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The Swedish national innovation system and its relevance for the emergence of global innovation networks

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The Swedish national innovation system and its relevance for the emergence of global innovation networks

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Abstract

Sweden is considered to be one of the most advanced countries in terms of innovation worldwide. Sweden always ranks high in all international reports on Science and Technology indicators such as the ones regularly published by the OECD or Eurostat. As many small countries, the Sweden economy has a strong international orientation and this is also reflected in the national innovation system. The NIS is dominated by internationally oriented industrial firms and universities. Furthermore, since 1988, the country has experienced a growing trend of mergers and acquisitions of technology intensive firms by foreign companies (Vinnova, 2006) whose presence, particularly in certain industries, is very noticeable. The aim of this paper is to explore the links between the NIS in Sweden and the participation of Swedish firms and Swedish universities in Global Innovation Networks. More specifically, it attempts to answer the following questions: a) To what extent are Swedish actors participating in GINs? b) To what extent is the Swedish NIS attracting GINs? c) What is the role of the Swedish NIS in supporting the participation of Swedish Universities and Swedish firms in GINs? d) What is the role of the Swedish NIS in attracting actors in GINs into Sweden?. The paper is based on secondary sources and has a rather descriptive nature. In its current form (June 2010) is a report submitted to the EU Commission as part of the deliverables of the INGINEUS project.

Keywords: globalization, innovations systems, Sweden

THE SWEDISH NATIONAL INNOVATION SYSTEM AND ITS RELEVANCE FOR THE EMERGENCE OF GINs

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1. Introduction

Sweden is considered to be one of the most advanced countries in terms of innovation worldwide. Sweden always ranks high in all international reports on Science and Technology indicators such as the ones regularly published by the OECD or Eurostat. In 2009 Sweden invested a 3,75% of the GDP in R&D well above US (2,77 %) and slightly higher than Japan (2,44 %[2]) (OECD, 2010). The number of full time R&D employees per 1000 employees was 17,0 in 2000, only below that of Finland (22,4) and Iceland (17,5) in the ranking of OECD countries.

As we will argue in this paper, the high performance in terms of innovation is due, among other things to the industrial structure of Sweden, dominated by large R&D intensive multinational groups (such as Ericsson) as well as a strong specialization in high-tech industries and services. Both the National Innovation System as well as the Global Innovation Networks in which Sweden participate are highly influenced by the industrial structure of Sweden.

The outstanding performance in terms of S&T has not been in parallel to an equally high performance in terms of growth, productivity and competitiveness (Marklundet al.2004) for the whole economy. This mismatch between innovation performance and growth has been labeled the *Swedish Paradox* and it is still today the focus of many discussions on the innovation system of Sweden and its performance (Edquist et al., 2008; Ejermo et al 2008; Kander and Ejermo, 2009). Among the possible reasons for the relatively poor economic performance is the dominance of large R&D intensive multinational groups, the lack of support for SMEs or the strong focus on basic research[3].

As many small countries, the Sweden economy has a strong international orientation and this is also reflected in the national innovation system. The NIS is dominated by internationally oriented industrial firms and universities. Furthermore, since 1988, the country has experienced a growing trend of mergers and acquisitions of technology intensive firms by foreign companies (Vinnova, 2006) whose presence, particularly in certain industries, is very noticeable.

The aim of this paper is to explore the links between the NIS in Sweden and the participation of Swedish firms and Swedish universities in Global Innovation Networks. More specifically, it attempts to answer the following questions: a) To what extent are Swedish actors participating in

[2] Data of 2008

[3] While it is not the objective of this paper to discuss the relationship between innovation and economic performance in Sweden, the previous discussion in important to highlight why, in this paper, we will try to move beyond R&D indicators (and other S&T-based indicators) to try to provide an accurate picture of the NIS and its relationship with GINs.

GINs? b) To what extent is the Swedish NIS attracting GINs? c) What is the role of the Swedish NIS in supporting the participation of Swedish Universities and Swedish firms in GINs? d) What is the role of the Swedish NIS in attracting actors in GINs into Sweden?

GINs in this paper are defined as “globally organized networks of interconnected and integrated functions and operations by firms and non-firm organizations engaged in the development or diffusion of innovations” (Chaminade, 2009:12). GINs embrace three forms of globalization of innovations: global research collaboration, global sourcing of technology and innovations and global generation of innovations (technology based FDI) (Archibugi and Mitchie, 1995; Plechero and Chaminade, 2010). The global research collaboration alludes to the collaboration of different partners from different countries in the development of know-how or innovation. 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 organizations, including firms, research centers, universities, government, etc. The global sourcing of technology refers to the acquisition or import of technology (machinery, patents, know-how, etc) from a different country. 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 this paper, we also make a distinction between global innovation networks (GINs) and regional innovation networks (RINs) (Chaminade, 2009). GINs have a global geographical spread and engage actors beyond the traditional Triad (in our case, we are interested in the involvement of organizations from BICS). RIS are international networks confined to a specific supra-national region – for example, within the European Union. In this paper, we consider North-North networks –that is, networks within the Triad as RINs and those involving actors outside the Triad as GINs.

A final note on the data used in this paper. For the tables and graphs presented in this paper we have tried to use the latest data available, which is 2008 for most of the statistics produced in Sweden and 2004-2006 for international statistics, such as the Community Innovation Survey (Eurostat) or those published by the OECD.

2. Main actors in NIS and their international dimension

In international comparison, one could say that Sweden industrial structure is characterized by a comparatively large knowledge-intensive and export-oriented manufacturing sector, a relatively small private service sector but a comparatively large public service sector. Both the public and the private sector are dominated by large organizations.

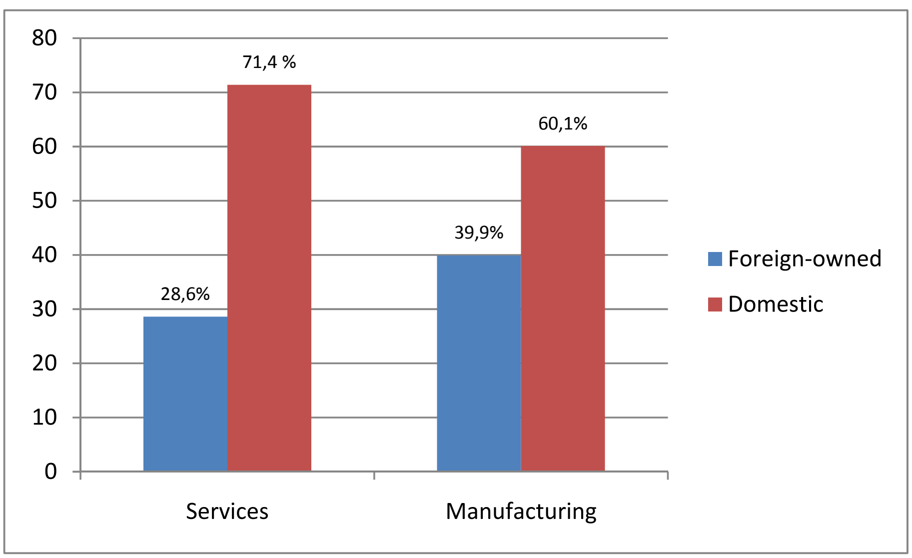
The Swedish National Innovation System (NIS) is quite polarized into two main groups of actors: on the one hand a small number of large multinational groups –about 10- and, on the other hand, a similar number of universities. These two groups are responsible for a larger part of the R&D performed in Sweden (Marklund et al, 2004).

2.1. Firms

In relation to the size of its economy Sweden has a broad industrial structure with world-leading international companies such as Ericsson (ICT), AstraZeneca (Pharmaceuticals), Volvo, Scania and Autoliv (Automotive), Industrial machinery (ABB), Packing (Tetrapack), Household appliances (Electrolux). These large multinational companies have a great impact on the functioning of the NIS and, at the same time, are responsible for the high degree of participation of the Swedish innovation system in GINs, They use extensively GINs in their innovation strategy, including global collaboration, sourcing and generation of innovations, as we will discuss later.

In 2004, the number of foreign affiliates in Sweden was 9273 which represents barely a 1,2 % of the national total. They are concentrated in Telecommunications (15% of the units) followed by air transport (10% of the units) and electricity, gas and water supply. Despite their marginal importance in terms of number, they contribute significantly to the country's turnover, as plotted next.

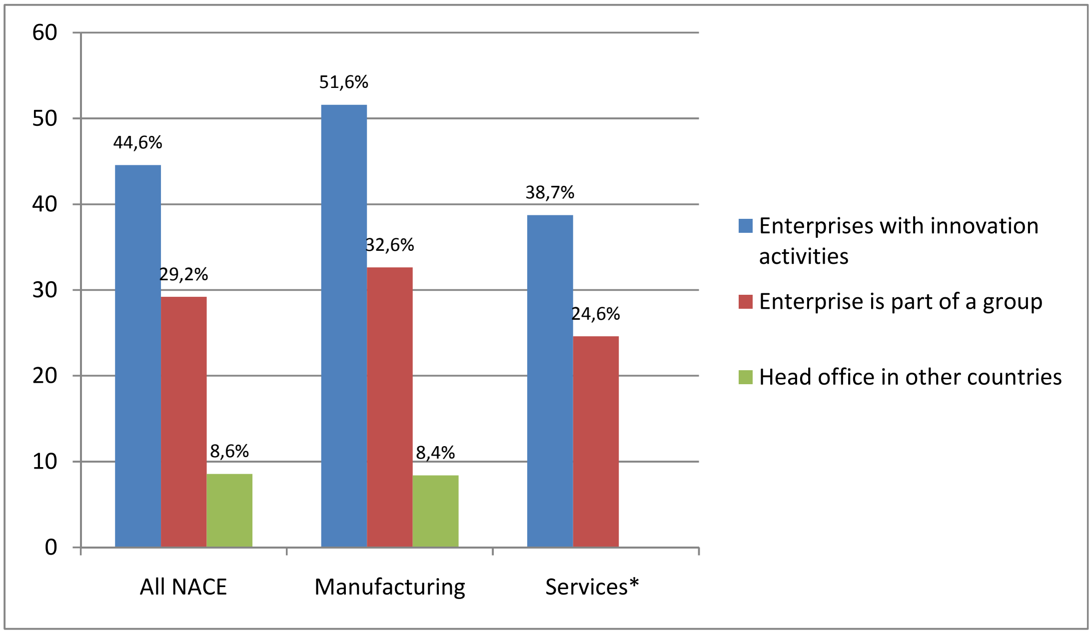
Graph 1. – *Percentage distribution of national turnover of domestic and foreign-affiliated companies in services and manufacturing (2004).*



Source: OECD (2008)

Around 7217 firms have introduced product or process innovation in the period 2004-2006 (Eurostat, 2007), which represents 44,6 percent of the sampled population. The proportion of innovative firms is higher in manufacturing than in services, reflecting also the presence of large multinational companies in manufacturing.

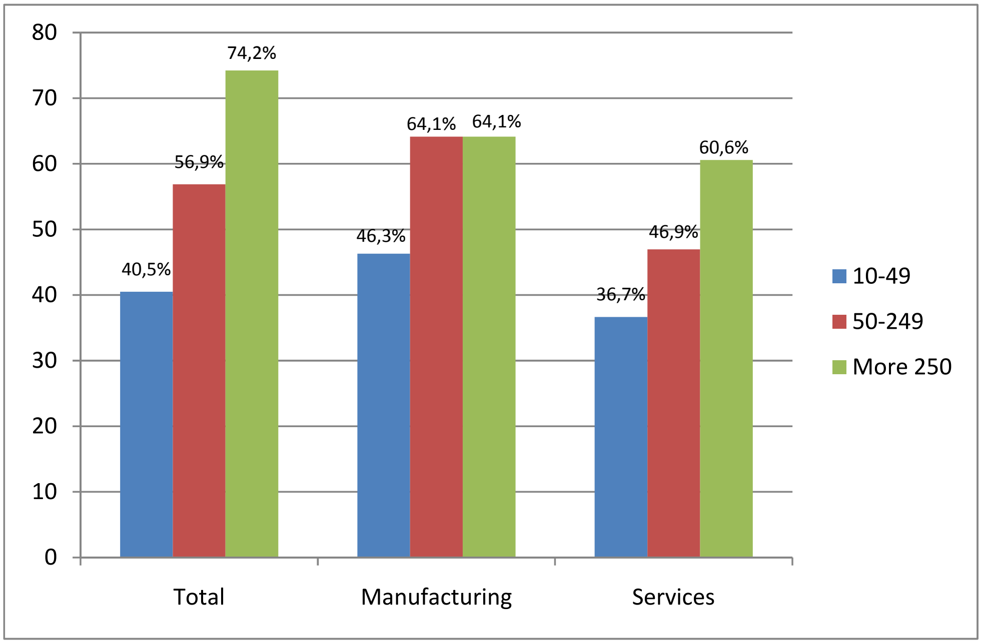
Graph 2. - *Enterprises in Sweden – percentage (2004-2006).*



* Excluding public administration - *Source:* Eurostat (2007) – CIS (2004-2006)

As it would be expected the proportion of innovative firms to total population is directly related to the size of the firm. The proportion of innovative firms in large firms is higher than in small firms. Yet the proportion of SMEs that are innovative in Sweden is quite high, particularly in manufacturing and next graph shows.

Graph 3. – *Enterprises with innovation activities in Sweden, percentage distribution by size of the firm (2004-2006).*



Source: Eurostat (2007) – CIS (2004-2006)

2.2. Universities and research centers

Similarly to the business sector, the university sector is dominated by approximately 10 universities which are responsible for almost all R&D performance in the country: The Karolinska Institute, Chalmers University of Technology, Uppsala University, Lund University, Gothenborg University, the Royal Institute of Technology (KTH), Stockholm University, Linköping University and Luleå University being the most important ones. The size of the universities in terms of the number of students (FTE) in 2008 is plotted next:

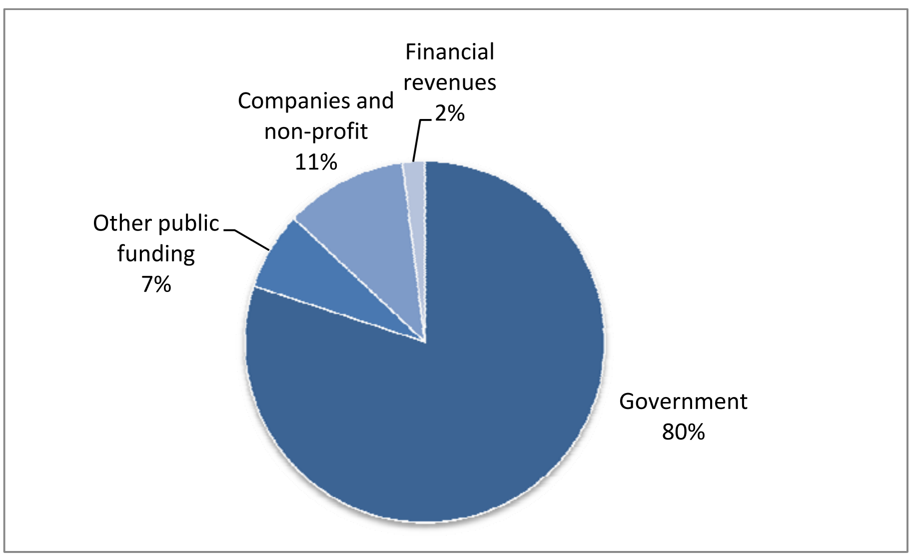
Table 1. - *Number of students enrolled in the 10 largest Swedish Universities (2008).*

University	Number of Students FTE
Lund University	24600
Gothenburg University	24100
Stockholm University	22400
Uppsala University	19900
Linköping Univ.	16900
Umeå	15600
Linnaeus Univ.	15000
Royal Institute of Technology (KTH)	11700
Chalmers	8471

Source: Swedish Higher Education Authority (2009)

With few exceptions (Karolinska Institute and the Royal Institute of Technology), most of the funding of Swedish Universities comes from the public sources (regional and national government and EU) and only a small proportion (approximately 11%) is funded by private firms and foundations, as shown next:

Graph 4. - *Sources of funding of Swedish universities.*



Source: Authors' with data from SNAHE (2010).

Additionally, Sweden has a number of University Colleges (Swedish Högskola) that provide degrees at graduate (University diplomas and Bachelor degrees) and post-graduate level (Master and Doctorate). In comparison with Universities, University colleges are usually specialized in just one academic discipline. For example, Blekinge Institute of Technology and Mälardalen University are specialized in Engineering, while Stockholm School of Economics is in Business and Economics and Malmö University (although is currently diversifying) has a strong focus on Medicine.

With regards to Research Institutes, the Swedish R&D institute sector is one of the smallest in the OECD, mostly due to the fact that almost all public R&D investments go to the Universities in Sweden (Marklund et al, 2004). Despite their small size, they are active in a variety of industries. Some of the most important ones are the Swedish Defense Research Agency (FOI) (aprox. 1250 employees), the industrial research institutes (jointly owned by the government and industrial associations, employing aprox. 2100 employees) and other government research institutes and agencies like the Swedish Institute for Infectious Disease Control or the National Institute for Working Life, employing aprox. 430 researchers full time (VINNOVA, 2006).

3. Competences in the Swedish NIS and their potential role in GINs

3.1. Human capital and its international dimension

3.1.1. Tertiary education in Sweden

Although the proportion of higher educated people in Sweden is high, Sweden is not at the top of the OECD rankings that measure the proportion of higher educated people to the total population. Table 2 summarizes the number of students participating in tertiary education in 2006 in total and as a proportion of the population between 20-26.

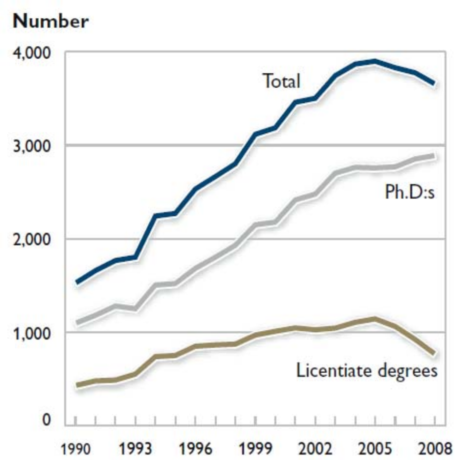
Table 2. - *Number of students enrolled in Tertiary education (all cycles) and number of Graduates (2006)*

	Students enrolled in tertiary education		Graduates 2006	
	Total numbers	% population 20-29	Total numbers	% population 20-29
In any field	422614	39,1	60762	5,6
In Science, Maths and Computing	43910	3,8	--	--
In Engineering, Manufacturing and Construction	68846	6,4	--	--

Source: Eurostat (2009)

Since 2008, tertiary education in Sweden has been divided into three cycles: Bachelor, Master and PhD, which is showing different trends over time. While the number of degrees awarded to the first and second cycle has decreased over time, the number of doctorates awarded has slightly increased, particularly in the last year for which data is available (2008).

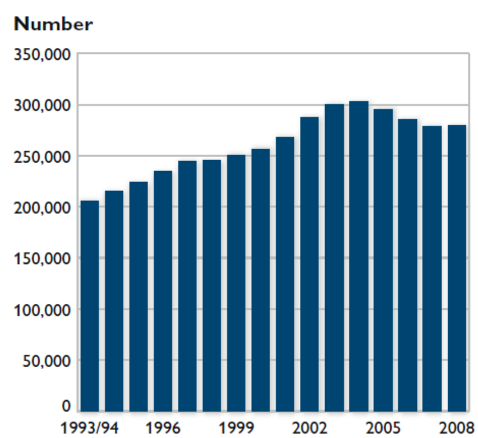
Graph 5. - *Number of degrees awarded in tertiary education (1990-2008).*



Source: SNAHE (2010)

The declining trend observed in the first and second cycle is not a good indicator, particularly taking into account the role that competences play in the emergence and development of Global innovation networks: we may expect, that countries and regions with higher proportion of qualified human resources will be also the ones better positioned to attract GINs and to participate in GINs. However, one may expect this negative trend to reverse in the next future as 2008 showed, for the first time since 2003, an increase in the number of FTE in first and second cycles which may translate into an increase in the number of graduates in the coming years.

Graph 6. - *Number of FTE in first and second cycle of tertiary education (1993-2008).*

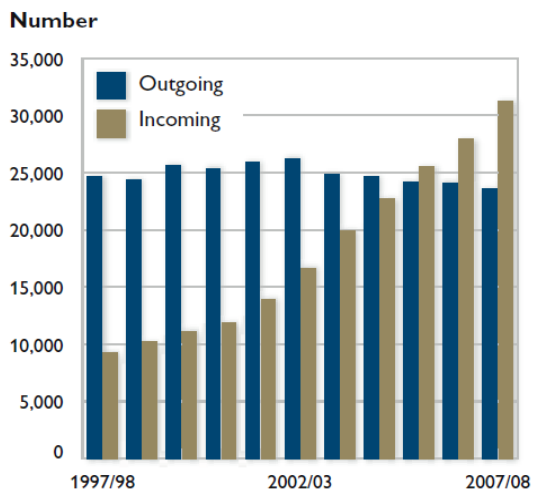


Source: SNAHE (2010)

3.1.2. International mobility of students

The higher education system in Sweden has very strong international linkages. About 13% of the Swedish students enrolled in tertiary education studied abroad in 2008 (SNAHE, 2010). In the same year, more than 31000 foreign students came to Sweden, almost tripling the amount of foreign students one decade ago. The result is that since 2005/2006 the number of foreign students coming to Sweden has exceeded the number of outward students (Swedish students going abroad).

Graph 7. - *Number of Outgoing/Incoming students (1997/98-2007/2008)*



Source: SNAHE, 2010.

The geographical spread of the student exchange has also varied over the last years. Although still two out of three Swedish students that go abroad travel to Europe, the proportion of students that chose to go to Asia in the last year is six times higher than in 2001/02. Similarly, about 35 per cent of the students that had arranged their own studies in Sweden came from Asia. Table 3 summarizes the countries of origin and destination of students in Tertiary education. The proportion of students to and from the BICSs countries is also included when available.

Table 3. – *Number and percentage distribution of students in Tertiary education*

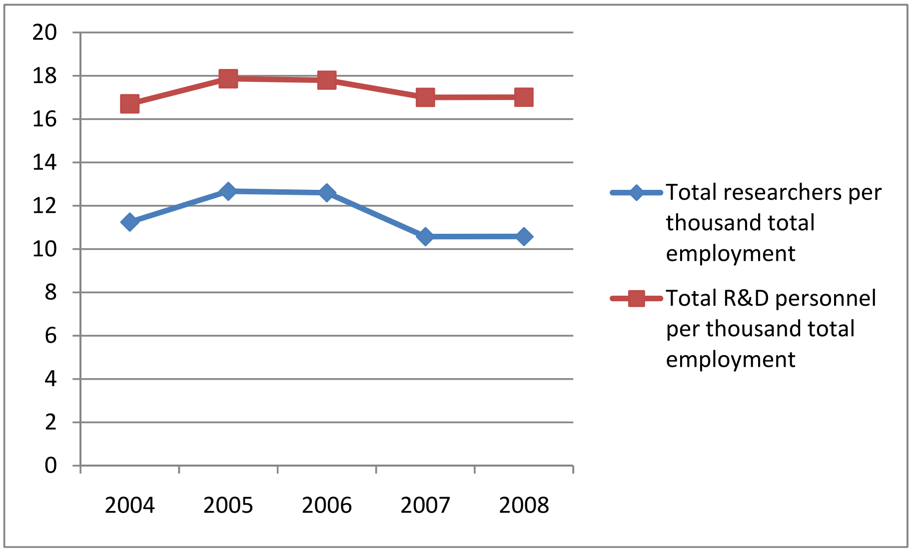
Country of destination/Origin	**Swedish students abroad- Foreign students in Sweden**		**Foreign students in Sweden**	
	Number	%	Number	%
Nordic countries	2890	11,90	2714	8,69
Europe excl. Nordic countries	12273	50,55	11266	36,08
Africa	260	1,07	1314	4,21
South Africa	107	0,44	0	0,00
North and Central America	4621	19,03	1580	5,06
South America	406	1,67	385	1,23
Brazil	0	0,00	109	0,35
Asia	1789	7,37	7709	24,69
China	595	2,45	2253	7,22
India	0	0,00	866	2,77
Oceania	2038	8,39	455	1,46
TOTAL	24277	100,00	31224	100,00

Source: Table elaborated by authors with data from SNAHE (2010)

3.1.3. Researchers and R&D personnel in the Swedish NIS

The decline in the number of students enrolled in tertiary education in Sweden over the last years has had an impact on the proportion of researchers and R&D personal in the Swedish innovation system, as it could be expected. This, again, is not a good sign if one takes into account that one of the most important determinants in the location of innovation activities in a certain country or region is the availability of competences (qualified human capital).

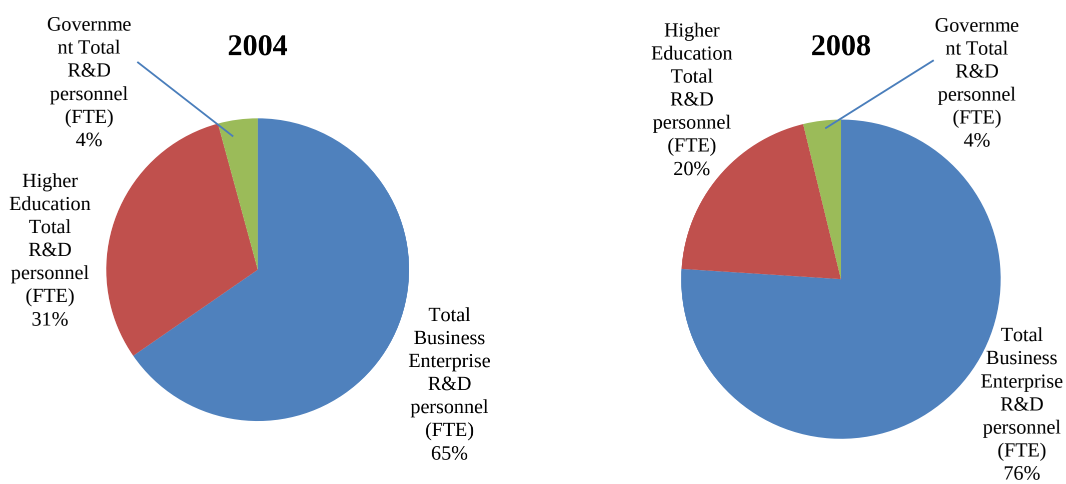
Graph 8. - *Total Researchers and R&D personnel per thousand total employment 2004/2008).*



Source: Authors' own elaboration with data from OECD (2010)

The business sector has traditionally the most important employer of R&D personnel in general and of researchers in particular and its importance in relative terms has increased over time, as next graphs show:

Graphs 9. - *Percentage distribution of R&D personnel (FTE) between Business enterprises, Higher Education and Government in Sweden (2004 and 2008).*



Source: Authors' own elaboration with data from OECD (2010)

3.2. Knowledge base in firms

3.2.1. Human capital in firms

One of the most important sources of innovation for any firm is its employees and one of the most conventional indicators of the qualification of human resources in firms is the proportion of employees with a university degree. People with a higher education degree in Sweden are to be found mainly on the high-tech manufacturing groups (usually the large MNCs that dominate the Swedish NIS), some knowledge intensive services (KISs) and Universities, once again reflecting the polarized structure of the system of innovation. The proportion of scientists and engineers that are currently employed in KISs has increased very rapidly in the last years and currently employ more scientist and engineers than in the manufacturing industry (Marklund et al, 2004).

Next table 4, provides information on the country of origin of the R&D personnel employed in major Swedish groups. It is worth pointing out at the increase in the number of R&D personnel from China between 1997 and 2007- from 2 to 2046 R&D employees. None of the other groups have experienced such a dramatic increase.

Table 4. *Number R&D person-years (full-time annual equivalents) in major international Swedish groups*

Country/region	R&D person-year					
	1997	**1999**	**2001**	**2003**	**2005**	**2007**
Total in world	**45135**	**38846**	**40037**	**30803**	**38204**	**45614**
Sweden	27517	22022	20923	19085	21720	23239
Abroad	17618	16824	19114	11718	16484	22375
EU15	10013	8814	10475	7053	8902	11983
China	2	107	313	388	974	2046
India	30	9	286	2	120	429
South America	332	216	401	256	323	398
USA	3865	4440	4249	1814	3421	3838

Source: ITPS (2007)

The level of education provides an indication of the stock of knowledge but not about how the firm uses that knowledge. In a recent study, Lorenz and Lundvall (Forthcoming) discuss the proportion of creative workers in a selection of European firms and its impact in innovation. As it can be observed, the Scandinavian countries, who are also the ones that perform better in terms of innovation in Europe, are also the ones showing a higher proportion of firms with creative workers in striking contrast with countries in the South and East of Europe. This is particularly relevant, when one sees that the proportion of creative workers seem to be positively correlated with the innovation performance of firms (Lorenz and Lundvall, Forthcoming).

Table 5. - *National differences in types of learners in firms (EU 27) (percent of occupied persons by country and type of learner)*

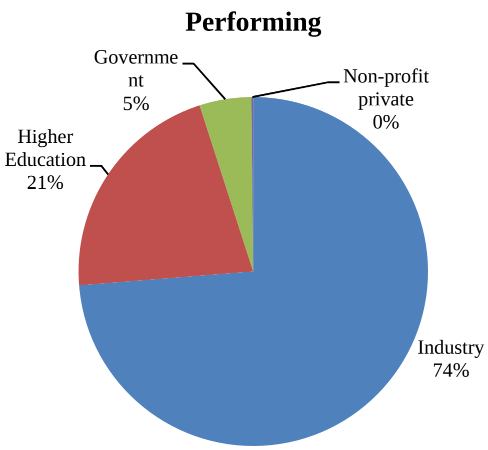
	Creative Worker	Routine problem solvers	Taylorized workers	Total
		NORTH		
Sweden	82	10	8	100
Denmark	70	15	14	100
Finland	66	21	13	100
		SOUTH		
Greece	39	33	28	100
Italy	37	29	34	100
Spain	35	30	36	100
		EAST		
Lithuania	35	27	38	100
Romania	35	38	27	100
Slovakia	33	22	35	100
EU-27	**51**	**24**	**25**	**100**

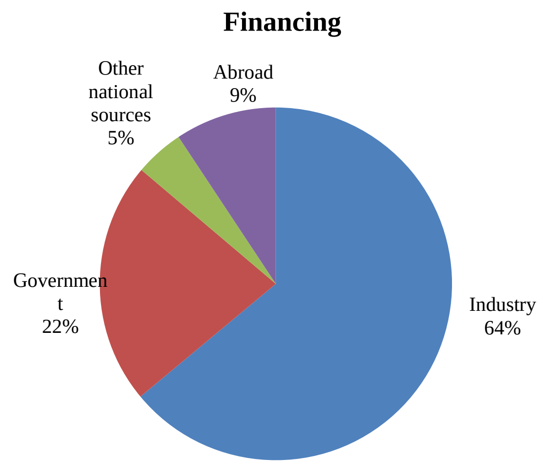
Source: Lorenz and Lundvall (forthcoming)

3.2.2. R&D in firms

As indicated earlier, the R&D system in Sweden is concentrated in a small number of large multinationals and some of the oldest universities in the country. Furthermore, the industry is, by far, the main financing and performing actor when it comes to gross domestic expenditure in R&D (GERD) as next graph shows:

Graph 10. - *R&D expenditure; Performing and Financing (2007)*

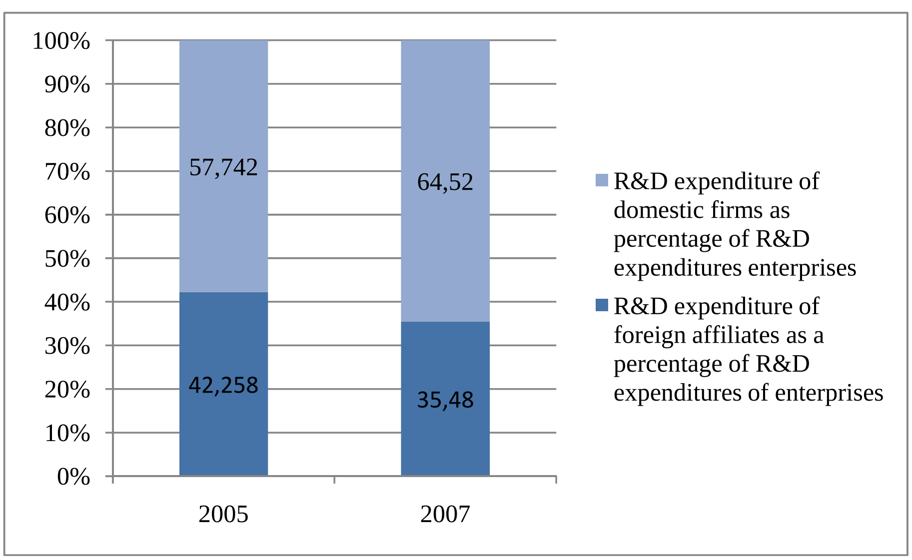




Source: Authors' based on OECD (2010)

Foreign firms have traditionally played a major role in the R&D expenditures of the country (GERD) however their importance has been diminishing over time. The country of origin of the largest R&D investors in Sweden is USA and the United Kingdom. The statistics do not provide specific information on the R&D investment of MNCs from any of the BICS countries part of INGINEUS however, the amount of investments that comes from MNCs whose headquarter is in USA and Europe is barely 1,9 % of the total R&D investments of foreign firms in Sweden, giving an indication of the regionalization (and not globalization) of inward R&D.

Graph 11. - *R&D expenditure of domestic vs foreign affiliates. Percentage (2005 and 2007).*



Source: Authors' based on OECD (2010)

3.2.3. Specialization/clusters

Global innovation and production activities are attracted to certain regions or clusters which have accumulated competences in a particular industrial area. It is therefore important to understand which are the clusters in which the country (and the national innovation system) is specialized. In the case of Sweden, those areas of specialization are cleantech, automotive, ICT, materials science and life sciences (ISA, 2009):

Cleantech: One of the newest clusters in Sweden is the one of Clean or Green Technologies (Cleantech) and, particularly of Biofuels, wind power and solar cell manufacturing. Somehow, the cleantech cluster has built upon the accumulation of competences of Sweden in engineering. The cluster is located in Stockholm (including Uppsala) to the north.

Automotive: Sweden has a long tradition in automotive innovation which is built on a long specialization in the production of passenger and commercial vehicles. Although the industry is currently under re-structuration (Volvo cars has been acquired by the Chinese Geely and Saab by the dutch Spyker), some of the most innovative companies worldwide in car safety (for example Autoliv) and Intelligent transport systems have their headquarters in Sweden, like Autoliv. The cluster has attracted production and innovation activities worldwide, including MNCs subsidiaries from BICS countries like Bharat Forge from India. The cluster is located around Gothenburg.

Information and Communication Technologies (ICT): One of the most important clusters in Sweden is that of ICT, particularly mobile communications, media (IPTV) and computer games. Three are the main factors that explain the specialization of Swedish NIS in ICTs: the presence of world leaders in communication technologies, like Ericsson; the pool of qualified human resources in related communication technologies; and the demand of the customers. One of the main drivers of innovation in the ICT industries is the proximity to the customer (Pavitt, 1984). Swedish customers are among the quickest in the world to adopt new applications and services (ISA; 2009: 8), which makes Sweden a good test market for new applications. This clusters has attracted a large number of R&D centers from MNCs all over the world, including some from BICS countries, like TCS and Infosys from India or ZTE, Huawei and Lenovo from China. The cluster is mainly located in Kista, in the outskirts of Stockholm although there are two emerging clusters in Skåne (for computer games) and Linköping (for web servers and IPTV).

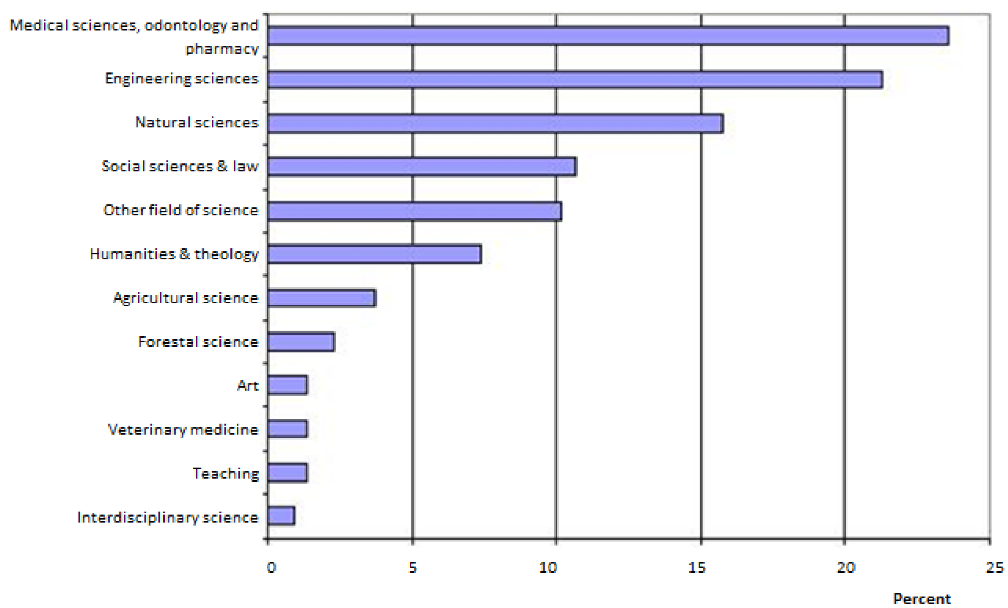
Materials science: The specialization of the Swedish NIS in materials science can be explained by the combination of research specialization at the University and the accumulation of industrial know-how in paper and pulp and packaging technologies based on cellulose fiber –like Tetrapack- (another offspring of the forestry past of Sweden). Sweden will be hosting the largest European research facility for materials research – the European Spallation Source (ESS). In contrast with the previous clusters, the materials science cluster is spread all over the country: e.g. materials research on packaging in Lund and Stockholm and material research related to textiles in Borås (close to Gothenburg).

Life sciences: As in the previous case, the specialization in life sciences is based on the combination of world class research institutions (for example. The Karolinksa Institute in Stockholm) and medical universities and a cluster of large multinational companies in biotechnology (including biomed) and pharmaceuticals like Astra Zeneca, Elektra, Gambro or Pharmacia. There are two main clusters in Life Sciences, one in the South of Sweden – the Medicon Valley- and another one in Stockholm, which have specialized in biotech tools, diagnostics, medical devices, biomaterials and regenerative medicine.

3.3. Knowledge base in Universities and Research centers

Higher education institutions are responsible of 20% of the R&D performed in Sweden as shown in Graph 9. Although it is not possible to find the breakdown of that R&D investment by subject areas, it is possible to have a rough idea by looking at the distribution of R&D employees by subject areas in Swedish Universities. As can be observed, most R&D personnel are concentrated in medicine, engineering and live sciences.

Graph 12. - *Proportion of R&D man-years (FTE) at Swedish universities in 2003distributed by subjects.*



Source: SCB, ”Forskning och utveckling inom universitet och högskolesektorn 2005”

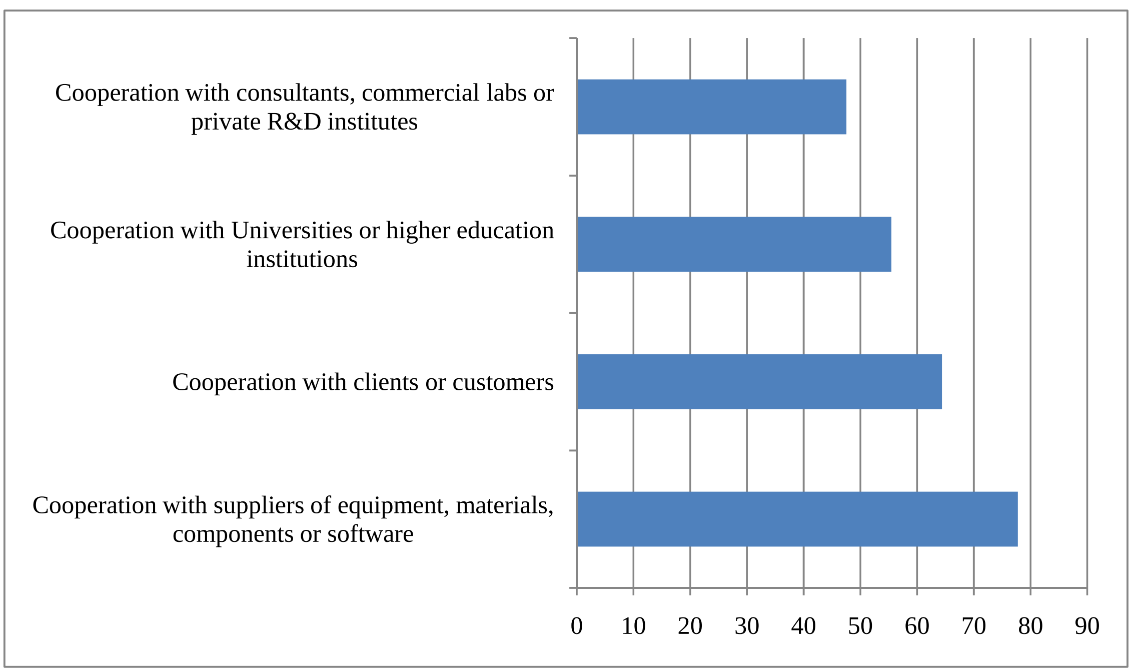
4. Innovation networks and their international dimension

As indicated in the introduction to this report, we distinguish between 3 forms of globalization of innovation and, as a consequence, global innovation networks: global research collaboration, global sourcing of technology and global generation of innovations. For analyzing these three forms, we use the information on collaboration in innovation from the innovation survey, the imports of high-tech products and the R&D FDI respectively.

4.1. Global research collaboration

The innovation survey provides information on the collaboration in innovation by partner and by the country of origin of the partner separately. As can be observed in Graph 13, about 78 % of Swedish innovative firms have cooperated with suppliers in their innovation process and 64% have done so with clients and customers. This result is different from the average in Europe at least in one respect: the most important partner for collaboration in innovation in Europe is the customer, while in Sweden is the supplier. This difference can be explained by the industrial specialization of Sweden in industries in which suppliers of technology play a fundamental role in the innovation process: automotive, clean tech, ICT, etc. These are also the industries that concentrate a larger proportion of the R&D in manufacturing and host some of the largest companies as well.

Graph 13. - *Percentage of innovative firms that have collaborated in innovation by partner (2004-2006).*



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

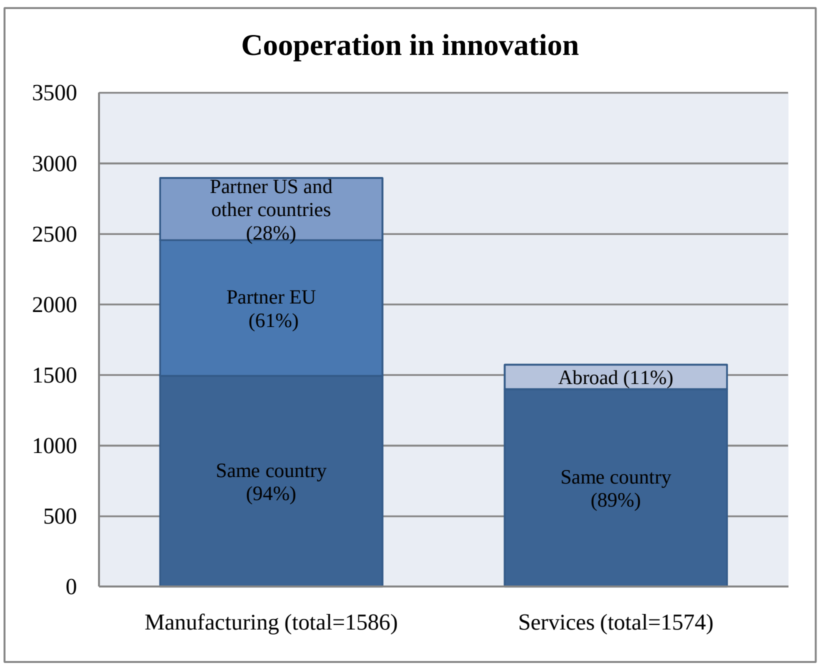
Looking at the origin of the partners, we can see that most of the research & innovation networks are either national or European; that is, we are mainly talking about regional innovation networks (RINs) and not about global ones (GINs). However it is worth mentioning that about 20% of the SMEs (less than 250 employees) and 30% of the large firms have some form of collaboration in innovation with China and India.

Table 6. - *Percentage of firms that cooperate in innovation by size and location of the partner*.

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

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

Graph 14. - *Cooperation in innovation by origin of the partner*



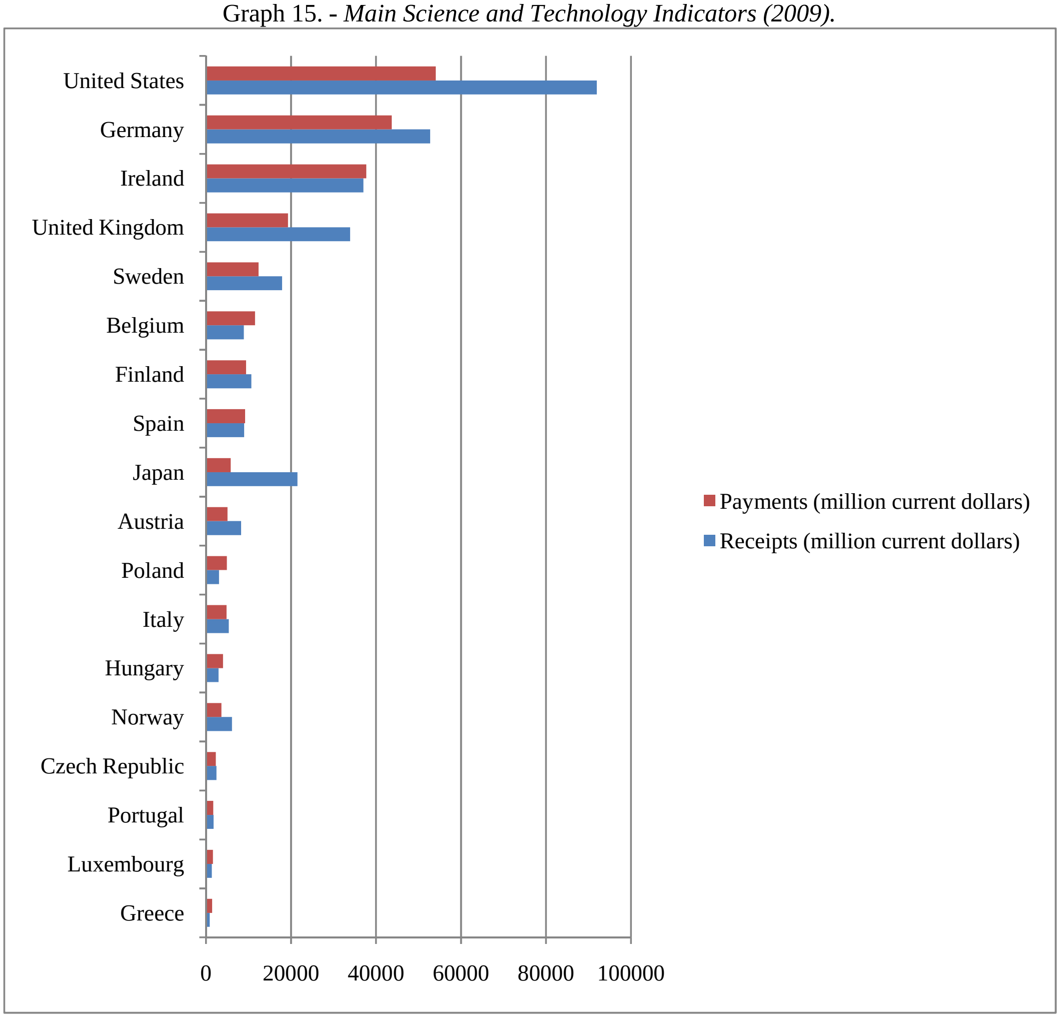
Source: Authors' own elaboration with CIS data (Eurostat, 2007)

4.2. Global sourcing of technology

As a proxy of the global sourcing of technology we will use the technology balance of payments (TBP) data published by the OECD (2009). The TBP informs about the trade of disembodied technology between one country and the rest of the world. It includes the receipts and payments for the transfer of techniques (through patents, licenses, know-how), the transfer of designs, trademarks and patterns, trade of services with a technical content (like technical and engineering studies or technical assistance) and industrial R&D. It does not include information on the acquisition of embodied technology, such as machinery.

As it can be observed in Graph 15, Sweden has a positive TBP, receiving more payments for technology licensing and services abroad than what the country pays for technology and services acquired from abroad. The global sourcing of (disembodied) technology in Sweden[4] is relatively small as compared to USA, Germany, Ireland and the United Kingdom but still quite superior to many other European countries[5].

Graph 15. - *Main Science and Technology Indicators (2009).*



Source: OECD (2010)

[4] Measured by the payments

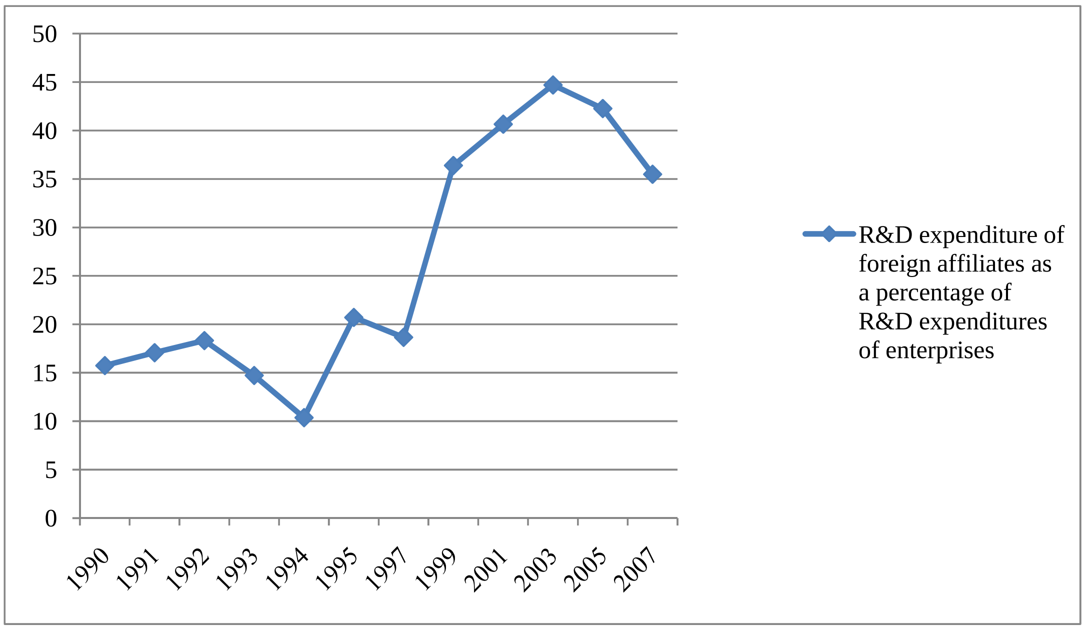
[5] Regretfully, the data published by the OECD does not include information on the origin and destination of the technology payments to assess the geographical spread of the global sourcing of technology.

4.3. Global generation of technology

4.3.1. Inward R&D

Inward R&D investment is measured by the R&D expenditure of foreign-owned affiliates in a certain country. As shown in Graph XX, in 2007 foreign affiliates were responsible for about 35,48 % of the total R&D expenditure in Sweden, which is very high. However, inward R&D has decreased in the past few years, both in absolute terms (expenditure in million SEK) as well as a percentage of the R&D expenditures of the business sector, as graph 16 shows.

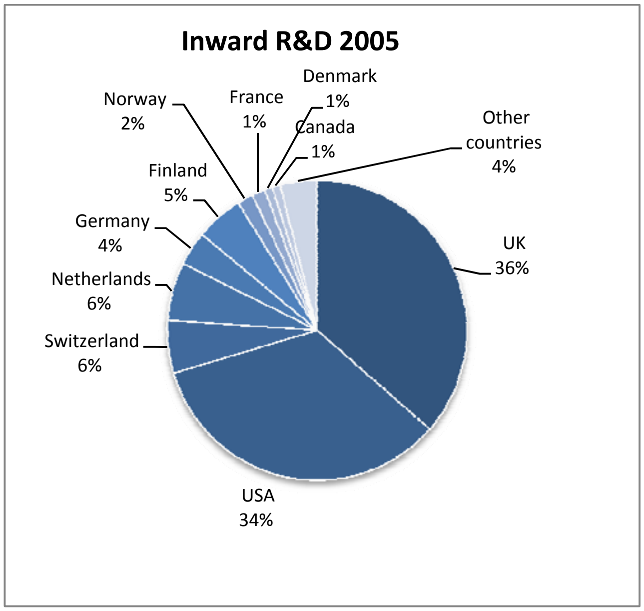
Graph 16. - *Inward R&D – R&D expenditure by foreign-owned affiliates in Sweden (1990-2007).*



Source: OECD (2010)

The latest available data on the distribution of R&D expenditures of foreign enterprises in Sweden by country of origin which is dated in 2005, shows the predominance of R&D investments from UK and USA foreign affiliates as compared to affiliates from other parts of the world. Once again, the predominance of European affiliates is clear.

Graph 17. - Distribution of R&D expenditures of foreign affiliates in Sweden by country of origin (2005).

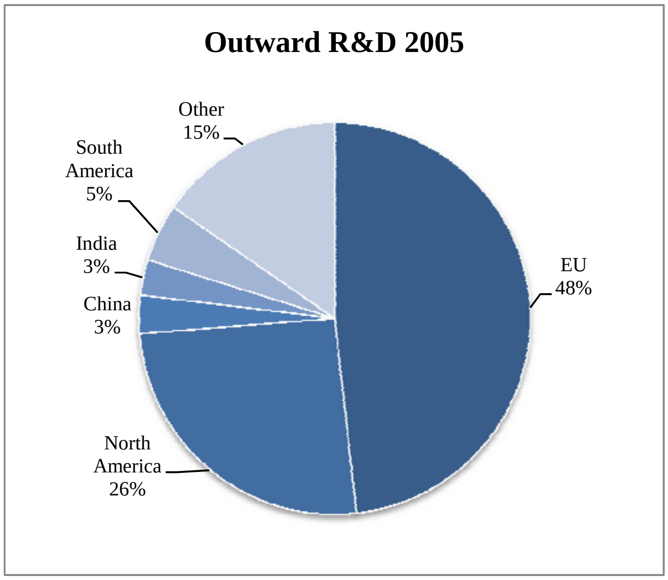


Source: ITPS (2007)

4.3.2. Outward R&D – country of destination

The distribution of outward R&D by country of destination is very similar to inward R&D interms of the predominance of Europe. However, it is important to note that about 3% of the outward R&D is to China and another 3% to India.

Graph 18. – *Outward R&D in Sweden (2005).*



Source: ITPS (2007)

In sum, Sweden has strong international linkages in innovation, particularly with regards to global scientific collaboration and global generation of innovations. However, the geographical spread of these networks is still more regional (confined to Europe and USA) than truly global. With the data available, it is too early to say if this trend will reverse in the near future, although we can see a growing role of China as partner in research and innovation as well as a destination of global R&D which could be interpreted as an increasing globalization (as opposed to regionalization) of Swedish firms.

5. Institutional frameworks and GINs

In Sweden the private sector is the main source of R&D funding. Public funds for R&D are usually directed towards Higher Education Institutions (HEIs) or through research councils, publics foundations or sectoral agencies (Forskning.se, 2009). Public research institute play a minor role except in the area of Defense (Vinnova, 2006).

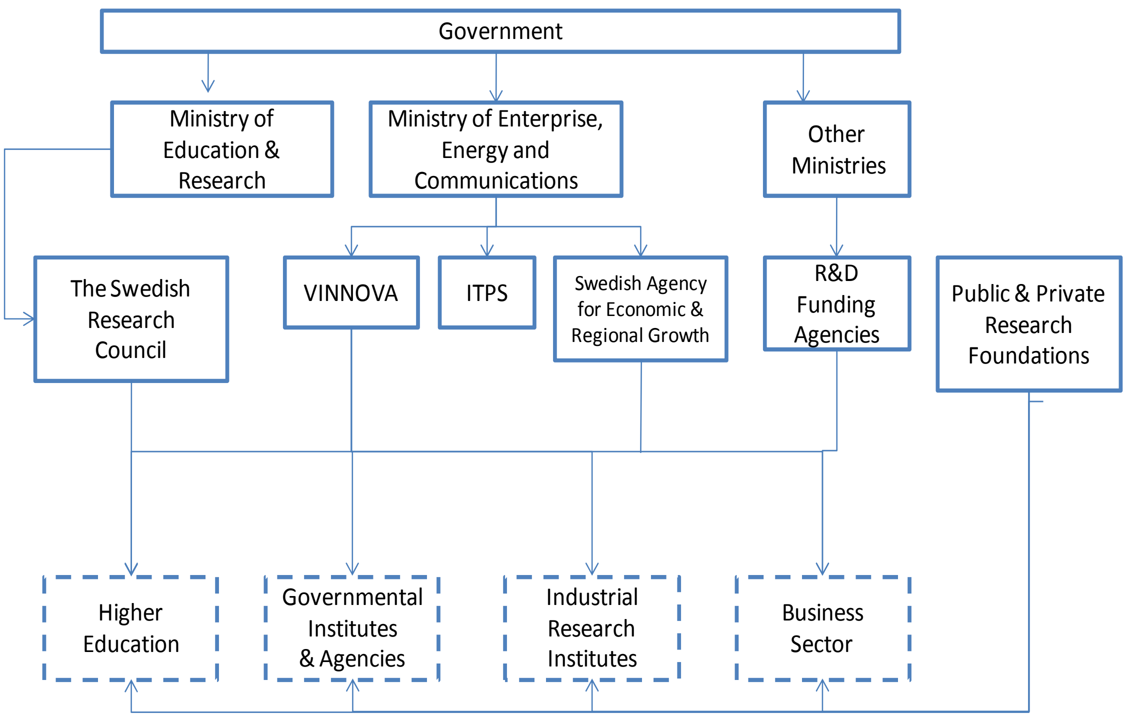
As in many other countries the Ministry of Research and Education and the Ministry of Industry (in Sweden called Ministry of Enterprise, Energy and Communications) are responsible for most of the public agencies and research council that finance research in Sweden. The Swedish innovation policy went through a major reorganization in the year 2000, with the creation of new agencies and the reorganization of some of the sectorial research funding agencies like NUTEK. One of this new agencie was VINNOVA.

VINNOVA's main task is to "promote sustainable growth and development for the business community, society and individuals by developing effective innovation systems …" (VINNOVA, 2001). The general objective is translated into three main functions (Jacobs, 2004): Advising the Government on innovation policy issues; Commissioning and conducting in-house research on innovation related issues; Design and implement (national, regional and sectoral) policy programmes to support and stimulate innovation.

VINNOVA has adopted very specifically the system of innovation approach in policy making. Policy actions deployed by VINNOVA aim at promoting problem solving research and develop *effective* innovation systems. VINNOVA defines *effective innovation systems* "as consisting of actors from science, business and politics, which interact to develop, exchange and apply new technologies and new knowledge in order to promote sustainable growth by means of new products, services and processes" (VINNOVA, 2002:3). VINNOVA aims to promote the effective interaction of these actors to facilitate the transformation of new knowledge into products, services and processes as well as ensuring the effective links with other innovation systems (national, regional and sectoral).

The regional programme VINNVÄXT is the best example of how network problems are being addressed by VINNOVA. All initiatives funded at the regional level have to involve all relevant actors at that level, including policy-makers. To increase the cooperation between the organisations VINNOVA trains "innovation system developers", that is, facilitators that can "mobilise the level of commitment and resources needed to create efficient groups and processes which will produce concrete results" (VINNOVA, 2001:11)

Graph 19. - *Structure of the Swedish research funding system.*



Source: Adapted (and updated) from Roos et al (2005).

The industrial research institutes focus on applied research and are jointly funded by the government and the industry. The institutes were created with the aim of providing some research capabilities to industries that were fundamentally dominated by SMEs (Arnold et al, 2007). The institutes, therefore, in principle tackle two of the problems of the Swedish NIS- the low participation of SMEs in R&D investments and the focus on basic research. However, in contrast to some other countries, the industrial research institutes (often called IRECO institutes) play a minor role in the

Swedish innovation system, with even decreasing budgets over time (Vinnova, 2006). An example of some of the industrial research institutes are the Institute for Electronic, Optics and Communication Technologies (ACREO), the Institute for Manufacturing Technology (SWEREA IVF) or the Swedish Institute for Food and Bio-Technology (SIK).

A very particular feature of the Swedish NIS is that university teachers have the right to own their inventions (the so-called teacher's exemption). Currently a new IPR system is being discussed, which places in the Universities the right to commercialize the patents generated by their researchers. The purpose of this measure is solving what is considered a systemic problem which is the extreme focus of the system in basic research and the low level of commercialization of research results.

Sweden has a series of programs supporting R&D in certain strategic areas that are particularly targeted to foreign actors. For example, in the automotive sector, the Swedish government has the *Strategic Vehicle Research and Innovation Initiative* that supports applied research in energy and the environment, transport efficiency, vehicle and traffic safety, vehicle development and sustainable production (ISA, 2009). Funding is eligible to any foreign company with subsidiary in Sweden and with an established agreement with a Swedish company or to any university or research institute from abroad that have unique competences not available in Sweden.

6. Performance of the system or impact of the NIS on GINs?

This paper has focuses upon the major features of the Swedish National Innovation System and the influence it has had on the emergence of Global Innovation Networks in the country. This last section is intended to provide an overall perspective on these two issues, providing a set of indicators related to the performance of an innovation system on the one hand, and other related to the characteristics of Global Innovation Networks. Regarding the performance, we distinguish between two different types: economic performance and Science, Technology and Innovation (STI) performance (see Table 7).

The main purpose of an innovation system is to pursue innovation processes; to develop and diffuse innovations, which includes introducing and diffusing them not only in the firms but also on the market. During the last years, and as a matter of increasing interests from policy-makers concerning public accountability a long stream of literature has emerged in relation to the measurement, management, or evaluation of innovation systems performance. Several related concepts have popped up regarding the propensity of territories to innovate, such as 'innovative capacity', 'innovation potential', 'innovation capabilities', 'innovation intensity' or 'innovativeness'. Despite all these different notions, all of them are oriented to capture the performance in innovation. According to Spronk and Vermeulen (2003: 482) "performance refers to the result(s) of an activity (or set of activities)", that is to the results achieved once the activity has taken place, which translated to the innovation systems framework, drives us to talk about these two types of performance.

Indeed, it is not possible to say whether certain innovation intensities are high or low in a concrete system if there are no comparisons with those from other systems. This has to do with the fact that we cannot identify optimal or ideal innovation intensities (or optimal innovation systems). Hence, and in order to address the measurement of the performance, it is necessary to make comparisons among systems. Such comparisons can be made between the same systems over time, or between different existing systems. In this case, since the focus of the paper is the Swedish NIS, we have tried to provide both views. On the one hand, we aim at offering a dynamic view of its performance, by analyzing its major trends as illustrated by several indicators, while on the other we also aim to offer a comparative perspective with regard to the other two Scandinavian countries, Denmark and Norway.

First, and regarding the economic performance of the Swedish NIS, we have included three indicators that provide an overall view about this. Concerning the population between 25-64 years with tertiary education (as a percentage of total population) we can observe that the three countries have very similar values. However, despite Sweden is the country with the lowest values during the last 2004-2006 period, it seems that the growth in terms of Swedish tertiary educated people (8,7%) is much higher than those observed in the neighbor countries. Interestingly, when compared to the 2006-1996 period, one can observe that the growth on both Denmark and Norway (29,96 and 14,12% respectively) are much higher than those for Sweden. Accordingly, it is possible to conclude that both Denmark and Norway have had a more sudden growth during the last 10 years than Sweden, who clearly shows a much more stable pattern. As to the employment rates observed, the three countries seem to have very similar and high patterns during the last 10 years considered. Finally, and in relation to the GDP per capital and its relative growth, Sweden is the country with the lowest GDP per capita and the lowest growth rates.

Second, we aim to characterize the STI performance by means of five indicators: R&D expenditure growth, R&D personnel growth, innovation expenditures, patent applications to the EPO (per million inhabitants) and triadic patent families[6]. Concerning the first of these measures, we have calculated the growth of the R&D expenditures executed by the different sectors (business enterprise, government and higher education). From an overall perspective it seems that during the 2004.2006 period, Norway is the country who has in relative terms increased more its R&D expenditures. However, this is probably related to the fact that Norway does not invest as much as Sweden and Denmark on R&D activities. Concerning the Swedish case, interestingly enough, it can be observed a clear differentiation in the pattern of R&D expenses. During the 1996-2006 period, the government sector was the main

[6] The data concerning STI performance need to be complemented with a set of new indicators we are still collecting and processing: publications per million inhabitants, % of turnover due to new to the firm products and % of turnover due to new to the market products.

driver of the growth in R&D activities, in the latter 2004-2006 period, this sector shows decreasing growth rates. However, the business enterprise sector shows a more stable pattern. This outline is followed in parallel by the growth observed in terms of R&D personnel and number of researchers employed in these sectors. Finally and as to the patents are concerned, Sweden shows the highest values both in terms of triadic patent families and EPO patent applications, with a clear relative advantage compared the its neighbor countries.

Finally, our last block of measures is intended to characterize the Global Innovation Networks by means of the following indicators: firms that cooperated in innovation, R&D executed by source of funds and job-to-job mobility of Human Resources in Science and Technology (HRST)[7]. Concerning the cooperation in innovation activities, Swedish firms (both in the manufacturing and services sectors) seem to cooperate much more than those in Denmark and Norway respectively. As to those in the services sector, some mention is needed. Despite during the 1996-2006 period the services sector in Sweden did not cooperate to the extent observed in the neighbor countries, between 2004-2006, the firms in this sector caught up in this sense, not only taking over those values observed in the other countries but also approaching the ones in the Swedish manufacturing sector. When analyzing thee cooperation patterns depending on the geographical level of the cooperation, the three countries show a clear tendency to cooperate with other organizations within their own countries or within the EU, rather than establishing cooperation agreements with organizations in the USA or Japan. However, we also consider that these dynamics will require further investigation, since as its has been illustrated along the paper, the impact of GINs, particularly in Sweden, has changed a lot during the last years. The second of our measures aims to capture the amount of R&D expenditures executed in-house but which are funded by foreign organizations. In this sense, the Swedish NIS seems to be the one that has a clearer tendency towards supporting open innovation activities, not only within the business enterprise sector but also among higher education organizations. Finally, and a propos the job-to-job mobility of HRST, the only data available for Sweden refer to the 1996-2006 period. In this sense, we can observe something already pointed out before. The efforts done within the services sector in order to increase its level of cooperation is also reflected in this particular indicator. Next, and quite logically, firms within the knowledge-intensive sectors are those that higher mobility rates show within the Swedish economy.

In this section we have tried to complement the information and evidence included in the previous sections as to the main characteristics of the Swedish NIS, not only in terms of its performance, but also in terms of the role played by the GINs as one of the main determinants of innovation activities. As it is well known from the literature, the Swedish NIS has traditionally had an structural

[7] The data concerning Global Innovation Networks need to be complemented with a set of new indicators we are still collecting and processing: co-authored patents (% of all patents) and Co-authored publications (% of all publications).

characteristic by which the very high values of input indicators for innovation do not correspond with the low values achieved for output indicators. A feature than has been labeled by several scholars as the "Swedish Paradox" (Edquist and Hommen, 2008; Kander and Ejermo, 2009). In this paper we have not addressed this issue directly. However, we think that the structural change that is being observed in the Swedish economy towards smaller and more service oriented firms, and the relevance that during the last years are taking the GINs may have a direct impact on this paradox. This is a matter of further research. Related to it, the entrepreneurial properties of the new firms should also be considered. In fact, new firms in Sweden tend to be smaller, more diversified, employing a considerable part of the creative workers in the country, and with a clear view of their GINs. We consider that these aspects briefly addressed here should be analysed more in-depth in order to get a more comprehensive understanding about the new dynamics observed within the Swedish NIS.

Table 7. *Main features of the Swedish NIS and its GINs*

	2006-2004			2006-1996		
	Denmark	Norway	Sweden	Denmark	Norway	Sweden
Economic performance						
Population between 25-64 years with tertiary education (% of total population) [in brackets the growth of the population with tertiary ed. in %]	18,9 (4,54)	17,7 (2,16)	16,1 (8,70)	14,5* (29,96)	15,5* (14,12)	14,9* (8,56)
Employment rate [in brackets the growth of the employment rate in %]	77,4 (2,25)	73,1 (0,40)	75,4 (1,39)	73,8 (4,88)	-	70,3 (3,98)
GDP per capita in € [in brackets the growth of GDP pc in %]	40200 (10,14)	57600 (26,87)	35000 (8,02)	27600 (45,65)	28800 (100)	24600 (42,28)
STI performance						
R&D expenditure growth (%)**						
All sectors	3,66	8,55	0,27	32,81	1,23	3,74
Business enterprise sector	5,95	7,32	1,53	50,85	-4,35	2,31
Government sector	-50	4,16	-5,55	-73,33	-7,41	41,66
Higher education sector	13,33	10,64	-2,53	58,14	20,93	2,66
R&D personnel growth (%) [in brackets researchers growth]**						
All sectors	7,33 (7,22)	6,25 (8,79)	-3,63 (-15,38)	31,97 (67,74)	-	7,43 (19,28)
Business enterprise sector	9,18 (8,20)	4,48 (11,11)	-2,52 (-17,95)	50,70 (144,4)	-	17,17 (36,17)
Government sector	-45,45 (-42,86)	4,54 (14,29)	-12,5 (-33,33)	-70 (-69,23)	-	-12,5 (-33,33)
Higher education sector	17,5 (13,79)	12,82 (9,68)	-5,26 (-3,12)	62,07 (50)	-	-12,19 (3,33)
Innovation expenditures (% of GDP)	5,689,209	-	11,970,62	3,044	1,242	12,930
Patent applications to the EPO per million inhabitants [in brackets the growth of patent applications to EPO in %]	210,15 (10,03)	111,3 (30,34)	271,28 (10,48)	118,22 (77,76)	61,83 (80,01)	204,16 (32,88)
Triadic patents families [in brackets the growth of triadic patents]	277,08 (8,15)	131,42 (19,27)	847,15 (13,40)	226,22 (22,48)	75,26 (74,63)	913,93 (-7,31)
Global Innovation Networks						
Firms that have cooperated in innovation *** [in brackets the % of firms that have cooperated in innovation activities as a % of enterprises with innovation activities]	961/790 (37/31)	509/384 (33/26)	1586/1574 (42/35)	1243/963 (57/66)	553/540 (49/61)	1217/878 (59-48)
Cooperation with partner in the same country	757/555	407/279	1494/1400	1036/834	513/503	1115/834
Cooperation with partner in the EU	416/452	216/143	962/-	829/461	294/188	684/262
Cooperation with partner in the US	298/394****	109/134****	441/-****	192/228	111/88	378/78
Cooperation with partner in Japan	-	-	-	76/80	35/20	104/54
Cooperation with partner elsewhere	-	-	-	290/179	47/48	148/59

R&D executed by sources of funds**						
Business enterprise sector (execute) – abroad (funded)	5,26	11,11	16,66	100	42,86	211,11
Government sector (execute) – abroad (funded)	-50	0	-	0	0	-
Higher education sector (execute) – abroad (funded)	0	0	0	300	0	66,66
Job-to-job mobility of HRST, employed, 25-64 years old (% of job-to-job mobile HRST)**						
All sectors	34,29	-	-	60,23	46,57	-
Manufacturing sectors	41,75	-	-	131,75	-	-3,77
Services sectors	34,61	-	-	52,17	-	50,68
Knowledge Intensive sectors	22,86	-	-	35,79	-	48,57

Notes:
* The last available data at Eurostat is 1999.
** The period of reference is 2007 – 2005 and 2007-1997 respectively.
*** The data refer to the manufacturing and services sectors correspondingly.
**** For CIS 2006, the data regarding the cooperation in innovation only considers the cooperation within the same country, within Europe and “within US and other countries”.

7. The Swedish NIS and GINs – final reflections

The Swedish innovation system is highly internationalized in terms of global research collaboration, global generation of innovation and global sourcing. Firms as well as universities are very active internationally in terms of their research and innovation activities. However, the geographical analysis of the flows of knowledge shows a high preponderance of USA and Europe as the origin and destination of those knowledge flows. That is, the innovation networks in which Swedish firms and universities are engaged are, as of today, more regional than global.

However, this is gradually changing. The percentage of students from BICSs countries in Swedish Universities has increased dramatically over the last decade. The same can be said for innovation collaboration and for offshoring of R&D activities by Swedish multinational. In that respect, one could argue that the Swedish Innovation System is gradually engaging in innovation activities and networks with BICSs countries, more specifically, China and India. This is true for the large enterprises (that dominate the Swedish Innovation System) as well as for SMEs: about 20% of Swedish SMEs have engaged in some form of collaboration in innovation with partners of China and India.

The data presented in this report also points out to some challenges for the future. If GINs are attracted by the accumulation of competences in certain regions and countries worldwide, Sweden may be in danger of losing its attractiveness, as the amount of students in tertiary education decreases over time. This could partly explain the gradual decrease in inward R&D in Sweden. As other regions in the world rapidly accumulate research and innovation capabilities while maintaining relatively lower costs, they become more attractive for the location of R&D activities which may move from Sweden to other parts of the world. The challenge for the Swedish Innovation System and GINs is to continue investing in world-class research and innovation capabilities beyond large multinational companies (i.e. supporting SMEs), to continue the support of certain industries which attract a large proportion of knowledge intensive activities into the country (for example, the industries/clusters in which Sweden is specialized) and to facilitate the mobility of highly qualified workers into Sweden.

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ADDITIONAL TABLES

Turnover by Industry (2002/2004)

	National Turnover by Industry			Turnover by Industry Foreign			As a % of national total		
	2002	2003	2004	2002	2003	2004	2002	2003	2004
01/05 Agriculture, hunting, forestry, fishing	99693	100000	106708	8773	8900	9497	8,8	8,9	8,9
15/37 Total manufacturing	1402717	1475706	1558266	549865	612418	621748	39,2	41,5	39,9
45 Construction industry	269173	270734	284871	27994	25449	28772	10,4	9,4	10,1
50/93 TOTAL SERVICES	2843170	2941671	3092535	736381	850143	884465	25,9	28,9	28,6
50/52 Wholesale and retail trade, repair	1566883	1596621	1686803	510804	555624	565079	32,6	34,8	33,5
50 Sales and repair establishments for motor vehicles and motorcycles; petrol stations	276254	290000	302596	79285	87580	104093	28,7	30,2	34,4
51 Wholesale trade and commission trade	782489	877470	937124	348990	390474	377661	44,6	44,5	40,3
52 Retail trade, repair shops for personal and household good	426872	428564	443218	46529	77570	83325	10,9	18,1	18,8
55 Hotels and restaurants	67777	69360	70959	11861	13664	13837	17,5	19,7	19,5
60/64 Transport and communications	416316	454207	471234	93671	144892	171058	22,5	31,9	36,3
60/63 Transport and storage	305260	339242	357049	78757	126198	129966	25,8	37,2	36,4
60 Land transport companies	41673	54568	58232	11210	15279	15082	26,9	28,0	25,9
70/74 Real estate, renting & business act	611073	613426	640530	108160	115324	118498	17,7	18,8	18,5
70 Real estate companies	186661	197625	209552	11013	15810	18231	5,9	8,0	8,7
72 Data consultancy and data service companies	117173	123964	135846	36675	44379	38852	31,3	35,8	28,6
74 Other business services companies	180917	178671	183971	39440	39665	43785	21,8	22,2	23,8
80/93 Community, social & personal serv	182846	198281	203155	11885	12690	14424	6,5	6,4	7,1
92 Recreational, cultural and sporting establishments	72451	76708	79807	6593	5523	7023	9,1	7,2	8,8
01/93 GRAND TOTAL	**4810181**	**4999114**	**5266668**	**1380522**	**1584719**	**1632667**	**28,7**	**31,7**	**31,0**

Source: Authors based on OECD (2008)

R&D expenditure and R&D person-years in foreign, international Swedish and domestic enterprises in Sweden by business sector (2005-2007)- SEK million.

Business sector	Enterprise category	R&D espeditur, SEK million		R&D person-years	
		2007	2005	2007	2005
Knowledge intensive					
Manufacturing industry	Foreign controlled enterpreises	21819	20377	13503	15346
	Swedish controlled international enterprises	30196	24577	20112	18952
	Doestic enterprises	1140	912	942	872
	Total	53156	45866	34557	35171
Services	Foreign controlled enterpreises	3950	4720	3504	4266
	Swedish controlled international enterprises	11466	7668	6910	5616
	Doestic enterprises	3665	3508	3285	3203
	Total	19081	15896	13699	13084
Capital Intensive					
Manufacturing industry	Foreign controlled enterpreises	2206	2304	1777	1720
	Swedish controlled international enterprises	2043	1930	1724	1518
	Doestic enterprises	124	94	170	108
	Total	4374	4328	3672	3345
Services	Foreign controlled enterpreises	121	161	77	40
	Swedish controlled international enterprises	546	209	554	177
	Doestic enterprises	42	103	45	78
	Total	709	473	676	295
Labour Intensive					
Manufacturing industry	Foreign controlled enterpreises	486	596	378	544
	Swedish controlled international enterprises	752	713	705	718
	Doestic enterprises	231	167	215	233
	Total	1468	1476	1298	1495
Services	Foreign controlled enterpreises	1233	1694	839	1277
	Swedish controlled international enterprises	106	1392	849	948
	Doestic enterprises	170	248	160	213
	Total	2463	3334	1849	2438
Other activities					
	Foreign controlled enterpreises	35	36	33	34
	Swedish controlled international enterprises	93	215	91	186
	Doestic enterprises	68	78	65	57
	Total	195	329	189	278
Business sector					
	Foreign controlled enterpreises	29850	29888	20111	23227
	Swedish controlled international enterprises	46156	36704	30945	28115
	Doestic enterprises	5440	5109	4883	4763
	Total	81445	71701	55940	56106

Source: ITPS (2007)

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