end, Rogerson (2004) observes the increasing trend toward sub-national planning taking place across low and middle income countries in Asia, Latin America and Africa. Helmsing in Rogerson (2004) notes a feature of sub- national planning in the South, this being the development of what is termed 'meso-institutions', which operate at the level of sector and/or region and which have played a central role in sub-national development planning. The competitiveness of local enterprises depends not only upon their own efforts but also upon supply networks and the local business environment. Enterprises that are located in regions that are well-endowed with specialised infrastructures and institutions, such as meso-institutions, to assist them in their restructuring for competitiveness potentially may have a decisive edge over firms located in regions with adverse business environments (Rogerson, 2004).

The Technology Innovation Agency

The Technology Innovation Agency (TIA) is a new public entity that is aimed at stimulating and intensifying innovation and inventions in order to improve the economic growth as well as enhance the quality of life of all South Africans by developing and exploiting technological innovations and interventions and creating an enabling environment wherein these could be commercialized. TIA geared towards addressing "market failure" and building bridges and institutional linkages along the innovation value chain (DST, 2009, oecd.org). The objectives of TIA are:

- Stimulating the development of technology-based services and products;
- Stimulating the development of technology-based enterprises - both public and private;
- Providing a nursery for technology commercialisation;
- Stimulating investment by means of venture capital, foreign direct investment, and other mechanisms;
- Facilitating the development of human capital for innovation.

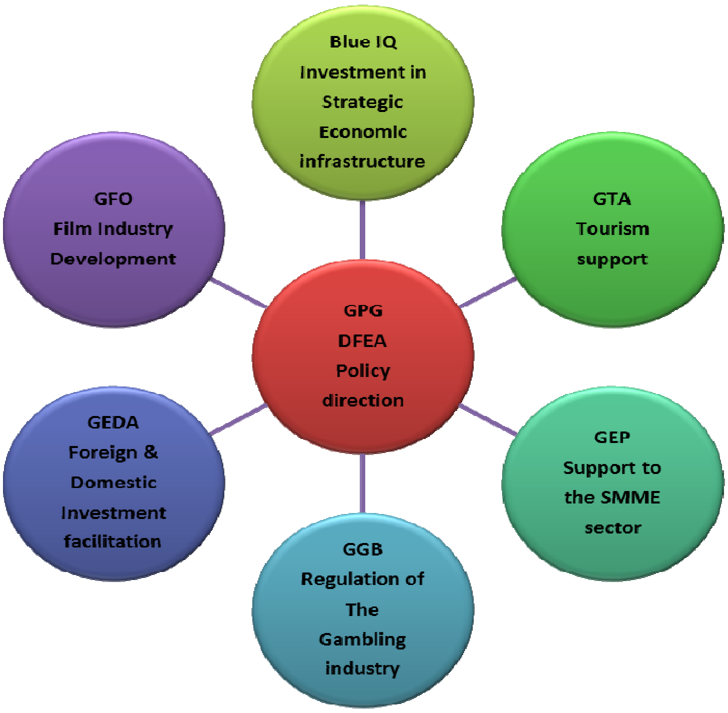
The TIA is tasked to:

- Coordinate and leverage support, particularly through the creation of strategic local and international partnerships to increase capital inflows for technological development and technology transfer in SA
- Lead to new products and services on the market
- Grow the number of technology-based start-up companies

- Support key industry sectors that are better able to utilize local and international technology innovation to enhance their global competitiveness, and a growing positive impact on the SA economy

The TIA will focus its financial and non-financial offerings along the innovation chasm, and will operate across the innovation value chain through mobilising and leveraging national, regional and international partnerships (DST, 2009, oecd.org).

Figure 5: Diagrammatic structure of Gauteng meso-institutions



Gauteng Economic Development Agency (GEDA), Blue IQ, Gauteng Enterprise Propeller (GEP), Gauteng Tourism Authority (GTA), and the Gauteng Film Commission (GFC)

GEDA - www.geda.co.za

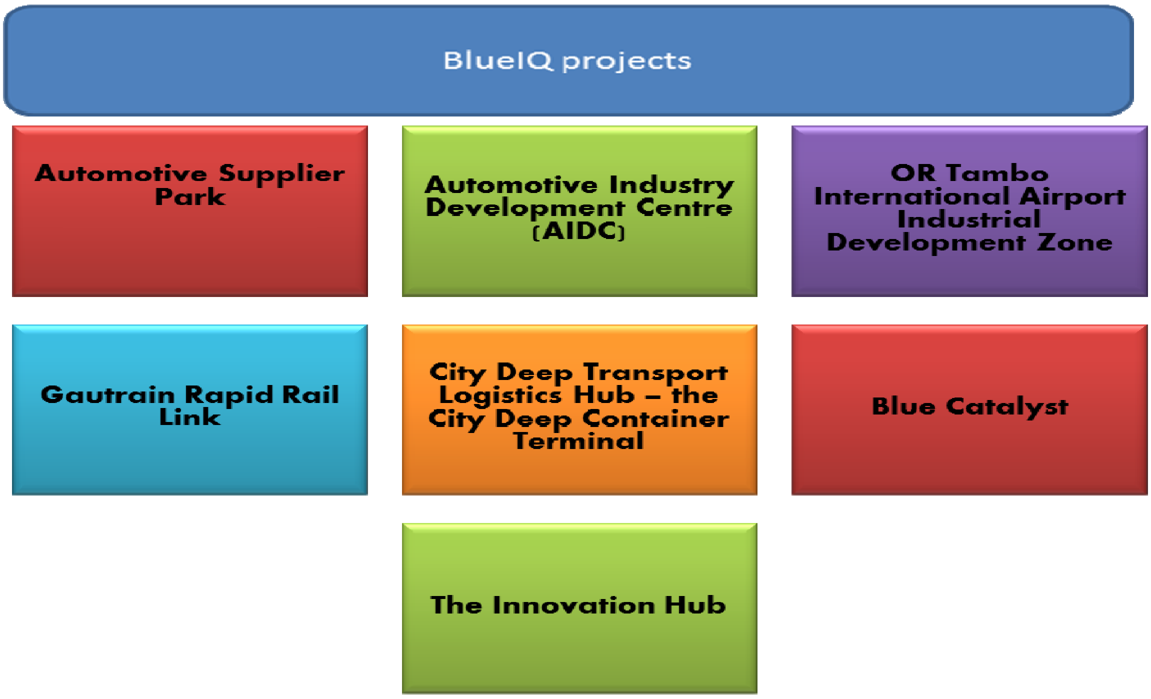
The Gauteng Economic Development Agency (GEDA) is tasked with creating a local and foreign investor friendly environment aligned with national and provincial government objectives. The Agency markets, promotes, supports and facilitates the economic development, investment and trade within the Gauteng Province.

The Gauteng SDI was the first in South Africa to be backed by substantial financial commitments made by a provincial government (Moleketi 2000). This fund was regarded as the basis to propel the province 'into the information age and lessen its dependence on heavy industry' (Moleketi, 2000). The Strategic Economic Infrastructure Investment Programme (SEIIP), was to build Gauteng's role as the "smart" hub of Africa' with a special emphasis upon promoting strategic investments in the four areas of technology, high value-added manufacturing, transport and tourism. Through this programme R1.2bn was injected into the regional economy over three years (Moleketi, 2000). The SEIIP was restyled and re-branded as the Blue IQ initiative in 2001. This meso-institution undertook the responsibility to 'develop world-class infrastructure, implement marketing and investment strategies, reduce bureaucratic red tape for investors and suppliers, and encourage skills training and resource building in the areas of technology' (Rogerson, 2004).

The Gauteng Provincial Government announced a further expansion of funding into the Blue IQ initiative in 2002 with an increased budgetary allocation to R3.5 billion over a period of five years. The operations of Blue IQ are to enhance the competitive potential of Gauteng province in the global economy. Rogerson (2004) quotes the Blue IQ Chief Executive Officer as saying: 'Gauteng is not in competition with the other (South African) provinces. It's in competition with Vietnam, India, China and Mexico, Ireland and Portugal. That's our competition'.

The section below offers a description of how BlueIQ through its various bodies influences the regional innovation system. Figure 2 is a diagrammatic representation of the activities of BlueIQ.

Figure 6: Gauteng region Blueiq projects



As part of its mandate to position Gauteng as the technology hub, Blue IQ partnered with the CSIR and University of Pretoria to create the Innovation Hub which was designed to be a catalyst for knowledge-intensive industries and to increase the "smart" sector's contribution to GGP by new IT and electronics businesses (Moleketi, 2000). The overall goal of the Innovation Hub is not only to enhance Gauteng's existing position in terms of 'smart activities' in South Africa but also to maintain the province's edge over the aggressive competition for high technology and knowledge- based activities offered by the Western Cape (Rogerson, 2004).

Facilities will include sophisticated fibre optic/ISDN infrastructure, an entrepreneurial business support centre, venture capital support, educational support, and an "e-Incubator" with sophisticated research capacity (Moleketi, 2000)

Blue IQ: Automotive Supplier Park - www.supplierpark.co.za
Blue IQ has already invested over R303 million in the ASP, which has attracted an additional R63 million in private sector investment and generated more than R458 million in taxes for government The Gauteng Automotive Cluster project is designed to aggregate automotive assemblers, component manufacturers and material suppliers located in the same area which, together account for some 40% of motor vehicle production in the country. The Automotive Supplier Park (ASP) is one of the components of this automotive cluster.. The ASP component concentrates component manufacturers and suppliers in one location adjacent to the key Original Equipment Manufacturer (OEM) assembly plants so as to enhance the efficiency of the supply chain in a fast growing industry with substantial potential for further growth to meet expanding domestic and export demand.

BlueIQ: Automotive Industry Development Centre -www.aidc.co.za
The Automotive Industry Development Centre (AIDC) is the second component of the Gauteng Automotive Cluster project. It is designed to provide world class services for automotive design and testing, automotive research and development and human resource development. The purpose of the project is to deliver support services to the industry to improve their productivity and competitiveness in the international market place. Core focus areas include skills development, supplier development and logistics development. Over 600 companies and institutions have already been impacted by AIDC projects.

BlueIQ: OR Tambo International Airport Industrial Development Zone
The OR Tambo International Airport, is already the busiest, most modern and most efficient passenger and freight hub in southern Africa. The purpose of the IDZ project is to provide an efficient import and export duty free zone for high value-added, light manufactured goods for export by air freight. The IDZ will be a marketing platform for South African goods and the location for light export-oriented manufacturing industries, together with the avionics and aerospace cluster. The Innovation Hub - www.theinnovationhub.com

Blue Catalyst - www.bluecatalyst.co.za
Blue Catalyst was launched to promote the commercialisation of sustainable start-up technology and knowledge-based businesses in Gauteng. The object is to bridge the skills, funding and credibility gaps that hamper start-up enterprises, enabling entrepreneurs the opportunity to have their products and services converted in to profitable businesses in the shortest possible time. The project has two components – the portal and the matching fund. The portal helps match entrepreneurs with skills they require. The fund is designed to encourage venture capitalists to co-invest in early stage technological ventures.

City Deep Transport Logistics Hub – the City Deep Container Terminal
This is the country's premier container depot. It is located in the centre of the nation's industrial base with access to road, rail and air connections to all of South Africa and the region, nearly a third of all South African exports move through it.

Wadeville-Alrode Industrial Corridor
This project aims to create a major manufacturing zone to upgrade and regenerate a traditionally heavy industry area. Close to the OR Tambo International Airport and City Deep, it provides investment opportunities in metal fabrication, food and beverages, agro-processing, containers and packaging, plastics and chemicals, transport, warehousing and distribution, among others.

Gautrain Rapid Rail Link - www.gautrain.co.za
This R20 billion project is the single biggest of all the Gauteng infrastructure projects. The 80 km mass transit system will provide speedy transportation between Johannesburg, Pretoria (Tshwane) and the OR Tambo International Airport, create over 40,000 jobs during construction and another 60,000 on completion. It will service three of South Africa's six metropolitan municipalities.

Gauteng Enterprise Propeller (GEP) - www.gep.co.za
GEP was established to provide both financial and non-financial support to SMMEs in Gauteng. By focusing on the SMME sector, GEP aims to help small companies get their fair share of the opportunities created by the numerous current and future public and private sector projects in Gauteng.

Gauteng Tourism Authority - www.visitgauteng.net
The Gauteng Tourism Authority (GTA) is mandated to develop, promote, co-ordinate and facilitate sustainable tourism in Gauteng. It also aims to create a world-class destination for business visitors and all other tourists to the province. Among other services, the GTA provides:

- media and trade programmes
- events listings and updates
- enterprise and tourism support programmes
- tourist guide registration

Gauteng Film Commission (GFC) - www.gautengfilm.org.za

The Gauteng Film Commission is tasked with the development and promotion of the audiovisual industries in Gauteng by:

- Marketing Gauteng as a location of choice.
- Acting as a centralized industry intelligence hub and resource.

- Working with, and providing advice to industry, government agencies and other key stakeholders about the support, development and growth of a sustainable audiovisual industry.
- Promoting and celebrating an active screen culture across the province.
- Supporting the transformation of the sector into a world-class industry that is reflective of South Africa in its entirety.

Below is an outline of the Five Strategic Pillars of the Province (GEDA):

- To move away from heavy industry towards more sophisticated, value-added production
- Develop Gauteng as the country's smart centre, with emphasis on information technology, telecommunications equipment and biomedical industry.
- Strengthen the finance and business service sectors targeting financial services and technology, auxiliary business services and technology, corporate head office location and business tourism.
- Encourage job creation in all sectors with the objective of alleviating poverty and unemployment
- Draw in participants at ownership and management level from a wide spectrum, including those presently without wealth, assets and skills. Concentrating on newer enterprises rather than expanding larger ones.

The provincial government programmes outlined in this document have been highly focused on creating a 'smart' province in order to solidify the global competitiveness of Gauteng. From the above it can be seen that Gauteng is attempting, through a network of meso-institutions, to create a more structured regional innovation system with the intent of meeting the strategic requirements listed above. There is an indication that the funds poured into the development of an innovation system are having a positive impact on the region's economy (Moleketi, 2004).

There does not seem to be any shortage of policy documentation for the Province, the plans for enhancing Gauteng's innovation system appear well developed. It is at the delivery level where the Provincial government is criticised as failing to deliver and as being riddled with corruption.

In July of 2009 the much awaited Seacom cable was completed and commissioned. This 17,000 kilometre undersea fibre optic cable system links south and east Africa to global networks via India and Europe. It provides high quality broadband at 1, 28 Terabits per second (Tbps). Experts however insist that the costs of communication are too high and cite lack of competition in the market as a cause. High barriers to entry and the presence of monopolies in the telecommunications industry are blamed on Icasa (the Independent Communications Authority of South Africa) (Alfreds, 2010). High prices and a lack of competitiveness in the telecommunications industry are stumbling blocks in the path to creating a 'smart' competitive regional environment.

South Africa's Gini coefficient index shows the level of income inequality at 0.679. This figure, calculated by Haroon Bhorat, an economics professor at UCT, using data from

Statistics SA's income and expenditure survey and based on household income in the 2005/06 year, indicated that SA had overtaken Brazil as the country with the widest gap between rich and poor (Pressly, 2009). Despite its wealth, Gauteng does not escape this national problem. Often described as a dual economy with a first world and 3rd world operating alongside each other, the country has developed an interesting economic dynamic due in large part to the legacy of apartheid. It is characterised by a disproportionate number of large globally competitive multinational firms (e.g. MTN, SAB MILLER, Anglo-American, Standard Bank, BHP Billiton, De Beers, Netcare, Discovery) when compared with the size of the economy. It is always a balancing act for the Provincial government to help maintain the global competitiveness of its firms whilst at the same time balancing this with the needs of the large numbers of unskilled and jobless members of society.

A senior person at the DST remarked that focussing on innovation was a first world activity but that they had to balance the resources and priorities of the masses of poor with the demands of firms for international competitiveness. These two worlds are not however irreconcilable. Our research is however starting to show that cutting edge technology and innovation are being used by large firms to service the unmet needs of these lower income groups especially with a host of financial services products and are making an economic impact on poverty by growing their consumer base into these untapped markets.

The following section will explore and unpack through case studies the experiences of firms who interact and depend on the Gauteng regional innovation system.

5. Cases

The previous section provided background about Gauteng's dominant role in the South African (and indeed, African) economy. This section investigates in greater depth the nature of the interaction that firms have with the region. What then is the nature of the Gauteng regional innovation system? A survey that was conducted in 2008-2009 highlights that sectors still matter, as there are important differences between the software and automotive industries46:

[46] The data for the software and automotive industries was based on the questionnaire developed as part of a larger international project under the auspices of the University of Lund in Sweden. The original questionnaire was developed in Sweden with the inputs from Chinese and Indian counterparts working on this project.
The questionnaire was adapted for South Africa in a workshop in South Africa in May 2008. Local academics and industry experts (automotive and software) gave their inputs as well. The questionnaire constitutes of several questions and has the following broad categories:
- Company background
- Strategy to access local and foreign markets
- Resources of innovation
- Type and importance of innovation
- Linkages and channels

Automotive
The database of NAACAM (National Association Automotive and Component Assemblers and Manufacturing) constituting of 174 automotive firms was used as sampling frame. These firms constitute almost the entire population of active firms in automotive sector of South Africa. A response rate of 43.67% (76 firms) was obtained.

	Software	Automotive
Average firm age	13.03 years	30.84 years
Average number of employees	10-49	100-249
Average total sales	Less than $2 million	Between $10 and $50 million
Types of firm	Mainly independent units	Mainly subsidiaries
Ownership: % of domestic capital	92.7%	42.27%
Destination of sales: Domestic Developed world Emerging markets	 85.85% 5.68% 8.47%	 65.32% 32.23% 2.55%

It is clear that compared to firms in the automotive industry, the software firms are younger, smaller and generally not foreign-owned – reflecting the fact that ICT is an emerging entry where the barriers to entry are relatively low.

To not conflate the effects of the region with industry effects, interviews were only conducted with ICT firms. Interviews were conducted with small local firms, larger local firms with a multinational footprint and with multinational corporations. Interviews were conducted mainly in Gauteng, but also in the Western Cape.

5.1. Small local firms

Nineteen small ICT businesses based in Gauteng were interviewed. (These firms have requested to remain anonymous; the larger firms will identified and discussions will be more

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Students doing a Masters of Engineering Management course at the Graduate School of Technology (University of Pretoria) assisted with the data collection for the automotive industry. The purpose of the questionnaire and the interview techniques were explained to the students in a training session prior to the starting of the fieldwork. Each student conducted 10 to 15 interviews in person at the automotive firms. The students did not target specific persons with titles for responses. They identified appropriate respondents by taking the suggestion of the person in charge of innovation, process development or new product development. In some instances, the data was cross-referenced with other respondents at the respective companies. Once all the data was gathered centrally, a faculty member familiar with automotive industry reviewed the consistency of coding.

Software

The software industry is an emerging industry, and the firms are not very well-organised in terms of industry associations and/or directories. The Johannesburg Centre for Software Engineering was approached for a database of active software firms. This database did not include some of the big banks and telecommunication companies as software firms since their core business was not software. This is why CSSA was approached. CSSA supports and recognises individuals who work in software industry. The individual members are generally not opposed to disclosing their affiliations to the companies they work for. Thus 355 software firms were identified as sampling frame using a bottom-up approach. 78 responses, a response rate of 21.97%, were obtained.

A recent graduate was appointed to gather responses from the firms in the software industry. The interviewer was trained with the purpose of the questionnaire and telephonic interview techniques. He contacted the companies telephonically. He identified appropriate respondents by taking suggestions from the individuals who had membership at CSSA. In case of large organisations, where multiple members were present in an organisation a random method was used to contact one of them for the recommendation of an appropriate respondent. One advantage of having a single interviewer was the consistency in terms of the interpretation of the questions and coding.

detailed.) Of the fifteen businesses that were prepared to disclose their profit, eleven had less than R10 million in sales annually, a similar pattern to that seen in the software survey.

Sector detail	Product	Customers	Interviewee
Telecoms (prepaid)	Prepaid recharge voucher creation and distribution	*Nigerian cellular network operators*	Owner
Consulting on new products	Simulation of new products	*Cellular network operator in RSA; Large international vendor of network equipment*	Owner
Information technology	Payroll systems	Various	Owner
Financial	Unit trust investment platform	Portfolio managers	CEO
Information technology	Project management software; Blackberry integration; Customer Relationship Management & ERP systems	Various	Director
Business documentation	Creating/storing/archiving/ e-publishing	*Large bank in South Africa, Vehicle tracing company, large packaging company, and various other*	Owner
Inter/intranet security	Encryption technology	*RSA government*	MD / shareholder
Financial	Banking core equipment	*Banks (300 customers in 50 countries)*	Senior vice president
Software engineering	Financial simulation, ecommerce, database design, network security	*RSA government, various other*	Owners
Financial	Investment software	*Banks in South Africa*	Owner
Telecoms (cellular)	New product development / consultation	*Large cellular network operator in South Africa*	Owner
Security	Electronic gated community security systems	Gated communities in Pretoria	Founder
Marketing	Cellular telephony marketing technology	*Large cellular network operator in South Africa; YouTube*	Director
Telecom	Geographical information systems	*Large cellular network operator in South Africa; other in Ireland, Bangladesh, Hong Kong*	Senior consultant
Telecom	Consulting	*Large cellular network operator in South Africa; offices in Madeira and London*	Owner
Telecom / IT equipment reseller	Sales services	Various	Owner

Telecom / IT equipment reseller	Sales / integration / consulting service	*Large cellular network operator in South Africa and various other*	Executive director & co-owner
Financial	Transferring sensitive financial information between financial institutions	*Large banks in South Africa and various other*	Senior employee
Information technology	ERP; Business intelligence; Computerised management maintenance; Laboratory information management systems	Various - local and international	MD

The table highlights the critical role of large customers (in italics). Most of these small firms are specialist providers to much larger firms, suggesting that the small firms were in Pavitt's taxonomy of innovators, "specialised suppliers" (1984). Indeed, one interview question ("describe who are your competitors") had to be changed to first establish whether firms had competitors. In most cases, firms operated in such a narrow niche that they did not have any real competition. The relationship between the small firms and their larger customers was generally close: One of the interviewees said that they spent a lot of time with their customers just sitting and talking and "drinking coffee" and through that they discovered needs which, in some cases, the customers did not mention before. The central role of customers in driving innovation – thirteen of the nineteen small firms said that innovations were triggered by a customer need – suggests that the regional innovation system has definite characteristics of a "grassroots" RIS where innovation is driven by demand.

It is important to note that the networks in these small firms and within grassroots RISs are essentially social. They run very deep, but are very rarely expressed in formal terms. Respondents in Gauteng referred to family and friends or to favourite sports teams as reasons for locating in the region, while respondents from the Western Cape referred to the scenic beauty and lifestyle.

However, firms also demonstrate some institutional involvement within the region. The survey (referred to earlier) finds that the level of involvement in government is low for both the automotive and the software industries, but that there is a difference in terms of the type of government that each accesses: Software firms are more likely to draw on incentives and information from local government, while automotive firms are more likely to use national government. For example, about half of the case study respondents attended and valued industry seminars organised by local professional bodies. Where they spread their net more widely, it was typically to go to foreign conferences. Leaving the Gauteng region for a national conference or trade show happened rarely.

The major institutional interaction is with the university. The university is firstly seen as a source of skilled people; some companies said that they do talent hunting at the "university's computer science project displays" and fifteen of the firms said that they support students. However, almost all the firms (fourteen out of the nineteen companies) said that most learning happens through "learning-by-doing".

The universities were seen as particularly useful contributors to more advanced processes of knowledge creation. R&D took place in all but two of the small companies and firms clearly recognised the value of universities in supporting those process. However, linkages still occurred in the main informally, through:

- Friendships with lecturers
- An employee who was busy with a PhD
- Research supervision of students employed by the company
- Provision student internships
- Sponsorship of university laboratories
- Participation in a university project
- Training of post-graduate students

As regards other actors in the system, it is relevant to note that a number of the companies had a strong foreign client base. The Lund survey also provided evidence that ICT firms operating in the developed world tend to be smaller than those operating in the developing world. This is probably due to the nature of their offerings. In the developed world, South African firms are likely to offer niche services, such as laboratory information management software. In contrast, in the rest of Africa, the South African firms tend to offer a more comprehensive suite of options, often by necessity as the business infrastructure in most African countries is not developed well enough to support a high level of specialisation.

The interaction with clients abroad and universities suggests some transition to a regionally networked innovation system, a development that was also suggested in the interviews with the larger South African firms.

5.2. Larger, internationally connected local firms

Three interviews were conducted with larger local firms with an international footprint: Clickatell, Cornastone and MXIT. The activities of each firm are first discussed, and then common themes are highlighted.

Clickatell

Clickatell in some ways resembles a small firm like those just discussed. It has about 100 employees, but operates only in a very narrow niche: The sending of bulk SMSs. Yet Clickatell also resembles the larger ICT firms in South Africa for the innovativeness of its offering and the scope of its reach. Clickatell is currently connecting 840 cell phone networks in 220 countries and territories

Clickatell's main competitors are Cybase, V65 and Merisign, all foreign companies, and competition is strong as patent protection is not useful in this fast-changing industry, and the main competitors are good at imitating innovations in the industry. However, competitors sometimes also act as aggregators and so as clients: A competitor wishing to send SMSs into South Africa will connect with Clickatell rather than with the three cellphone networks. Likewise, Clickatell will sometimes use one of its competitors as an aggregator in a region.

Having worldwide coverage is an important selling point for Clickatell, but the usage of networks follows an 80/20 principle: Most of the traffic flows through a few networks, and extensive collaborative agreements are needed to deliver to the rest of the world.

Clickatell was founded in Cape Town in 2000 (where it is still based) and launched the world's first web-to-mobile messaging products. In 2001, the company developed both the Mobile Messaging industry's first real-time, global SMS services for businesses, and a pre-paid model for PC-to-mobile messaging.

In 2002, Clickatell launched Messenger-PRO, a standalone PC application, which enables users to manage Bulk SMS messages and campaigns from their computers. Between 2003 and 2004, it helped create the world's largest mobile messaging developer community, after becoming the first mobile messaging provider to reach over 500 operators. Clickatell has further developed a platform or 'mobile messaging market' that showcases innovative third party applications.

In 2006, the company merged with Multimode Inc, who offered greater multimode functionality, established its Silicon Valley presence and also joined with Oracle Corporation. The company secured further funding from Sequoia Capital, a Silicon Valley-base venture capital firm with a South African founder, and established its presence in the USA in 2007.

It has worked with the following organisations on a variety of projects, using web-based API's that SMS-enable their applications, systems and sites. Examples include:

The European Commission's Joint Research Centre selected Clickatell to run its EMM (European Media Monitoring) SMS alert service. CNN chose Clickatell to power SMS breaking news service and SMS mobile alerts for its coverage of the 2008 Beijing Olympic Games. Clickatell and Metropolitan Life pioneered insurance by mobile phone with Cover2go. Clickatell has worked with international healthcare organizations to provide mobile solutions for delivering critical medication information. Parliamentarians representing 140 countries used Clickatell to power SMS alert service at the 118th assembly of the Inter-Parliamentary Union. Clickatell assisted Christie's in expanding their auction reach using mobile messaging. Clickatell partnered with RSA Security to provide on-demand authentication using mobile phones, and with S1 Corporation to provide on-demand text banking. Clickatell partnered with Moneybookers, one of Europe's largest online payment systems, to offer mobile SMS alerts on transactions to over 5 million E-Wallet customers. New Heights Microfinance Bank Ltd, Nigeria selected Clickatell to provide mobile messaging services to customers.

Clickatell decided to pursue the gap in the market for the sending of bulk SMSs as a form of marketing when it realised that although SMSing is a very cost-effective way of communicating with constituents, it requires specialised coding skills to send SMSs from PCs to mobile phones. Clickatell realised that they can develop an easy-to-use template which would allow users to simply enter the text they wish to communicate. The firm earns a profit by buying SMSs in bulk at a discount, and reselling it to their user base at a slightly higher cost. The business was international from the outset; one of the founders and now CEO (Pieter de Villiers) states that his first customer was Indian and the second Australian, and it took a long time to convince South African businesses to use Clickatell.

The business has evolved over years. At first the very concept of easy PC-to-mobile communication was an innovation, and customers were themselves early technology adopters who were happy to figure out software. As preventable problems became evident, the company focused on improving its internal systems, and then increased its coverage of cell phone networks as its aim is to be a one-stop-shop to clients with multinational reach. The third phase was to increase their reliability. For example, by tracking the movement of cell phone traffic on a network, Clickatell can schedule the delivery of messages so that they do not overload the network and are successfully delivered.

Len Pienaar, the EVP of Products and Marketing, says that the current emphasis is to become more customer-centric again. The customer base increasingly represents late adopters who need more intuitive processes and more guidance. The customer focus is characterised by the fact that "our customers never come to a building. They literally register, get a user name and password and depending on their development team they are up and running in 24 hours." Although Clickatell has a sales office in Johannesburg and one in Silicon Valley (for when the US market starts to make more extensive use of text messages rather than calls), the aim is to have as close as 100% of customers online.

This requires a different approach to customer-centricity, and Pienaar explains how they have recently managed to convince the NGO community of the value of their offering. Clickatell has long regarded its offering as potentially useful for large NGOs, but the appetite for technology adoption among such agencies is limited. After the earthquake in Haiti, there were a few cell phone towers still standing and mobile communication was the only effective way of connecting with survivors. In the weeks post the earthquake, Clickatell provided free bulk SMSs to Haiti and managed to convince the international aid community of the value of bulk SMSs. Clickatell has since fielded a number of calls from international aid agencies wishing to budget for bulk SMSing as part of their disaster recovery programmes.

It is clear that contact with the customer has been completely changed by the virtual interface. The relationship with suppliers is also virtually entirely on-line. Clickatell develops its core technology (its message engine) in-house but buys supporting programmes from outside. Yet as the dialogue demonstrates, there is no concern for the location of suppliers:

Can you give an example of what you buy?

Our webtracking tools. So we need to know where you are, what your experience is, how fast your website goes in your country. So that we have appointed a company for that and they do that for us.

Where are they based?

Don't even know. I have never met them; we bought the service on-line.

So in this world borders don't really matter?

As long as you don't move money. As long as it is digital goods. So we buy web tracking tools, we have just bought a marketing e mail server – we communicate with email a lot and we need to know certain things about those emails, so we have bought a server.

Similarly, the business can draw on skills from across the world – for example, it often draws on legal advice from the US. Pienaar (who until recently was working on mobile applications for a South African bank in Johannesburg) comments that he finds it hard to adjust to an inbox that is always filling up, and to project meetings where only some members can be present for initial scoping. He comments that he underestimated the importance of being able to see people while they talk.

Pienaar also comments on the difficulties of finding skilled people in the Western Cape. The company relies heavily on internal promotion (e.g. from customer service to business analysis) but that requires a minimum of six months investment before the person is effective in the role. Clickatell also relies on personal networks and recruitment agencies to find people, but it still typically takes four months to fill a position. Pienaar, who was born and raised in the Western Cape and who has returned there from Gauteng, has been surprised at how hard it is to convince Gauteng-based people to move down. Although most claim to wish to live in the beautiful Cape surroundings, the reality of family and friends often means that people choose not to move.

Cornastone

Founded in 2000 by Hamilton Ratshefola and Lufuno Nevhutalu, this Johannesburg-based firm with more than 300 employees started out as a reseller of Hewlett-Packard equipment. (See the table for an overview of the evolution of the firm.) However as reseller, a firm is reliant on margins driven by a party external to the firm, and Cornastone exited that business and started pursing a consultancy business. As an overwhelmingly black-owned business, Cornastone was well positioned to tap into preferential business opportunities with government, and did initially do some government work. Although the consulting division still specialises in infrastructure delivery (mainly water), the firm has since started focusing on corporate clients because "government is not a good customer", with extensive bureaucratic requirements, slow payment and potentially reputation-damaging scandals. Cornastone delivers security solutions to banks, and the company was wary of the reputational risk of being too closely associated with government.

A third iteration of Cornastone's strategy occurred when the firm realised the cost of license fees, especially US$ denominated fees. Cornastone was expanding into the rest of Africa, and most currencies in Africa steadily depreciate against the US$ which made potential business opportunities in, for example, Mozambique, untenable. In contrast, once software has been developed, relatively little investment is needed to maintain the software, and owning their own IP made a number of previously marginal investments possible.

Ratshefola pointed out that investment in the creation of IP requires a mindset that is focused on the longer term rather than on immediate returns, and highlighted the large number of successful IT companies from the Western Cape. This includes arguably the greatest success story of South African IT, Mark Shuttleworth who developed Thawte, a specialist in digital certificates and internet security, now part of VeriSign. According to Ratshefola, the mindset in Gauteng where most economic activity happens is so focused on time-to-market and efficiency that many firms are unwilling to develop software from scratch: "They look for something the Indians have already done." In contrast, in the more laid back Western Cape (a dismissive Afrikaans term for "Kaapstad" is "Slaapstad") people are prepared to invest in the development of IP as it offers the promise of them earning relatively "passive" licensing revenues!

Recognising the importance of owning its own IP, especially to be able to access markets in the rest of Africa (although software is now exported to a number of other countries too), Cornastone started an R&D unit and developed applications for banking security and mobile applications, for example the "please call me" software. This allows a cell phone user to send a free SMS to another person with a request to be called. The cost of the SMS is covered by advertising that is delivered as part of the message.

Strategy evolution	Mode of Business	Business Model
Generation 1 – 2000 to 2003	**Reseller Model** Generic Business Strategy Opportunistic	Margin Driven
Generation 2 – 2003 ongoing	**Consulting, Outsourcing** Annuity, repeatable business	Time and Material Fixed Price contract
Generation 3 – 2006 ongoing	**Software Development** Industry Focus Telco Banking	License Fee based Model Annual Maintenance Fees
Generation 4 – 2010 ongoing	**Mobile software Development** Mobile Payments Mobile Lotto	Revenue Sharing
Generation 5 – 2011/12	**Build-Operate-Transfer Model**	Transaction fee based model

The mobile software development gained further momentum, and Cornastome launched a number of revenue sharing projects in 2010, for example software that enables the lotto to be played by using a mobile application. Mobile phones as a de facto personal computer have become more and more prevalent, but the challenge in developing mobile applications is that the institutional infrastructure (e.g. mail delivery) is generally so weak that only services can be delivered via mobile. A number of players have been developing payment systems for services such as mobile phone time and electricity.

In searching for other services that could be delivered profitably, Cornastone has started investigating partnering with governments in the rest of Africa in the development of infrastructural solutions, e.g. tax collection via mobile phone. This innovation is still under development, but can evolve into a major strategic direction for the firm. In addition to technical challenges, the strategy involves engaging with governments and managing reputational risk at the same time.

As the firm has internationalised, it benefits from its dual understanding of developed and emerging markets. Thus Cornastone won the contract for the delivery of mobile banking solutions for a Spanish firm operating in Ghana – and admits that it took hard work to develop software for the very poor quality hardware ("Chinese phones we've never heard of") they found there.

Throughout its existence, Cornastone has strived to move into two directions. First, it has strived to connect with end-users rather than corporate intermediaries, and second, it has strived to move up the "IT stack". The foundation of the stack, the hardware and software providing the access to data, has already become commoditised, and the interfaces (e.g. software as a service or service oriented architecture) are also in the process of becoming commoditised. Higher up in the stack lies business process management systems like groupware and workflow management, but according to Ratshefola, the greatest competitive advantage is to be gained from operating at the customer-interfacing application level.

	Business Model	**Strategy Driver 1**	**Strategy Driver 2**	**Differentiation**
Corporate consumers	Reseller	IT Stack Driven	Dominating brand driven Opportunistic	Cost Effectiveness Flawless execution
↓	Consulting and Outsourcing	Annuity Revenue driven	Water Services Industry Security Specialisation	Subject Matter Expertise Process-driven
	Software Development	IP Driven	Telco Value Added-revenue generating Core Banking	Currency-driven Flexibility and ease of use
End-users	Mobile Software Development		Mobile Payments Mobile Gaming	Integrated Approach

The strategy of the business is supported by a number of strategic acquisitions. For example, Ratshefola anticipates convergence between television delivery and personal computers, and a stake in a company with no revenues but a (scarce) TV license was obtained.

Company Name	**Equity Owned**	**Core Competencies**	**Size (# of people)**
DVT (2006)	32.5%	Application Development and Maintenance	165
ACI Worldwide (2008)	25.01%	Electronic Transaction Switching	20
Indigocube (2007)	25.01%	Software Development tools	35
WoWtv (2007)	40%	Broadcasting, TV License	8

Ratshefola had worked at IBM for 10 years before co-founding Cornastone. His experience at the US multinational gave him a depth of insight into the industry, for example, adequate confidence about emerging ICT developments to be willing to invest into such “risky” investments as broadcasting. Having experienced the rigour of IBM processes, Cornastone also developed extensive processes in the first months of its existence to enable the relatively painless growth of the firm, and also adopted a very similar strategy to IBM in terms of the development of its people.

Ratshefola does not agree with executives who regard the skills shortage as a problem primarily of the government: “Businesses are lazy, they want people who are perfect for a job, they do not want to do the work of developing people.” Cornastone follows the example of IBM’s very extensive training for its employees, and also offers more than twenty “learnerships” a year. The learnership programme was initiated by government to allow companies to offer work experience for newly matriculated or graduated students, but not have to assume the risk of employing them. Cornastone works with the University of Pretoria, and has employed nearly all of its learners.

Ratshefola is old enough to have experienced some of the Apartheid policies first-hand, and his experience as a newly graduated software engineer has left him with a strong belief in a meritocracy. “I’ve learnt that no matter what the policies, when the machine is down and you can fix it, they will let you in.”

MXIT

MXit originates from Stellenbosch, a university town in the Western Cape in South Africa. Its founder Herman Heunis had been involved in a variety of software companies, and aware of opportunities in the mobile space because one of his companies was doing development work for the largest cell phone provider in South Africa, Vodacom. Heunis established Swist Group Technologies in 1997 and focused primarily on the mobile telecommunications industry, developing software and providing system support to large telcos. In 2000 Clockspeed Mobile, a research and development division of Swist Group Technologies, developed a Massive Multiplayer Mobile game named Alaya. The game was SMS-based and was not successful due to the high cost of SMSing. In 2003 the game was reassessed and the MXit concept conceived. MXit has evolved to become a major IM player in the South African arena thereafter. In January 2007, the local media MNC Naspers acquired a 30% stake in the company.

MXit allows users to send and receive one-on-one text and multimedia messages to and from other users, as well as in general chat rooms, and its user group is concentrated in the 15 – 24 year old category. MXit also supports gateways to other instant messaging platforms such as MSN Messenger, ICQ and Google Talk. MXit does not charge for one-on-one messages, although mobile operators may charge for data usage.

MXit has a registered user-base of about 24 million users in over 120 countries. However, its user-base is concentrated in South Africa, where 10 million users are found. The second-largest user base is 3 million in Indonesia. MXit is officially supported in Malaysia, India, Indonesia, the United Kingdom, the United States, Nigeria, Brazil, France, Germany, Italy, Portugal and Spain. However, all these countries have access only to the MXit's "Chat" function. In 2010, MXit launched in Kenya, making it the first country outside of South Africa to have access to the full suite of MXit offerings, including virtual markets and music downloads.

South Africa continues to suffer some of the highest bandwidth cost in the world. In August 2007 MXit commissioned their European Data Centre located in Frankfurt, Germany in order to take over most of the international traffic from the South African servers.

The firm generates revenue through two main channels. First, there are a number of pay-services, including chat-rooms. However, their main source of revenue is advertising. This can take the form of corporate sponsorships, e.g. from the UNHDP for an awareness-raising campaign against child trafficking, or advertising for such clients as Adidas, Coke and Nando's (a South African based fast food chain). As a social networking site, they have a detailed understanding of the preferences of their users, and can therefore deliver highly targeted advertising. They are one of the very few, if not only, social networking sites in the world to be profitable.

Because of MXit's strong reliance on advertising, the founder argues that linkages are critical for the firm. He talks about an "eco-system" and singles out their clients and the recruitment agencies they use to find staff. (The firm currently has about 130 employees.) However, almost none of his clients are based in the Western Cape; they tend to be in Johannesburg or increasingly overseas. For example, with the 2010 World Cup, "budgets really came in directly from overseas, skipped local agencies here and just connected directly with us" according to the Marketing Director, Paul Stemmet. MXit develops these campaigns jointly with clients, and meet extensively with them. Thus MXit built a 30-story LED screen on a building in downtown Johannesburg (that was getting media exposure during the World Cup) and ran a campaign with Nike "Write the future on MXit". The suggested headlines for the game for the next day were generated by users. The campaign has been so successful that MXit has been asked by Nike to replicate it in 2014 in Brazil.

When asked why they are still located in Stellenbosch, the founder answered:

I think Stellenbosch is a university town, it is a vibrant environment and you will find especially this area here, Technopark, was I think the brainchild of Christo Viljoen, a professor at Stellenbosch university, after he visited I think Germany or whatever; they have similar sort of things there. And it took a long time to get off the ground but now that it is off the ground it is actually fantastic. We have Capitec here which is a very progressive bank, we have the satellite company that launched Africa's first satellite here, we have the guys that are coding for secure bank transactions here, so we have got a number of high tech companies here in this area, in African context. But to come back to Stellenbosch, it is a wonderful place. It has youth, it is a vibrant town and it has the varsity so a lot of our guys come from varsity, either from there or UCT and we do have from other universities as well but a lot of them come from Stellenbosch. […] And it is beautiful.

The importance of being in Technopark (a technology incubator), of being able to meet people from other firms at the local cafeteria, and of working in a beautiful setting was also mentioned by a number of other respondents.

They experience severe challenges to find enough people, and it can take up to five months to fill a position. There is a shortage of skills especially among "middle layer" employees. MXit is able to attract young employees straight from university, and is prominent enough to be able to attract quality senior people. But after a few years' of employment with MXit many employees leave to go work either in Johannesburg or abroad. Although some return, most do not.

Many firms from especially the Western Cape have a presence in Silicon Valley. When asked why MXit did not, Heunis answered that there is a level of infrastructure in Silicon Valley that can be misleading if one wants to develop an offering for emerging markets. For example, because connections are not as robust, MXit has been developed to not "drop" an application when there has been a break in connection. Likewise, he sees it to his advantage to have a better understanding of the prevalence of poorer quality phones and challenges of having phones charged when electricity is not universally available. He mentioned that the greatest attraction of Silicon Valley is the level of VC funding available, but that having been bought by a local MNC, it is not a central consideration for them anymore.

Discussion

Three aspects stand out in the case studies. The first is that history matters – patterns of economic development can often be traced back to patterns that were established decades before. Thus both founders of the Cape-based businesses are Afrikaans. Government is concentrated in Gauteng (Pretoria), and under Apartheid, Pretoria-based Afrikaners could aspire to leading positions in government. However, in the Cape there were only limited government positions available, so that Afrikaans leaders in the Cape tended to gravitate towards business. The leading Afrikaans entrepreneurs (e.g. Whitey Basson, Christo Wiese, Anton and Johann Rupert) have historically been based in the Cape. Although the government sector is no longer a preferred employer of Afrikaners, the emerging Afrikaans entrepreneurs in the Cape have a network of existing entrepreneurs with whom they can connect. For example, MXIT was bought by Naspers, a historically Afrikaans Cape-based media firm, while Johann Rupert provides venture capital to a number of ICT entrepreneurs.

Similarly, Cornastone's CEO Ratshefola has benefited from government programmes to encourage the development of black-owned businesses, but he estimates that truly innovative black-owned firms are unlikely to emerge for another 7 to 10 years. He argues that black ICT entrepreneurs have relatively few role models to help accelerate the necessary growth process to become innovative industry players.

A second point is that the market for ICT skills in the Cape is much thinner than in Gauteng, with there being both fewer possible employers and fewer possible employees. Both Clickatell and MXIT estimate that it takes at least 4 months to fill a position. Although Gauteng-based businesses often complain of a shortage of skills, that level of constraint is not mentioned. At the same time, the Western Cape seems more inclined to invest the time in projects with a riskier and longer-term payoff (but potentially greater return) than Gauteng, where on-time execution for customers seems to be a central concern. The longer-term focus of projects in the Cape perhaps mitigates some of the impact of long timelines when positions need to be filled.

One important type of partner that was mentioned was that of recruitment agencies. These agencies undertake the costly search process for skilled employees on behalf of firms, and there seems to be a qualitative difference in how they operate in South Africa versus the developed world. In the developed world, job seekers would typically approach an agency to help them find work and agencies would try to place people on their books. In South Africa, even for relatively standard jobs, companies would approach agencies with a specification of the type of applicant they need, and agencies would tap their networks to find suitable applicants.

Finally, it is important to note that the customer base in the Western Cape ICT firms seems to be significantly different to in Gauteng. Gauteng is important because customers are there, and businesses in Gauteng generally regard the proximity to other firms in the value chain as a key reason for locating there. (This is especially apparent in the location choice of the multinationals, discussed next.) In terms of interaction within the Gauteng region, Cornastone seems to be best described as a Asheim's second category firm, a network regional innovation system, where the firm actively works to strengthen institutions, in addition to close work with customers.

In contrast, the Western Cape firms interviewed (as well as others in the Western Cape such as Yola which offers a template for do-it-yourself websites and ChessCube, which develops online chess software) provide an offering for a truly globally dispersed market. MXIT supports 3 million users in Indonesia with only one person; Clickatell covers all the cell phone networks in the world (except for North Korea) from its office in the Western Cape. These firms do interact with users, but their users are part of an online community, and are not regionally based.

The ties binding firms to the region are often historical and personal. Although firms do engage with the institutional infrastructure to improve local conditions, they see themselves as fundamentally part of a global village, and often require little more from their institutions than reliable infrastructure (electricity, broadband) and greater mobility of transactions across national boundaries. As regards skilled employees, they have strong although informal relationships with universities, and they claim that they can generally find entry-level workers. However, they struggle to find workers with five or more years of experience. Such experience is likely to be found when there is a greater concentration of firms, not through institutional investment. The firms in the Western Cape seem to be a special case of Asheim's third category RIS – or perhaps entirely new case – and constitute a regionalised *international* innovation system.

5.3. Multinational firms

The case analysis focuses on Ericsson, a Swedish ICT firm with a subsidiary in Johannesburg. In addition to the interviews with Ericsson (five decision makers in the company were interviewed, all on their own areas of expertise), interviews were conducted with a European non-ICT MNC (Novozymes) and with a US-based ICT MNC (Microsoft). Although these interviews are not reported in any detail here, it is worth noting that many of the themes that had emerged during the Ericsson interviews are consistent with the themes raised by other MNCs.

Ericsson
Ericsson South Africa is based in Johannesburg, from where the entire African region is managed. There are other regional offices as well as satellites, but decision making and coordination happens from South Africa. The strategy of Ericsson globally has recently changed from connecting 5 billion users to 50 billion. In order to achieve this strategy,

connections can no longer be between users, but must be between institutions. This has necessitated a shift from working with telecommunications companies to work with a much wider scope of entities.

Thus the Ericsson client base has expanded from providing telcos to include the supplying of equipment to Eskom (the South African power generation company) for the management of their power grids, the City of Johannesburg (for the provision of infrastructure for their broadband initiative) and possibly the Ministry of Defence.

In addition, a number of new offerings are being developed. A core entity driving that change within Ericsson is its "Innovation and Partnering" unit. The unit used to be called "Innovations" before, but the head of the department, a South African of Greek descent, Konstantinos Tzingakis, argued for the name change on the basis that innovation is not possible without partnerships. The scope of his unit is general telecoms, health, education, agriculture, infrastructure and business arenas, and it operates across all of Africa. Ericsson regards Africa as an important growth area, as it is estimated that more than 90% of the growth in the mobile subscriber base will come from emerging regions.

The unit has been delivering about four major and twelve smaller innovations per year over the past few years. Some of its past successes include:

DDS (known locally as MTN Zone)

Software was developed to sense the level of load of calls a given tower was carrying. At off-peak times, users get substantial discounts. This allows a greater evenness of load, made best use of existing infrastructure, increased the calls made by users, increased their savings, but also increased revenues for the cell phone network, MTN

EVN

Because users in developing countries often share a telephone, there is a need to ensure accountability of users. This innovation allowed multiple number ownership but using a single handset.

ECC

The norm in telecommunication is that the caller pays. Charges can be swopped through a "collect call", but then the receiver carries the cost. With ECC, the two parties can agree what proportion of the cost can be carried by whom.

MST

Ericsson developed the ability to easily and quickly create and deploy survey forms that can be accessed via any mobile bearer (Web, WAP, SMS and USSD). Surveys can be used for marketing, polls, competitions, corporate and private interactions (e.g. insurance claims, medical records, voting services, etc.)

Although these innovations were developed with the needs of poor consumers in mind, many of them have applicability in the developed world. DDS allows for better network use across the world, and the capability of adding a telephone number to an existing phone is useful when wanting to rent out a property or sell a vehicle. Once the transaction has been concluded, the number can be discarded. These innovations are therefore fed back to Sweden for adaption to more developed markets.

A number of the projects in the pipeline relate directly to infrastructural development. The "Millenium Villages Project" (MVP) was initially branded as a corporate social investment (CSI) project. Ericsson often uses CSI projects as "living labs", because those projects have the needed high visibility without expectations of immediate results. In the case of the MVPS, twelve remote clusters of villages (each with about 5000 inhabitants) were provided with 3G and GSM infrastructure, mobile phones and solar chargers. Data from these villages would enable Ericsson to estimate what number and type of users to expect if they were to roll out cell phone networks across Africa. The reaction has been overwhelming (the firm started seeing a payback six weeks after going live), and Ericsson is now able to experiment with combinations of institutional connections, for example M-Health where health care delivered is facilitated through the use of cell phones, using cell phone data to improve the quality of weather data but also to feed back to users weather information and warnings, and mobile markets, a type of eBay for mobile users.

Again, most of these applications have potential use in the developed world too – for example, cell phone-enabled health care provision is currently being explored in the care of chronically ill or elderly patients. Although no formal R&D is conducted in South Africa – it is a small market with few engineers who are, by developing world standard, quite expensive – it is clear that there are a number of social innovations at the local subsidiary.

The core team driving these innovations consists of six people in South Africa, while two similar-sized support teams are located in Ghana and Kenya. These teams engage in extensive collaboration with a variety of partners:

Small specialist firms working for Ericsson on a per-project basis. Using these specialist firms reduces costs and increases flexibility: "Ericsson employees are expensive" says Tzingakis.

Large local customers, for example the cell phone network MTN. In many cases, the customer co-develops the solution with the Ericsson and specialist provider team

The R&D department in Sweden, especially when an innovation needs additional technological advancement, and has a potentially global impact

Government is often either a direct customer, or an indirect beneficiary. For example, the team is currently piloting a case where excess energy from the solar generators for cell phone towers is sent back into the electricity grid, while M-learning will provide global classrooms. The Innovations and Partnering team always works with the relevant government entities, and have had to withdraw from projects when governments felt uncomfortable with the innovations. (For example, M-Health is a big success in Ghana, but the South African Health Ministry remains concerned about its viability.)

In addition to conversations around specific projects, Ericsson SA generally engages in conversations with government and participation in industry forums, tasks that the firm regards not only as forms of lobbying, but also as a form of corporate social citizenship.

MNCs generally regard Gauteng (and especially Johannesburg) as central to the South African and indeed African economy. The perception is that the infrastructure in JHB is superior and less prone to failure in Gauteng than elsewhere, and that the skills to maintain the infrastructure is also more readily available and of a better quality.

In terms of business-specific skills, the usual complaints about scarce skills were raised. However, respondents expressed disbelief at the fact that ICT firms in the Western Cape could take up to 4 months to fill a position, suggesting that they had easier access to skilled candidates. They mentioned interaction with different universities to help identify and develop skills, but specifically mentioned the presence of other MNCs as a generator of a pool of experienced candidates: Because they know what type of work other SA-based MNC subsidiaries conducts, they find employees with experience working for other MNCs especially attractive.

There has been a reliance on expatriates by both Ericsson and the other MNCs. Very often the expatriates were required not so much for their skills as for their attitude. After decades of political and economic isolation, the South Africans often were unwilling to accept the governance of the MNC parent. For example, the General Manager of Novozymes commented that she often heard people claim that "things don't reach down to the bottom of Africa". After the end of Apartheid, Ericsson sent about 160 expatriates to South Africa. Although there is a stated 2-year rotation period, it was only strictly enforced when the global crisis necessitated serious cost cutting and there has recently been an accelerated South Africanisation of the Ericsson workforce.

Another strategy used by all the MNCs to reduce the geographic isolation from the rest of the MNC network is to have a sophisticated internal IT infrastructure. Most employees at ICT firms like Ericsson and Microsoft are IT-savvy and comfortable using on-line portals and procurement processes. These tools play a very important role in making the subsidiary feel 'part of the whole' and overcoming geographic isolation. In fact, some Ericsson employees said that they could be located anywhere as long as they had access to their internal systems.

There also seems to be a "follow-the-leader" effect around raising financing locally, where MNCs share experiences about financing processes and thus engender a greater level of confidence about the feasibility of procuring funds locally. It seems that there is an agglomeration dynamic around MNCs, where firms are emboldened by the fact that they have a number "peer" subsidiaries with which they can exchange information. Thus Ericsson pointed out that they were told before they experienced that the Gauteng financial services industry is well developed, and that it would enable them to raise the necessary large sums of money for their capitally intensive infrastructure industry within the required timeframe.

Most of the somewhat smaller firms in the Western Cape tend to require venture capital rather than capital raised through the formal financial markets. Where they are unable to obtain such funding locally (e.g. from the funds of Johann Rupert or Mark Shuttleworth), they tend to move some part of their operations to Silicon Valley. Indeed, one important source of their VC funding in Silicon Valley is Sequioa Capital, a firm founded by the South African Roelof Botha (incidentally the grandson of the erstwhile Minister of Foreign Affairs, Pik Botha). Where those firms need financing through more formal channels, they use Johannesburg-based services. E.g. the technologically highly advanced bank Capitec which is based in Stellenbosch used the Johannesburg-based investment bank RMB for additional funds.

Unlike the Cape-based firms, which seem designed to tap into global virtual communities, proximity to suppliers and customers was critical for MNCs. Novozymes (an agro-processing firm) only has a sales office with about twenty people servicing South Africa and increasingly Africa. They import all their needed enzymes (almost exclusively from Denmark), and given the large quantity of enzymes re-exported from South Africa to other African countries, they did a study into the feasibility of moving their office to Durban, the major port city of South Africa. However, they decided to stay in Johannesburg because that is where all their major customers are located or preferred them to be.

Similarly, one of Ericsson's biggest clients is MTN, a Gauteng-based South African MNC, and a number of their most important innovations were developed in close interaction with the MNC. Moreover, their strategy is evolving into vertical industries and away from purely telco clients, so they are also widening the pool of entities with which they interact, including by increasing their physical presence across Africa. Johannesburg offers them greater access to those players.

In addition to the large number of clients located in Johannesburg, Johannesburg also serves as an important transportation hub. Direct, on time flying is easier between Johannesburg and both Europe and other African countries than anywhere else in South Africa. The importance of minimising the time, cost and inconvenience of flying was mentioned by all MNCs, especially in those cases where they were responsible for setting up some form of operation or sales office elsewhere in Africa. While operations were still too small to support a local office, employees from the MNC had an extensive travel load, and easy access to an international airport hub was important.

This ties in to another key characteristic of Gauteng-based MNCs: They typically act as the hub for African operations. In the case of Ericsson, a number of African offices exist (e.g. Ghana and Kenya), but South Africa is still the main regional office. From its founding in the gold rush of 1882, Johannesburg has always been a city of immigrants, and MNCs seem to provide a portal through which skilled Africans from the rest of the continent enter Johannesburg. Thus the head of South African operations for Ericsson is a Kenyan, Magnus Nchungise (the Swedish first name is a pure coincidence!) while the head of Microsoft in South Africa is Zimbabwean. Due to business links and ongoing emigrants, Johannesburg sees itself as a bridge between the developed world and Africa to a much larger extent than Cape Town.

As a provider of (communications) infrastructure, Ericsson cannot fulfill its mandate without interacting with governments. Ericsson states that it sometimes finds it easier to work with governments that are lagging significantly in terms of infrastructure and legislative frameworks than with governments that are lagging only to a limited extent. They are able to leapfrog solutions, and are able to introduce highly innovative solutions, for example by using mobile applications for health care provision in Ghana. Ericsson also benefits from being recognised as knowledgeable in its field, and for example recently advised lawmakers in an African country who were considering legislating what would have amounted to a specific technology. Given the fast pace of technological change, the laws would soon have been obsolete, and Ericsson saw it as a benefit for them as well as for the country that they were able to recommend a better formulation for the laws. The MNCs generally engage extensively with government, and see it as much as good citizen behaviour as a strategy to position themselves favourably for the future. However, their interaction is typically at a national rather than a local level.

The behaviours of the MNCs in Gauteng suggest that the region acts as a regionalised national innovation system with extensive international linkages (both to the developed and the emerging world). They engage with governments and universities, and are important clients and enablers for small local enterprises. A number of smaller firms play an important role as specialised providers for the MNCs with direct input from and exposure to the knowledge sources of the MNCs, typically from the developed world. In turn, the MNCs benefit from expanded capacity at low cost.

6. Conclusions

The evidence from Gauteng is consistent with previous evidence on regional innovation systems. First, the small firms have informal and mainly social ties to the region, and tap those networks to access skilled labour or business opportunities. Larger firms start to engage in more formal interaction with institutions, but their product offering remains very strongly in response to customer needs. The MNCs use Gauteng as a hub from which they manage Africa, but in the process strengthen Gauteng in a number of ways. Because there are a number of MNCs, there is a network within which practices and strategies can be discussed. Hiring often takes place between MNCs, and MNCs also seem prepared to undertake the laborious process of getting work authorisation for other African nationals, thus expanding the skills pool in Gauteng. There is evidence that MNC networks can remain disconnected from the local networks (Feinberg and Majumdar, 2001) but the MNCs in Gauteng engage with government and use local providers in a way that strengthens the entire system.

However, the Cape-based companies seem to be at the forefront of a new conceptualisation of a region. Historically hamstrung by their distance from customers (who are clustered in Gauteng), the successful Cape-based firms tend to operate in a virtual world which makes many regional attractiveness factors less important. MXIT supports 23 million users from an office with 120 employees in the Western Cape, and its business model has been "modularised" to allow them to outsource enormous chunks of their offering – often to partners that they have only encountered online. They are similar to the Estonian firm Skype with a similarly small support base and enormous user base, and their main regional considerations seem to be access to skilled labour and to finance. Sometimes face-to-face contact with clients is required, but this type of region seems to occur basically only when an offering is entirely digital and virtual. Given the continued increase in the services dimension of the economy, it is likely that such regions could become more prevalent.

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