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CENTROPE Regional Development Report

Focus Report on Technology Policy, Research, Development and Innovation in CENTROPE

Zoltan Csismadia (WHRI),
Philipp Hergovich, Peter Huber (WIFO)

January 2012

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Abstract

This report analyses the innovation systems in CENTROPE. It finds a large heterogeneity both in terms of institutions and technological capacities among the regions of CENTROPE. Also co-operation in patenting seems to be limited to co-operation among the EU 10-regions in this region. The nuclei for the development of a cross-border innovation system may be the large number of universities in the region, the many regional clusters existing in CENTROPE or initiatives directed at increasing cross-border patenting co-operation.

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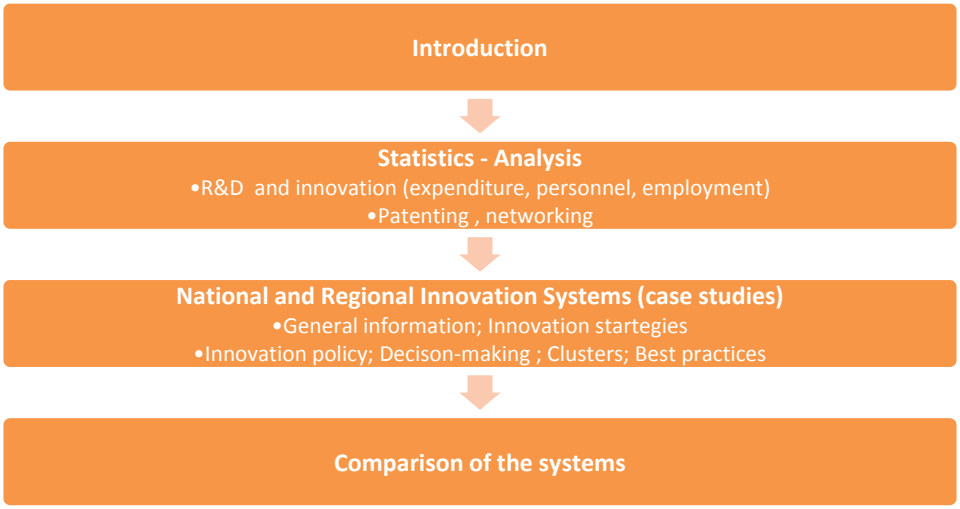
1. Introduction

Regional competitiveness increasingly depends on the efficiency of businesses of a region and the regional milieu determined by local externalities. While efficiency often has a strong connection to the innovativeness of enterprises and their research and development activities, the innovative milieu is shaped by policy interventions at local and regional level, which target science and technological background, clusterisation processes and networks and other areas of knowledge transfer (although it is of course also affected by national policy).

The thematic focus report on technology policy, R&D and innovation of the CENTROPE Regional Development Report project monitors, takes stock of and analyses the current R&D efforts and linkages (clusters/networks) within CENTROPE, since these are indicative of the competitive position of the CENTROPE partner regions in the EU. At the same time, a comparison with other EU regions serves as a tool to identify both comparative advantages and weaknesses in CENTROPE.

Figure 1.1: The structure of the thematic focus report

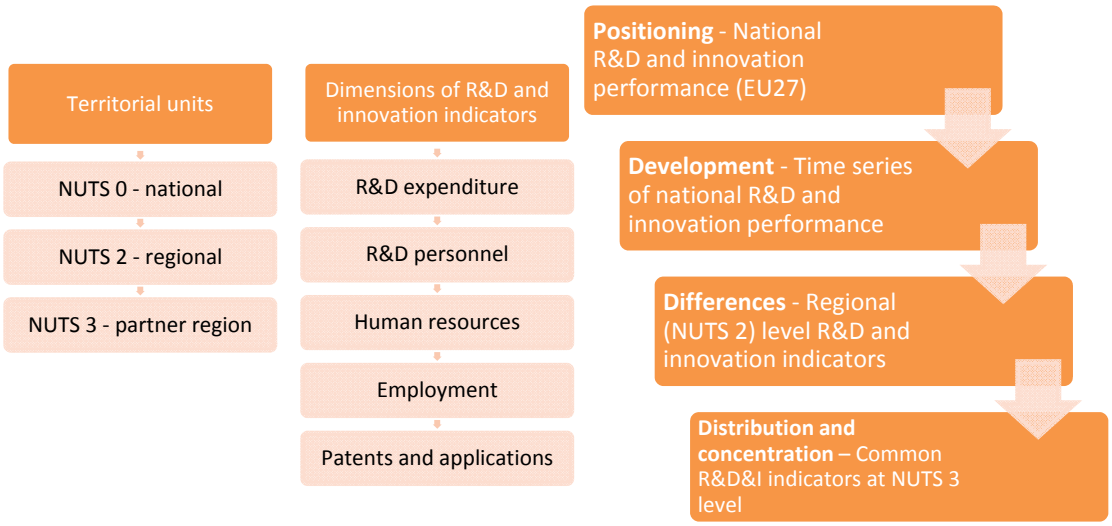


The elaboration of the thematic focus report on technology policy, R&D and innovation therefore is based on primary and secondary inputs (i.e. available statistics). Primary inputs are those regarding the soft factors and processes of innovation, R&D and policy interventions, which are not in traditional statistics and come from project partners. Each partner contributed to the report with a case study, in which they shortly summarize the

regional innovation system of the covered regions. The results of these case studies were collected in a separate stock taking report on technology policy, research, development and innovation in CENTROPE, which is published together with this report. They contain the institutional background of the regional innovation system, the most important strategic priorities and measures, the cluster and network policies, the results of former interventions and the role of international cooperation, especially cross-border cooperation within CENTROPE.

This report compares the R&D expenditures and personnel, human resources in the S&T field, employment in high technology sectors, and European patent applications, according to the available regional science and innovation statistics. This allows for a comparison of the R&D and innovation performance of CENTROPE regions to each other and the whole CENTROPE to the EU 27 average or other macro regions by using statistical data from Eurostat (from regional science and technology statistics). It also allows for an analysis of the processes over a longer time period (i.e. from 2000 to 2008). However the availability of statistical data presents a challenge both in terms of recency and territorial coverage.

Figure 1.2: Units, dimension and the main topics of the statistical analysis



In particular, in a number of cases also data is not very recent. In many instances this difficult data situation is due to very understandable reasons, such as for instance that processing budgetary and financial data on a regional level takes time and that therefore official budgetary data on regional general expenditure on research and development (GERD) is only available with a 5 year lag and that registering patents at the European Patent Office

(EPO) is a time consuming and complicated juridical process, so that patent statistics are currently available only up to the year 2007 and many other data are also not very recent. For researchers interested in recent data and policy makers interested in observing recent trends, this is, however, a major problem.

This is further complicated by the fact that most of the European comparative data are available only on a NUTS 2-level, while most CENTROPE member regions (in Hungary, Slovakia and the Czech Republic) are defined at NUTS 3-level. While again the reasons for this lack of data are well understood: EU regional policy is focused on the NUTS 2-level and many European surveys (such as for instance the European Labour Force survey) are representative only at the NUTS 2-level, for policy makers this lack of data implies that he (or she) is left with very little empirical guidance when it comes to formulating more local innovation policies.

Our approach therefore was to first of all analyse the rather limited number of comparable indicators available on a NUTS 3-level (which are mainly based on R&D personnel) and to augment this information with NUTS 2-level and national information wherever NUTS 3-level data was lacking. This implies that most of our analysis covers a territory slightly larger than CENTROPE. Finally, with respect to patenting data we collected some original data. Thus we were able to obtain individual level data on a NUTS 3 regional break down up to the year 2008 (while official statistics are still from the year 2007 for NUTS 2), so that – while still operating with rather old data – we can improve on official data by having slightly more recent data on the correct regional disaggregation level, which in contrast to official statistics also provides a possibility to analyse cross-border patenting networks in CENTROPE. This topic, to the best of our knowledge, has never been analysed previously.

In this way we are therefore able to augment the few previous studies that have analysed various other aspects of the emerging cross-border research and innovation system in CENTROPE. In this literature a recent study by ÖAR and CONVELOP (2010) analyzes the co-operation and participation of CENTROPE actors in the 7th Framework Program of the European Union. This study – which, however, in contrast to the current one, delimits the CENTROPE region by the CENTROPE countries, – finds that the research institutions of the CENTROPE countries are well integrated into European research networks with every 3rd project of the 7th framework “co-operation” program involving at least one institution from the CENTROPE countries. Furthermore, the study also finds that the institutions of the CENTROPE countries often co-operate with each other although some of the central actors

(such as the Czech Academy of Sciences and the Hungarian academy of sciences as well as the Budapest University of Technology and Economics) are often located outside the actual CENTROPE region, as it is defined in this project. Given these findings, however, this study also finds that the bulk of CENTROPE co-operations are oriented towards Western European countries and the network charts presented in this study also suggest that co-operation in CENTROPE is often focused on co-operation within countries (in particular among Austrian institutions) while cross-border co-operation in the region mostly focuses on the axis Vienna – Bratislava or on the co-operation of institutions located in the capital cities of the CENTROPE countries, that are not part of the actual CENTROPE region (i.e. Budapest and Prague). In addition this study also identifies different well developed thematic networks in the CENTROPE countries, in which these countries strong connectivity (these include the ICT, environment and security networks), fields of relative specialisation of CENTROPE countries (which include environment, transport and social sciences and humanities) and notes the often isolated role of private enterprises in co-operation in the CENTROPE region.

Another study (Rechnitzer and Smaho, 2007) by contrast focuses on the co-operation activities of universities in Eastern Austria and Western Transdanubia. Although this study only focuses on a part of the CENTROPE region, its results reflect many of the results of the ÖAR and CONVELOP (2010) study. Once more it finds a relatively strong integration of the universities of the region into international and in particular European research networks, but a much weaker intra-regional co-operation. The case studies, however, suggest that aside from the usual language problems and problems of identifying partners, that hamper cross-border co-operation in almost all areas, one additional problem that hampers the co-operation of universities in CENTROPE, is that the universities of the region often consider partners from other parts of the CENTROPE to have a lower academic reputation. This gives rise to a situation, where CENTROPE universities have a strong preference for partners from other countries (such as the Anglo-Saxon countries or Germany) over partners from other CENTROPE countries.

Given this scant knowledge-base on the development of the cross-border innovation system in CENTROPE, which in addition often only focuses on parts of the CENTROPE territory or the CENTROPE countries, this report adds to existing knowledge by first of all, in the next chapter, exploring the strengths and weaknesses of the national innovation systems – into which the individual CENTROPE regions are embedded – as well as describing the available

regional data on R&D and innovation in the CENTROPE region. Although this description is clearly hampered by problems with data availability both in terms of regional disaggregation and recency, we think that such an analysis is important because, first of all any attempt at increasing co-operation in the field of technology policy as well R&D and innovation policy in CENTROPE must start from existing conditions and available resources and because second of all, such co-operation is by definition also embedded in national innovation systems, so that taking stock of the current situation will allow policy makers a realistic appraisal of the strengths and weaknesses of the innovation systems in the region and of the goals that can be achieved in the region.

In the third chapter, by contrast, we add to the above literature by analyzing cross-border patenting networks in CENTROPE. In contrast to previous studies, which mainly focus on the university system and/or participation in publically funded programs explicitly directed at increasing cross-border co-operation, we therefore focus on an aspect of cross-border co-operation that is more akin to the private enterprise sector and the development of new marketable products. We would argue that this extension is of some importance, because first of all focusing exclusively on primarily publically funded actors or programs may provide a quite different picture than when focusing on the behaviour of private actors, and because the more apllied research conducted for patent applications is likely to also be more important than basic research activities for the future development of the less strongly urbanized regions among the CENTROPE regions (such as for instance Lower Austria, Burgenland, Trnava and the Hungarian part of CENTROPE), which account for the larger part of the territory but also population of CENTROPE. In chapter 4 finally we present conclusions and discuss some of the policy implications that can be drawn from our analysis.

2. Statistical analysis of R&D and innovation capacity of CENTROPE partner regions

Authors: Zoltán CSIZMADIA

2.1. Introduction

The goal of this chapter is to summarize and compare the R&D and innovation capacity of CENTROPE partner regions and the whole area using secondary data sources (like EUROSTAT) and reports (like Innovation Scoreboard). The questions which will guide this analysis are the following: How competitive is CENTROPE relative to the EU level in terms of science and innovation systems? How can we describe the long term development of these performance indicators? Is there a structural differentiation, regional concentration and imbalance among the partner regions? What are the most significant strengths and weaknesses of the whole region and its territorial components in the field of R&D, science and innovation? What are the special R&D and innovation characteristics of the partner regions?

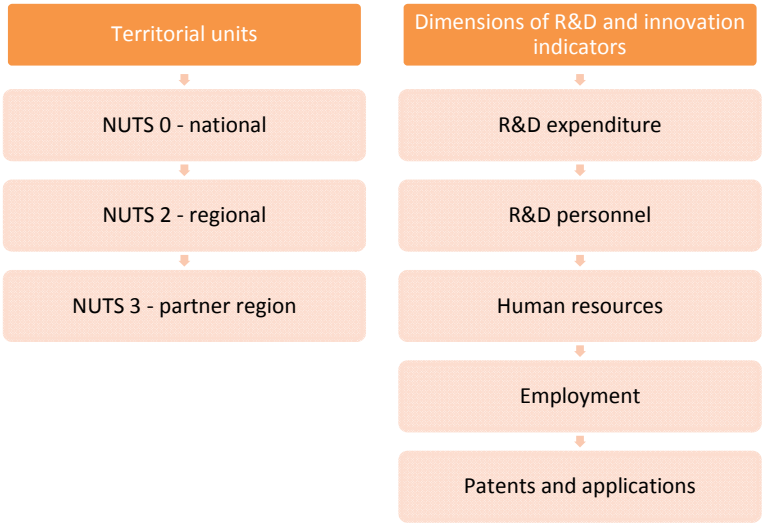
The main organizing principle in this chapter is the availability and territorial level of measurement of science and innovation statistics. Three territorial levels and four content related dimensions can be separated from each other.

First, the analysis starts with the 'big picture', which is the overall R&D and innovation performance of the four CENTROPE countries (positioning and comparison on national level). The reference points here are the EU 27 average and the performance of the other EU member states. The second analytical layer is the long-term development of the national technological and innovation system of the four CENTROPE countries which undoubtedly co-determines the regional R&D and innovation system. Finally, we use NUTS 2 and NUTS 3-level regional statistics in order to identify and measure the differences and special characteristics of the partner regions of CENTROPE. The problem with this territorial focus is the increasing limitation on the number of available and comparable indicators on the deeper levels of the spatial hierarchy, which is also the main reason for the combined usage of the three territorial levels.

According to the currently available regional (NUTS 2 and NUTS 3) science and innovation statistics in this report the following dimensions of R&D and innovation statistics will be analyzed in more detail:

- R&D expenditures and personnel,
- Human resources in the field of science and technology,
- Employment in high technology and knowledge-intensive sectors,
- European patent applications (see chapter 3).

Figure 2.1: Territorial and topical elements of the statistical analysis



The **sources** of the statistical analysis are the Innovation Union Scoreboard 2010 – The Innovation Union's performance scoreboard for research and innovation, 1 February 2011,[1] EUROSTAT's regional science and technology statistics (reg_sct)[2], the statistical yearbook of the Jihomoravský (Southmoravian) region 2010[3], and the yearbook of science and

[1] http://www.proinno-europe.eu/metrics

[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database

[3] http://www.czso.cz/csu/2010edicniplan.nsf/engp/641011-10

technology in the Slovak Republic 2010[4] and the publication Research and development 2009 – Hungary provided by the Hungarian Central Statistical Office[5].

2.2. Positioning – National R&D and innovation performance of the four CENTROPE countries

The most comprehensive comparative assessment with 25 indicators of the innovation performance and relative strength and weaknesses of the research and innovation systems of the EU 27 Member States is the Innovation Union Scoreboard (IUS). It is a very useful tool to position and rank the four CENTROPE countries (Austria, Czech Republic, Slovakia and Hungary) in the framework of the EU 27 innovation system. The reason is the strong impact of the level of development of the national innovation system on the regional system of innovation and technology. The IUS report groups the countries according to their performance, analysing the growth of performance – in different dimensions of R&D and innovation – as well as the country specific profile of innovation systems. We can compare the indicators of the four countries with each other and the EU average. Another interesting feature of the scoreboard is the separation of innovation performance and the country profiles based on different dimensions of the innovation and technology system of the CENTROPE countries.

The first and most important feature of the innovation performance of the four CENTROPE countries is the significant difference in the overall performance between Austria and the other three states. Austria is part of the so called 'innovation followers' and its position in the hierarchy is seventh, while the Czech Republic (17th), Hungary (21th) and Slovakia (23th) are only members of the group of so called 'moderate innovators' with a lower position in the ranking.[6]

Over a five-year period all countries (except Lithuania) show an absolute improvement in

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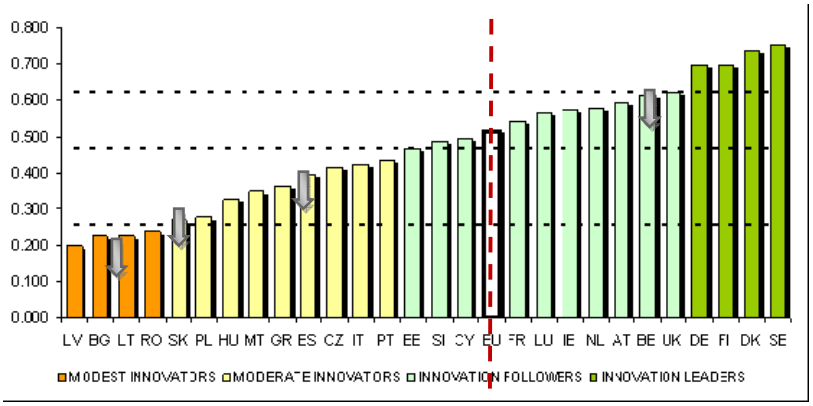
[4] http://portal.statistics.sk/showdoc.do?docid=29419

[5] http://portal.ksh.hu/pls/ksh/docs/eng/xstadat/xstadat_annual/i_ohk007a.html

[6] The performance of innovation leaders is 20% or more above that of the EU 27; for innovation followers it is less than 20% above but more than 10% below the EU 27 average; for moderate innovators it is less than 10% below but more than 50% below the EU 27 average; and for the modest innovators it is below 50% of the EU 27. (Innovation Union Scoreboard 2010).

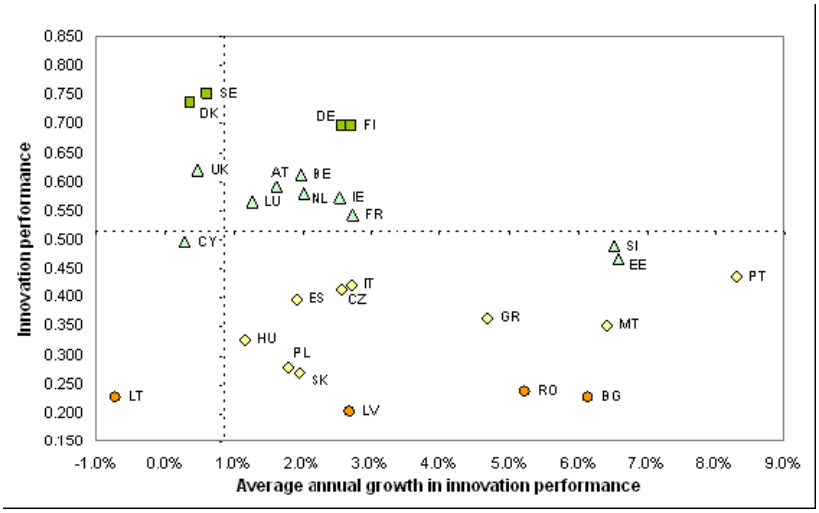
innovation performance, but the speed of average annual growth is very different. The annual growth of CENTROPE countries is between 1.2% (Hungary) and 2.8% (Czech Republic). In the last five years the growth rate of Hungary and Slovakia was very slow in the group of moderate innovators.

Figure 2.2: EU member states' innovation performance, 2010 – Summary innovation index



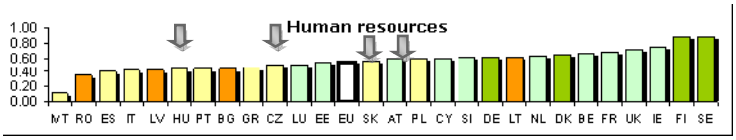
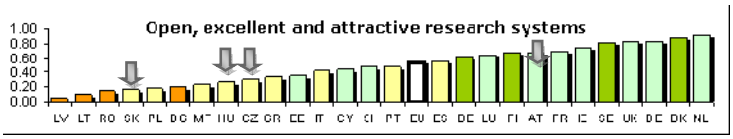
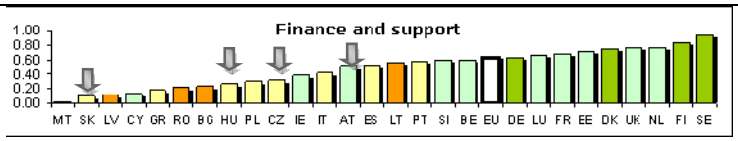
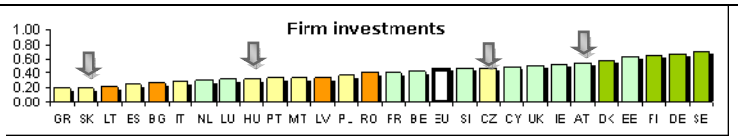
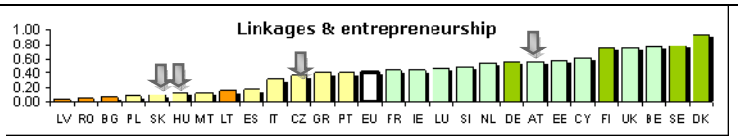
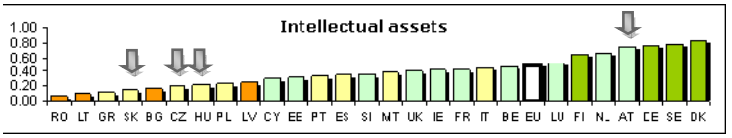
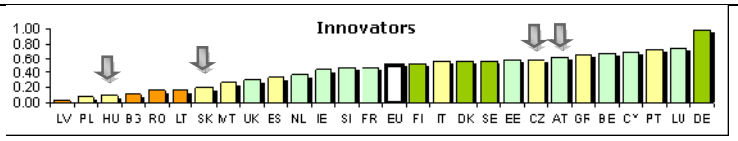
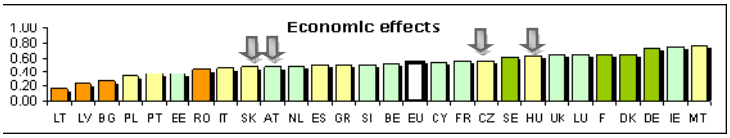
Source: Innovation Union Scoreboard 2010. – *Note*: Average performance is measured using a composite indicator building on data for 24 indicators going from the lowest possible performance of 0 to the maximum possible performance of 1. Average performance in 2010 reflects performance in 2008/2009 due to a lag in data availability.

Figure 2.3: Innovation performance growth, 2005-2010



Source: Innovation Union Scoreboard 2010. – *Note:* ■=innovation leaders▲= innovation followers, ◊= moderate inventors ●= modest inventors. Average annual growth rates as calculated over a five-year period. The dotted lines show EU 27 performance and growth.

Figure 2.4: Dimensions of innovation performance, 2010

	1.1.1 New doctorate graduates (ISCED 6) per 1000 population aged 25-34 1.1.2 Percentage population aged 30-34 having completed tertiary education 1.1.3 Percentage youth aged 20-24 having attained at least upper secondary level education
	1.2.1 International scientific co-publications per million population 1.2.2 Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country 1.2.3 Non-EU doctorate students as a % of all doctorate students
	1.3.1 Public R&D expenditures as % of GDP 1.3.2 Venture capital (early stage, expansion and replacement) as % of GDP
	2.1.1 Business R&D expenditures as % of GDP 2.1.2 Non-R&D innovation expenditures as % of turnover
	2.2.1 SMEs innovating in-house as % of SMEs 2.2.2 Innovative SMEs collaborating with others as % of SMEs 2.2.3 Public-private co-publications per million population
	2.3.1 PCT patents applications per billion GDP (in PPS€) 2.3.2 PCT patent applications in societal challenges per billion GDP (in PPS€) (climate change mitigation; health) 2.3.3 Community trademarks per billion GDP (in PPS€) 2.3.4 Community designs per billion GDP (in PPS€)
	3.1.1 SMEs introducing product or process innovations as % of SMEs 3.1.2 SMEs introducing marketing or organisational innovations as % of SMEs 3.1.3 High-growth innovative firms
	3.2.1 Employment in knowledge-intensive activities (manufacturing and services) as % of total employment 3.2.2 Medium and high-tech product exports as % total product exports 3.2.3 Knowledge-intensive services exports as % total service exports 3.2.4 Sales of new to market and new to firm innovations as % of turnover 3.2.5 License and patent revenues from abroad as % of GDP

Source: Innovation Union Scoreboard 2010.

Furthermore, if we differentiate the eight dimensions of innovation performance provided by IUS (Figure 2.4) a more detailed picture develops. In particular this figure indicates the differences in term of performance between the four countries: Performance is lowest in the dimension of human resources (education) and finance and support (R&D expenditure, venture capital). With respect to these indicators all CENTROPE countries, including Austria range in the lower half among the EU 27 countries. The reasons for this are on the one hand a low share of population with tertiary education – which is related to the high share of persons with vocational education in the regions already discussed in the CENTROPE Regional Development Report 2010 (see Rozmahel et al., 2010). On the other hand, very low provisions of venture capital (in % of GDP) lead to the rather unfavourable aggregate situation of CENTROPE. This suggests that financing R&D and development of human resources are shared problems in the national R&D systems of the CENTROPE countries.

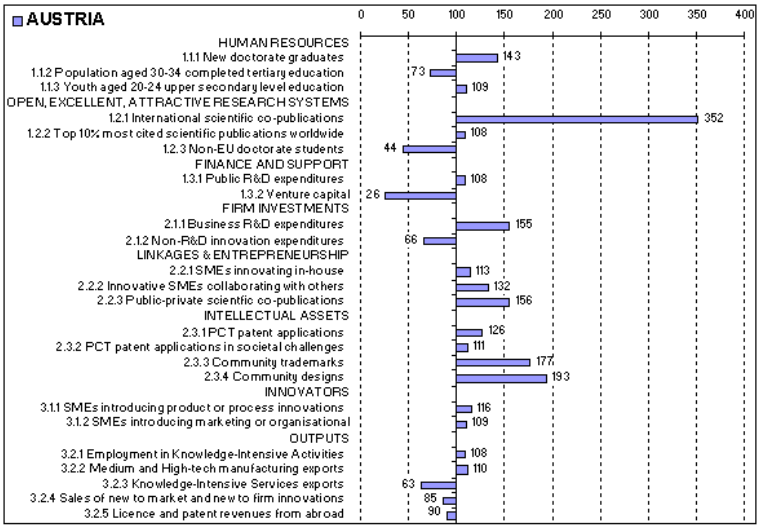
Unfortunately in the other six dimensions the gap between Austria and the other three, or Austria and the Czech Republic and the other two countries (Hungary and Slovakia) is rather wide. This indicates substantial differences in the efficiency of the innovation systems performance among the CENTROPE countries. In particular here there are three indicators where the lead of Austria over all other three CENTROPE countries is very large. These are the dimension of the research system (publications, doctorates), intellectual assets (patent applications, trademarks and designs) and linkages and entrepreneurship (innovative SME's collaborating with others, public private co-operations). These are therefore also the dimensions of the innovation system where differences between individual CENTROPE countries are largest.

With respect to the dimensions of firm investments (Business R&D, expenditures, non-R&D expenditures of businesses) and innovators (process or product innovation of SME's, organisational and marketing innovation of SME's), the Czech Republic is somewhat closer to Austria, so that these dimensions can be considered a source of relative strength for the Czech innovation system.

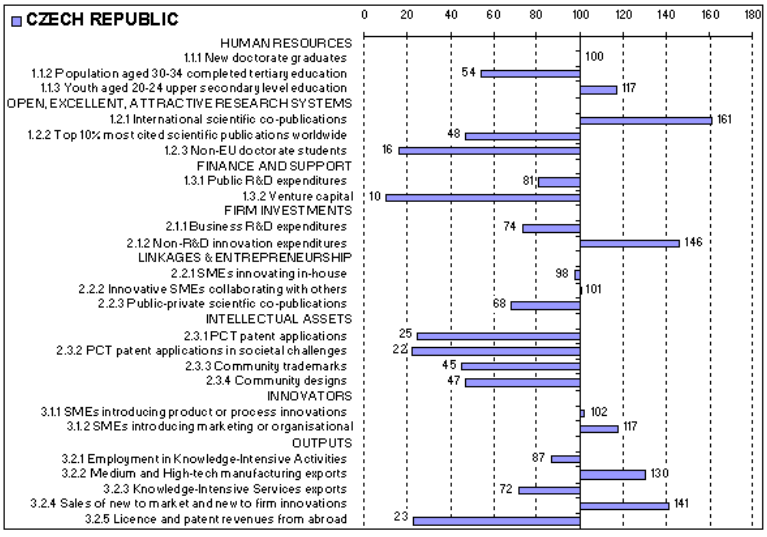
The only indicator where the ranking of CENTROPE countries differs relative to the other dimensions is that of economic effects (knowledge-intensive employment, medium and high tech product exports, knowledge intensive service exports, sales of innovations, license and patent revues from abroad). In this dimension Hungary and the Czech Republic outperform Austria and Slovakia substantially. Therefore the problems which lead to the worse position of Hungary and Slovakia in the overall ranking are the weak innovation performance and the

rather poor performance of these two countries in the dimensions of linkages and entrepreneurship.

Figure 2.5: Innovation performance - Country profiles, 2010



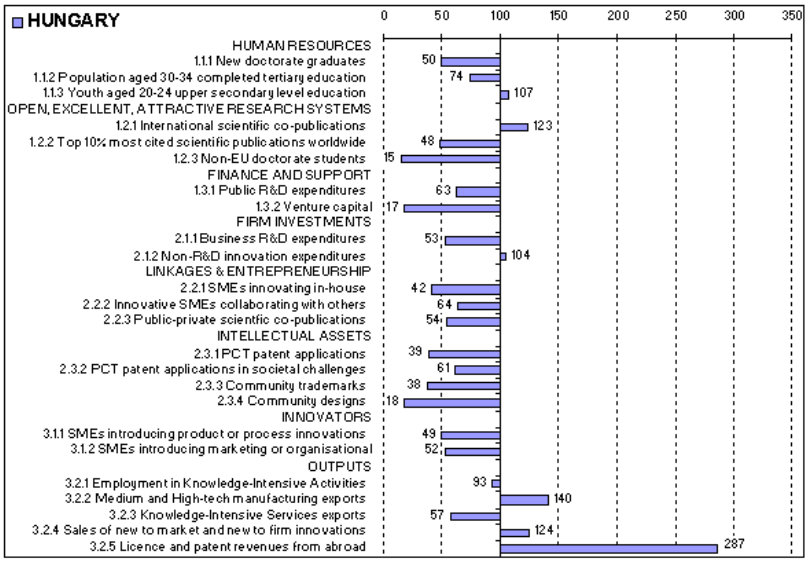
'Austria is one of the innovation followers with an above average performance. Relative **strengths** are in open, excellent and attractive research systems, linkages & entrepreneurship and Intellectual assets. Relative **weaknesses** are in outputs. high growth is observed for community trademarks and License and patent revenues from abroad. A strong **decline** is observed for venture capital. **Growth performance** in open, excellent and attractive research systems, intellectual assets and outputs are above average. In the other dimensions it is below average.'



'Czech Republic is one of the moderate innovators with a below average performance. Relative **strengths** are in human resources, firm investments, innovators and outputs. Relative **weaknesses** are in open, excellent and attractive research systems, finance and support and Intellectual assets. High **growth** is observed for community trademarks and public-private co-publications. A strong **decline** is observed for Non-EU doctorate students. **Growth performance** in human resources and intellectual assets is above average. In the other dimensions it is below average.'

Source: Innovation Union Scoreboard 2010. – Notes: Indicator values relative to the EU 27 (EU 27=100).

Figure 2.6 cont'd: Innovation performance - Country profiles, 2010



'Hungary is one of the moderate innovators with a below average performance. Relative **strengths** are in outputs. Relative **weaknesses** are open, excellent and attractive research systems, finance and support, firm investments, linkages & entrepreneurship, intellectual assets and innovators. High **growth** is observed for community trademarks and sales of new products. A strong **decline** is observed for venture capital and community designs. **Growth performance** in intellectual assets and outputs is above average. In the other dimensions it is below average.'

'Slovakia is one of the moderate innovators with a **below average performance**. Relative **strengths** are in human resources and outputs. Relative **weaknesses** are in open, excellent and attractive research systems, finance and support, firm investments, linkages & entrepreneurship, intellectual assets and innovators. High **growth** is observed for public-private co-publications, community trademarks and community designs. A strong **decline** is observed for Non-EU doctorate students and Non-R&D innovation expenditure. **Growth performance** in human resources, linkages & entrepreneurship and intellectual assets is above average. In the other dimensions it is below average.'

Source: Innovation Union Scoreboard 2010. – Notes: Indicator values relative to the EU 27 (EU 27=100).

Finally, the country profiles of innovation performance could (Figure 2.6.) provide further information on the internal structural development of the national innovation system. These profiles based on 25 indicators are presented in Figure 2.6 and once more highlight each country's relative strengths and weaknesses and the main drivers of innovation growth.

In total, therefore, the position of the four CENTROPE countries on an international (EU) level highlights the significant differences and the individual characteristics of the individual countries. According to the results the CENTROPE countries are a mixture and intersection of national and regional innovation systems at different stages of development (one innovation follower with an above average and three moderate innovators with a below average innovation performance) with very different relative strength and weaknesses and growth and decline potential. This fact is also corroborated by the case studies of the regional R&D and innovation systems collected in the stock taking report on technology policy, research, development and innovation in CENTROPE. On the other hand, however, aside from the substantial national differences also some common weaknesses emerge. These apply in particular to the dimension of human resources and finance and support in which all CENTROPE countries, including Austria range in the lower half among the EU 27 countries. The reasons for this are the low share of population with tertiary education and the very low provisions of venture capital. This suggests that financing R&D and development of human resources are shared problems in the national R&D systems of the CENTROPE countries and could be a starting point for cross-border policies.

The striking national differences but also the common weaknesses in the innovation performance among CENTROPE countries should, however, also be analyzed on a regional level, because in particular the Czech, Hungarian and Slovak regions of CENTROPE are also among the most developed territories of these countries, so that relative country rankings could differ from regional ones.

2.3. Development – Time series of national R&D and innovation performance of CENTROPE countries

Before discussing regional aspects, however, we would like to also discuss the relative growth performance of the CENTROPE countries, because given the large regional disparities in innovative performance also the question of convergence and divergence is of central importance for gauging the development perspectives of CENTROPE's innovation system and because the relative growth of innovation performance in the four countries was slow according to the overall index of the Innovation Union Scoreboard in the last five years. In this national level comparison we use the average of the EU 27 countries and the longest available time series of Eurostat's science, development and innovation database as a reference line. The main goal is to compare the most important longitudinal R&D indicators of

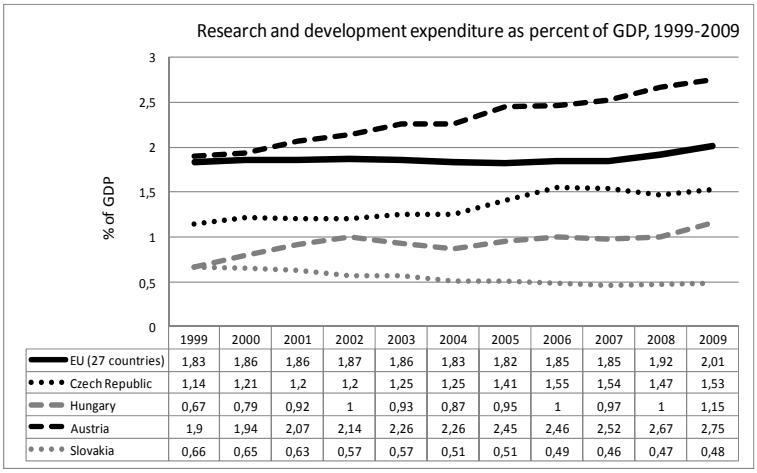
CENTROPE countries. What are the direction and the scale of performance growth? The available basic indicators for this comparison are: R&D expenditures (% of GDP), R&D personnel (% of labour force), Human resource in science and technology (% of labour force) and employment in knowledge-intensive sectors (% of total employment) as well as high-tech exports (% of total export).

The most important message of the following figures (Figure 2.7 to 2.12) is that the input indicators of R&D and innovation (expenditure, personnel and human resources) have usually increased in all CENTROPE countries in the last 10 or 15 years but that this has not been the case everywhere and that sometimes increases have been rather small. The patterns of relative changes over time compared to the EU 27 average indicate on the one hand a slow catching-up process (like R&D expenditures and personnel), or on the other hand a consistent following-the-global-international-trends like process (employment and HR in knowledge intensive science and technology sectors), where the initial internal differences and the lag of the CENTROPE states have remained. And finally the third pattern is a mixture of increasing or decreasing performance indicators where the emphasis is on structural changes (like high-tech export) or on the increasing weaknesses (like the share of business enterprise sector R&D expenditure in the total amount of R&D expenditures).

1. Patterns of a slow catching-up process as an improvement of R&D and innovation performance – Among the indicators showing a catching-up process the input indicators of R&D expenditure and R&D personnel (see Figure 2.7 and 2.8) indicate that in particular Hungary and the Czech Republic have shown substantial tendencies of converging to EU levels in the last years. This was, however, slightly more pronounced with respect to R&D expenditure, at least in Hungary. Austria by contrast has increased its advantage over the EU 27 average somewhat. The only country where no such clear convergence tendencies can be found is Slovakia.
2. Patterns of consistent following-the-global-international-trend like process and an improvement of the R&D and innovation performance parallel to the EU average – this is typical for the indicators of human resources in science and technology (HRST) and employment in knowledge intensive service sectors (see Figure 2.9 and 2.10). With respect to these indicators all of the CENTROPE countries continually perform below the EU average (except for Austria in one year with respect to R&D personnel) for the whole time period considered and develop by and large in parallel with this EU-average. There are, however, some differences in the ranking of CENTROPE countries across indicators.

In terms of HRST Austria leads only slightly before the Czech Republic, while Hungary and Slovakia follow at some distance. In terms of employment in knowledge intensive service sectors Austria is followed by Hungary, while Slovakia and the Czech Republic are at a similar level.

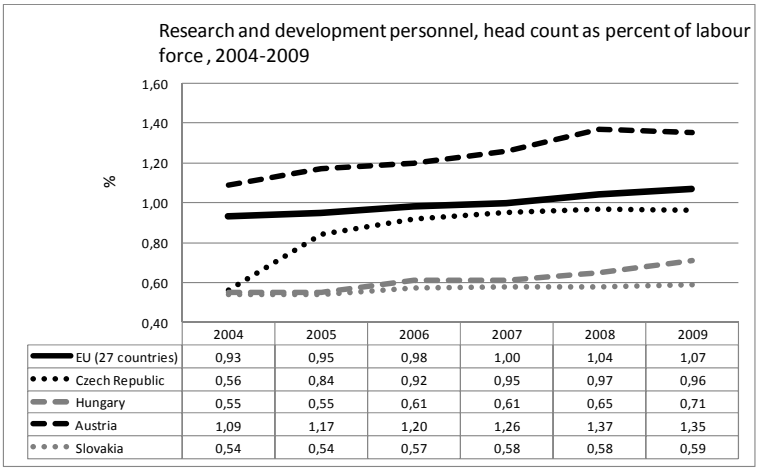
Figure 2.7: Research and development expenditure as percent of GDP, 1999-2009



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU (27 countries)	1,83	1,86	1,86	1,87	1,86	1,83	1,82	1,85	1,85	1,92	2,01
Czech Republic	1,14	1,21	1,2	1,2	1,25	1,25	1,41	1,55	1,54	1,47	1,53
Hungary	0,67	0,79	0,92	1	0,93	0,87	0,95	1	0,97	1	1,15
Austria	1,9	1,94	2,07	2,14	2,26	2,26	2,45	2,46	2,52	2,67	2,75
Slovakia	0,66	0,65	0,63	0,57	0,57	0,51	0,51	0,49	0,46	0,47	0,48

Source: Eurostat – Science, technology and innovation statistics. – *Note*: Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

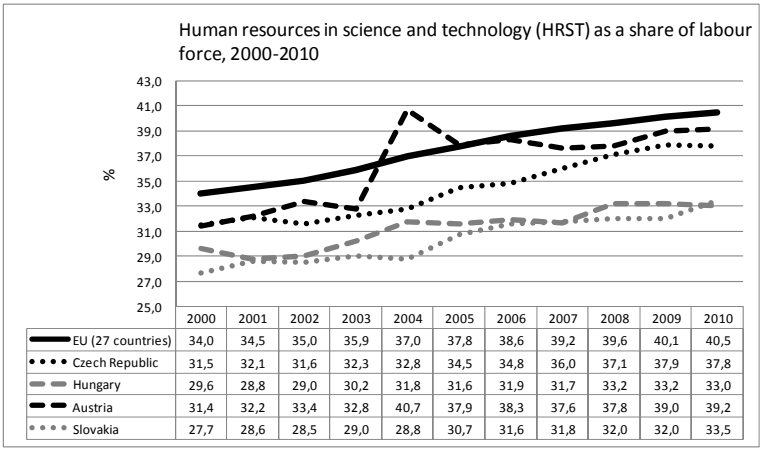
Figure 2.8: Research and development personnel, head counts as percent of labour force, 2004-2009



	2004	2005	2006	2007	2008	2009
EU (27 countries)	0,93	0,95	0,98	1,00	1,04	1,07
Czech Republic	0,56	0,84	0,92	0,95	0,97	0,96
Hungary	0,55	0,55	0,61	0,61	0,65	0,71
Austria	1,09	1,17	1,20	1,26	1,37	1,35
Slovakia	0,54	0,54	0,57	0,58	0,58	0,59

Source: Eurostat – Science, technology and innovation statistics. – *Note*: R&D personnel include all persons employed directly on R&D, plus persons supplying direct services to R&D, such as managers, administrative staff and office staff. The measure shown in this table is total R&D personnel in full time equivalents as a percentage of the economic active population.

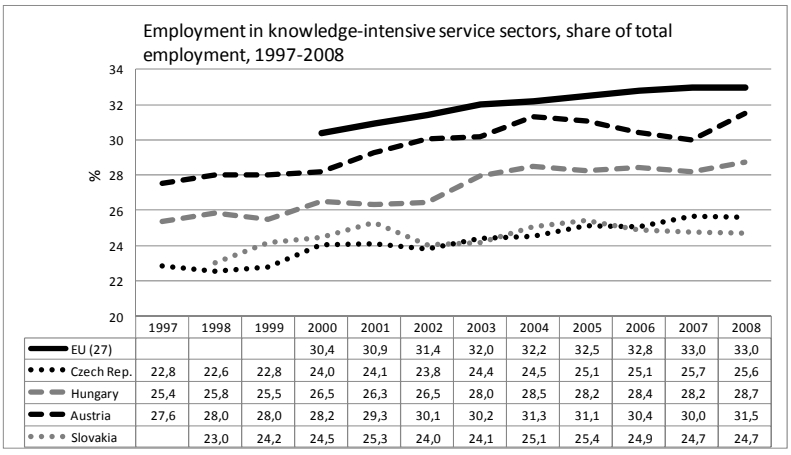
Figure 2.9: Human resources in science and technology (HRST) as a share of labour force, 2000-2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU (27 countries)	34,0	34,5	35,0	35,9	37,0	37,8	38,6	39,2	39,6	40,1	40,5
Czech Republic	31,5	32,1	31,6	32,3	32,8	34,5	34,8	36,0	37,1	37,9	37,8
Hungary	29,6	28,8	29,0	30,2	31,8	31,6	31,9	31,7	33,2	33,2	33,0
Austria	31,4	32,2	33,4	32,8	40,7	37,9	38,3	37,6	37,8	39,0	39,2
Slovakia	27,7	28,6	28,5	29,0	28,8	30,7	31,6	31,8	32,0	32,0	33,5

Source: Eurostat – Science, technology and innovation statistics. – *Note*: Human resources in science and technology (HRST) as a share of the economically active population in the age group 25-64. This indicator gives the percentage of the total labour force in the age group 25-64, that is classified as HRST, i.e. having either successfully completed an education at the third level in an S&T field of study or is employed in an occupation where such an education is normally required.

Figure 2.10: Employment in knowledge-intensive service sectors, 1997-2008



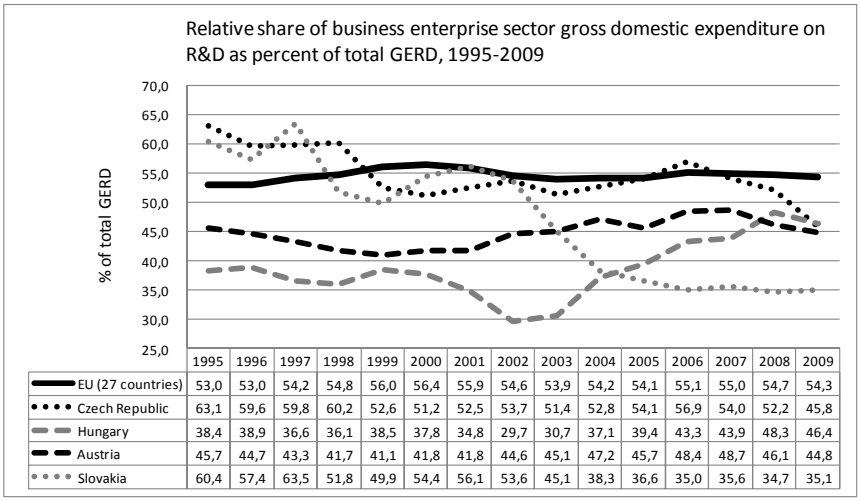
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
EU (27)				30,4	30,9	31,4	32,0	32,2	32,5	32,8	33,0	33,0
Czech Rep.	22,8	22,6	22,8	24,0	24,1	23,8	24,4	24,5	25,1	25,1	25,7	25,6
Hungary	25,4	25,8	25,5	26,5	26,3	26,5	28,0	28,5	28,2	28,4	28,2	28,7
Austria	27,6	28,0	28,0	28,2	29,3	30,1	30,2	31,3	31,1	30,4	30,0	31,5
Slovakia		23,0	24,2	24,5	25,3	24,0	24,1	25,1	25,4	24,9	24,7	24,7

Source: Eurostat – Science, technology and innovation statistics. – *Note*: The data shows per country the employment in knowledge-intensive service sectors as a share of total employment. Data source is the Community labour force survey (CLFS). The definition of knowledge-intensive services including high-technology services used by Eurostat is based on a selection of relevant items of NACE Rev. 1 on 2-digit level and is oriented on the ratio of highly qualified working in these areas.

3. Patterns of structural changes or decreasing performance over time – This pattern is found with respect to the indicators of share of business enterprises sector R&D expenditure and high tech exports (see Figure 2.11 and 2.12). In particular the share of business enterprises sector R&D expenditure shows substantial oscillation over time and countries, with Hungary experiencing a substantial improvement but Slovakia a substantial deterioration of the relative position as of the year 2002. The development of

high-tech exports, by contrast, has been more stable. Here, in particular Hungary has stably performed better than the EU average, while the Czech Republic and Slovakia have caught up to (and in the case of the Czech Republic even overtaken) Austria, which experienced declines since 2002.

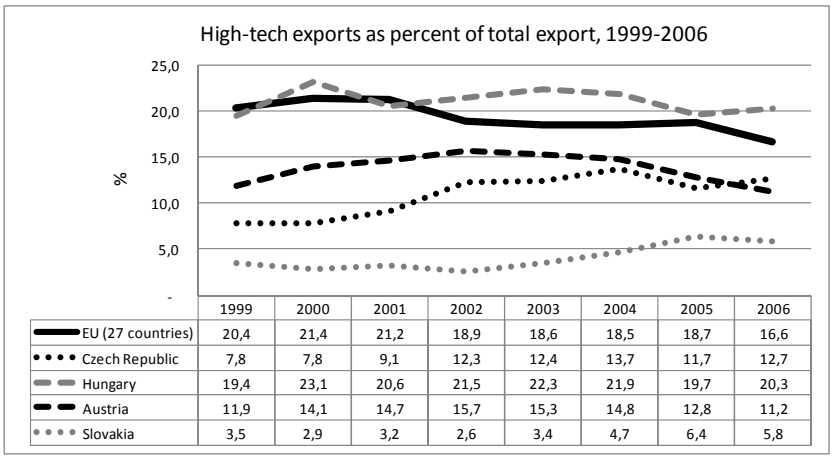
Figure 2.11: Relative share of business enterprise sector expenditure on R&D as percent of total GERD, 1995-2009



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU (27 countries)	53,0	53,0	54,2	54,8	56,0	56,4	55,9	54,6	53,9	54,2	54,1	55,1	55,0	54,7	54,3
Czech Republic	63,1	59,6	59,8	60,2	52,6	51,2	52,5	53,7	51,4	52,8	54,1	56,9	54,0	52,2	45,8
Hungary	38,4	38,9	36,6	36,1	38,5	37,8	34,8	29,7	30,7	37,1	39,4	43,3	43,9	48,3	46,4
Austria	45,7	44,7	43,3	41,7	41,1	41,8	41,8	44,6	45,1	47,2	45,7	48,4	48,7	46,1	44,8
Slovakia	60,4	57,4	63,5	51,8	49,9	54,4	56,1	53,6	45,1	38,3	36,6	35,0	35,6	34,7	35,1

Source: Eurostat – Science, technology and innovation statistics. – *Note*: This table presents the relative shares of the different sources of funds in R&D. More specifically the indicators provided are percentage of GERD (Gross domestic expenditure on R&D) financed respectively by industry. The importance of the source of funding has been recognized in one of the Barcelona targets of the Lisbon agenda where it is said that the appropriate split for R&D is 1/3 financed by public funds and 2/3 by private.

Figure 2.12: High-tech exports as percent of total export, 1999-2006



	1999	2000	2001	2002	2003	2004	2005	2006
EU (27 countries)	20,4	21,4	21,2	18,9	18,6	18,5	18,7	16,6
Czech Republic	7,8	7,8	9,1	12,3	12,4	13,7	11,7	12,7
Hungary	19,4	23,1	20,6	21,5	22,3	21,9	19,7	20,3
Austria	11,9	14,1	14,7	15,7	15,3	14,8	12,8	11,2
Slovakia	3,5	2,9	3,2	2,6	3,4	4,7	6,4	5,8

Source: Eurostat – Science, technology and innovation statistics. – *Note*: High Technology products are defined as the sum of the following products: Aerospace, Computers-office machines, Electronics-telecommunications, Pharmacy, Scientific instruments, Electrical machinery, Chemistry, Non-electrical machinery, Armament.

Table 2.1: Growth rate and relative performance of total intramural R&D expenditure (GERD, as % of GDP) in the CENTROPE regions, %, 2000-2007

Regions (NUTS 2)	GERD as % of GDP, 2007	Change of GERD as % of GDP 2000/2007	Regional GERD as % of EU 27 GERD, 2007	Regional GERD as % of National GERD, 2007
EU 27	1.85	3		
CZ - Czech Republic	1.54	21		
CZ06 – Jihovýchod	1.24	29	67	80
HU – Hungary	0.97	27		
HU22 - Nyugat-Dunántúl	0.60	175	32	62
AT – Austria	2.52	38		
AT11 - Burgenland (AT)	0.62	–5	33	25
AT12 – Niederösterreich	1.21	42	65	48
AT13 – Vienna	3.61	9	195	143
SK – Slovakia	0.46	–28		
SK01 - Bratislavský kraj	0.83	–18	45	180
SK02 - Západné Slovensko	0.38	–29	20	82
Average of the four countries	**1.37**	**12**		
CENTROPE – average	**1.21**	**11**	**65**	
CENTROPE - average without Vienna	**0.81**	**13**	**44**	

Source: Eurostat – Regional science and technology statistics.

Table 2.2: Growth rate and relative performance of total R&D personnel (RDP) (in % of active population) in the CENTROPE r regions, %, 2000-2007

Regions (NUTS 2)	RDP as % of active population, 2007	Change of RDP ratio, % (longest available duration)	Regional RDP ratio / EU 27 RDP ratio, %, 2007	Regional RDP ratio / National RDP ratio, %, 2007
EU 27 (2000-2008)	1.5	20		
CZ - Czech Republic (1998-2008)	*1.4*	*43*	*97*	
CZ06 – Jihovýchod (2001-2009)	1.5	46	102	106
HU – Hungary (1996-2008)	*1.2*	*27*	*80*	
HU22 - Nyugat-Dunántúl (1999-2008)	0.6	26	40	50
AT – Austria (2002-2007)	*2.1*	*54*	*145*	
AT11 - Burgenland (AT)	0.4	22	31	21
AT12 - Niederösterreich	0.7	34	51	35
AT13 - Vienna	4.3	13	297	204
SK – Slovakia(2000-2009)	0.9	–4	60	
SK01 - Bratislavský kraj	3.2	16	218	361
SK02 - Západné Slovensko	0.5	–5	36	60
Average of the four countries	**1.4**	**27**	**96**	
CENTROPE – average	**1.6**	**12**	**111**	
CENTROPE - average without Vienna and Bratislava	**0.8**	**18**	**52**	

Source: Eurostat – Regional science and technology statistics.

A slightly deeper, also regional, analysis can be conducted with respect to the performance indicators of R&D expenditure (see table 2.2) and research personnel (see table 2.3). The average growth rate of total intramural R&D expenditures (% of GDP) between 2000 and

2007 (this is the longest available duration in the Eurostat database at present) was 11% in the CENTROPE regions but the variation is very significant. The problem is the *low rate of total R&D expenditures in the CENTROPE partner regions*, the average ratio is only 1.21 percent of the GDP (this is just the 66% of the EU 27 average expenditures). If we exclude Vienna this relative performance indicator drops to 44%. So without Vienna the average total R&D expenditure was only 44% of the EU 27 mean value in the CENTROPE regions in 2007.

The average growth rate of R&D personnel (RDP) in CENTROPE (27%) was also higher than the EU 27 average (20%). Although this thus reflects positively on the development of CENTROPE, also the distribution of R&D personnel is rather unbalanced in CENTROPE, with a high concentration in the regions of the two capital cities (Vienna and Bratislava). The share of R&D personnel in total employment in Burgenland is only 31% of the average ratio of EU 27 member states, but the same ratio is 297% in the region of Vienna, 218% in Bratislava region and 102% in the Czech Southeast, where the city of Brno obviously improves the statistics. Nonetheless without Vienna the average ratio of total R&D personnel in the active population was only 52 percent of the EU 27 mean value in the CENTROPE regions in 2007.

In sum therefore comparing the available regional statistics of R&D performance growth it is evident that CENTROPE indeed outperforms the EU average. However, it also becomes apparent that this growth is territorially very unevenly distributed among individual regions and unbalanced, with in particular the two capital city regions of Vienna and Bratislava region and obviously also the city of Brno – for which we, however, have no separate data at this regional disaggregation - playing a key role in CENTROPE. If we exclude the two capital city regions, the aggregate average CENTROPE performance indicators reach only the 44 and 52 percent of the mean value of EU 27 member states.

2.4. Differences – Regional (NUTS 2) level R&D and innovation indicators of CENTROPE

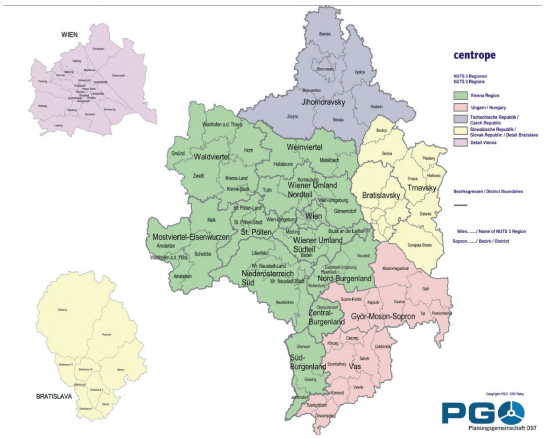
The original goal of this statistical analysis was to compare NUTS 3-level R&D and innovation statistics of the CENTROPE regions to give an exact and reliable overview. We collected and compared all the available databases and publications of the four national statistical offices but merging NUTS 3-level indicators was nearly impossible. The reason for this is simple: on this level the sets of similar (same year, same measurement and same unit)

indicators is limited to R&D expenditures and R&D personnel (see next subsection). This is the explanation why in this subsection only NUTS 2-level regional statistics are used.

Map 1: The CENTROPE region according to NUTS 3 region definition

The CENTROPE regions at NUTS 3-level

- Austrian Federal Provinces of Vienna,
- Lower Austria
- Burgenland,
- The Czech region of South Moravia,
- The Slovak regions of Bratislava region
- Trnava region
- The Hungarian counties of Győr-Moson-Sopron
- and Vas



Map 2: The CENTROPE region according to the (proxy) NUTS 2 region definition

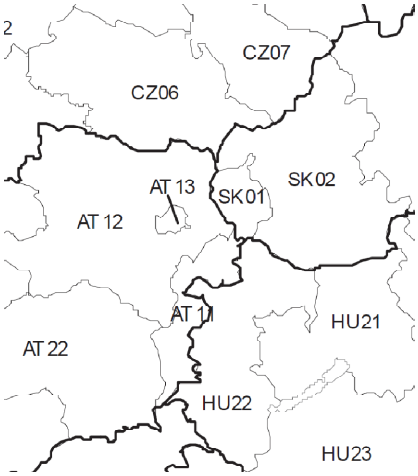
The CENTROPE region proxy at NUTS 2-level

Austria:
- AT13 - Vienna
- AT12 - Niederösterreich
- AT11 - Burgenland

Slovakia:
- SK01 - Bratislavský kraj
- SK02 - Západné Slovensko

Czech Republic:
- CZ06 - Jihovýchod

Hungary:
- HU22 - Nyugat-Dunántúl



Therefore in this subsection, because of this territorial difference, the statistics do not exactly match the official definition of CENTROPE, but are a good (and also the only possible) proxy-measure to provide a detailed comparative analysis based on secondary data. The latest available regional statistics in the same year (which were 2007, 2008 or 2009 depending on data type) were used for this analysis. Because of the comparative nature of the study, the most important criteria were that Eurostat regional statistics refer to the same year.

Three indicators will be analysed in this section at regional level: R&D expenditures, R&D personnel, higher education and human resource indicators in science and technology. The method will be the same in each topic: along with a short summary of the basic findings, detailed tables and charts will be presented. In these the reader can examine numeric details for individual sub-regions on the respective indicator. The aim of the collection and organization of the statistics into tables or charts was that they usefully highlight the regional differences, the CENTROPE as an aggregate as well as the internal structure of the indicators of R&D and innovation achievements. Usually the EU 27 or the CENTROPE average was used as a reference line during chart-building in order to clearly emphasize positively or negatively 'outstanding' regional performance.

Table 2.3: The most important R&D and innovation indicators of CENTROPE

CENTROPE as a combination of NUTS 2 regions	
Indicators	**Statistics**
Total GERD – million EUR (2007)	3,648
CENTROPE relative share as % of EU 27 total GERD (2007)	1.6%
Total GERD as % of GDP (2007)	1.21%
CENTROPE average regional GERD as percent of EU 27 average GERD (2007)	65%
CENTROPE average regional GERD as percent of EU 27 average GERD – without Vienna (2007)	44%
Total GERD, EUR per inhabitant (2007)	353
Total GERD in business enterprise sector as % of GDP (2007)	0.75%
Relative share of business enterprise sector in the total GERD (2007)	64%
Relative share of Vienna from the total GERD of CENTROPE (2007)	72%
R&D personnel – head count (2007)	73,845
R&D personnel as percent of active population (2007)	1.6%
CENTROPE average R&D personnel ratio as percent of EU 27 average (2007)	111%
Relative share of Vienna from the total R&D personnel of CENTROPE (2007)	49%
Relative share of business enterprise sector in the total number of R&D personals (2007)	45.2%
Number of students in tertiary education (2009)	422,895
Ratio of students in tertiary education (2009)	22.9%
Person aged 25-64 with tertiary education (2010)	20.9%
Employment in (HTC) high-technology and knowledge-intensive sectors (2009)	180,902
Ratio of HTC employment in all of the NACE activities (2009)	4.8%
Employment in (KIS) knowledge-intensive sectors (2009)	120,291
Ratio of KIS employment in all of the NACE activities (2009)	3.2%
Ratio of KIS as % of all HTC employment (2009)	66%
Number of human resources in science and technology (HRST) – thousand (2010)	1,854
Human resource as % of active population (2010)	37.6%

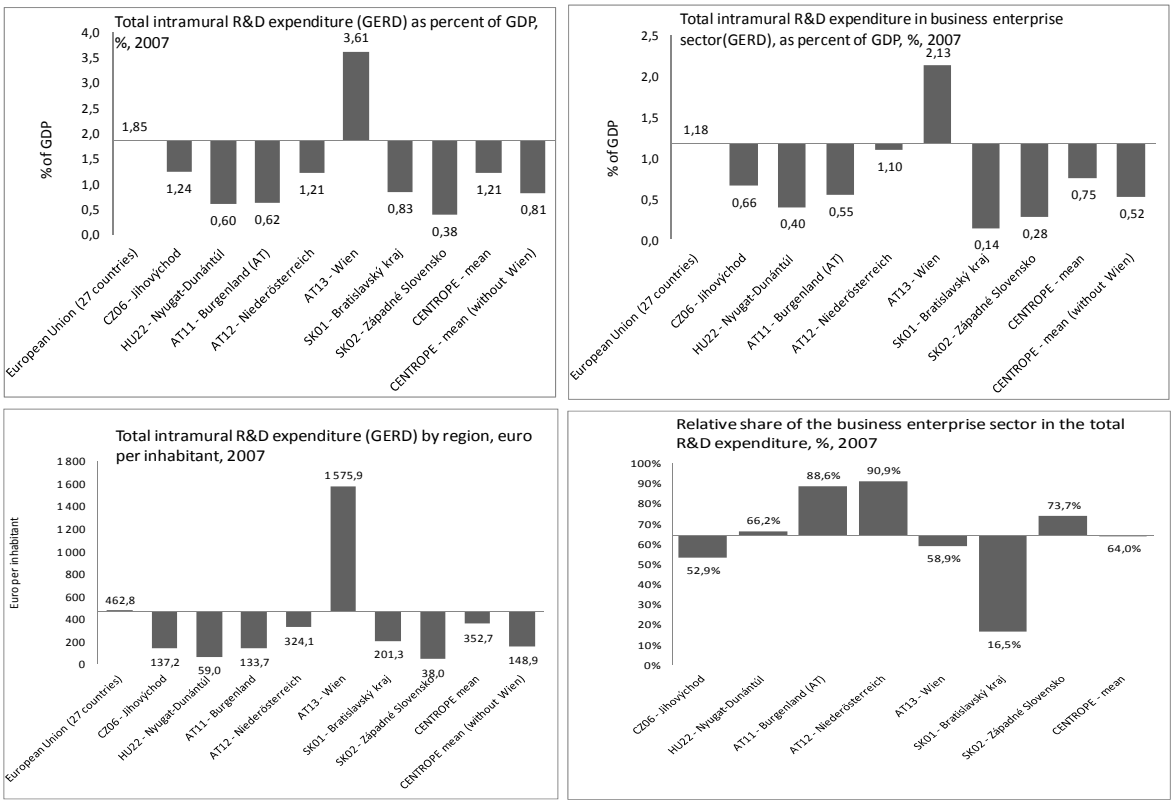
Sources: EUROSTAT – Regional science and technology statistics (reg_sct).

2.4.1. R&D expenditures

In this subtopic the following indicators were used to measure the overall performance of CENTROPE region (external positioning on EU scale) and the differences among the partner regions (internal positioning): the amount of R&D expenditures as million euro, R&D expenditures as percent of GDP, R&D expenditures in Euro per inhabitant, R&D expenditures as percent of EU 27 countries' average, the share of a regions expenditures by sectors in 2007. These indicators suggest the following quantitative findings:

- The total pool of R&D expenditures in CENTROPE is around € 3.6 billion (Table 2.3 and 2.4). This is 1.6% of the EU 27 countries' total intramural R&D expenditures and thus slightly below the population share of CENTROPE in total EU population.

Figure 2.13: Differences of the total and enterprise sector's R&D expenditures of the CENTROPE regions, 2007



Source: Eurostat – Regional science and technology statistics.

- The average R&D expenditure as percent of GDP is 1.21% which is only the 65% of the EU 27 mean value. This CENTROPE average is, however, distorted by the dominant position of Vienna in the share of total R&D expenditure in total CENTROPE R&D expenditure, 72% of the CENTROPE's R&D expenditures are concentrated in Vienna. Furthermore, 87% of the expenditures are undertaken by the Austrian regions. As a consequence if Vienna is excluded from the analysis, the CENTROPE partner regions' share in total EU R&D expenditures is only 0.45%, and all CENTROPE regions, except Vienna, have a lower R&D expenditure performance than the EU 27 average with the variance of this indicator being also very large among the regions, and going as low as 0.38% of GDP in Westen Slovakia (Zapadne Slovensko).
- The share of the business enterprise sector in total R&D expenditure in the CENTROPE is around 64% (2.3 billion), and the share of higher education (as the second biggest funding sector) is around 27% (987 million), while the government sector average spending is around 10% (365 million) and the private non-profit sector contributes only 0.4% of total R&D expenditure. These shares, however, also show substantial regional variation and reflect the rather different functional roles of the CENTROPE regions in their respective national innovation systems. The business sector attains an above average share in total R&D expenditure in the more industrialized and rural regions of CENTROPE, where only few universities are located (Lower Austria 91%, Burgenland 89%, Western Slovakia 74%), while in the capital city regions and in the Czech Southeast (Jihovychod) – on account of Brno – where more universities are located the higher education sector contributes over 30% of total R&D expenditure. In Western Transdanubia, however, the financing structure accords more closely to the CENTROPE average (table 2.4).
- Despite the important role of the business enterprise sector in total R&D expenditure the R&D expenditure in the business enterprise sector as a percentage of GDP is very low in the CENTROPE average and substantially below the EU average in all CENTROPE regions but Vienna (where it is above the EU average) and Lower Austria (where it is slightly below the EU average). In the CENTROPE aggregate only 0.75% of GDP (relative to an EU average of 1.2% for the EU 27) go to R&D and innovation of the enterprise sector, and without Vienna this ratio reduces to 0.52% (figure 2.13). This therefore suggests that low R&D expenditures by the business enterprise sector are an

important explanation for the overall below average performance of CENTROPE in terms of R&D expenditure as a percentage of GDP.

- All of the CENTROPE regions except for Vienna have very low levels of R&D expenditure per inhabitant. This suggests that the regions' R&D systems are often under-funded. According to the data on total intramural R&D expenditure per inhabitant in percent of the EU 27 countries' average the CENTROPE spends € 352 per inhabitant (76% of the average of EU 27) on R&D. Without Vienna the indicator is only € 149 per inhabitant (which is just 32% of the mean value of EU 27). Furthermore, in particular the higher education sector gets a lower share of total R&D expenditure (25%) than in the EU average and R&D in the non-profit sector is almost missing.

Table 2.4: Total intramural R&D expenditure (GERD) by sectors of performance, millions of euro, 2007

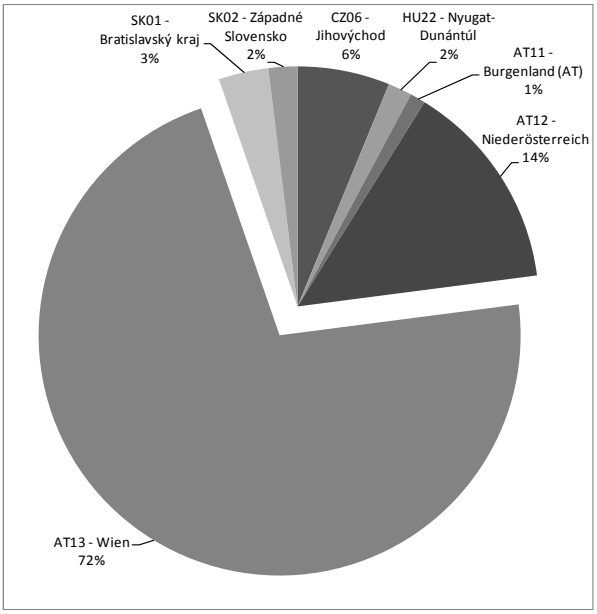
Region	Total	Business enterprise sector	Government sector	Higher education sector	Private non-profit sector
AT13 - Vienna	2,618.0	1,543.1	215.0	845.2	14.7
AT12 - Niederösterreich	514.9	468.0	30.5	15.5	0.8
AT11 - Burgenland (AT)	37.5	33.2			0.0
SK01 - Bratislavský kraj	122.1	20.2	64.5	37.4	
SK02 - Západné Slovensko	70.8	52.2	13.0	5.6	0.1
CZ06 - Jihovýchod	225.6	119.3	37.0	69.1	0.2
HU22 - Nyugat-Dunántúl	59.0	39.0	5.5	14.4	
CENTROPE - sum	**3,647.8**	**2,275.0**	**365.4**	**987.3**	**15.8**
Relative structure, % of CENTROPE total		**62.4%**	**10.0%**	**27.1%**	**0.4%**
CENTROPE - sum (without Vienna)	**1,029.8**	**731.9**	**150.5**	**142.0**	**1.1**
Relative structure (without Vienna), % of CENTROPE total		**71%**	**15%**	**14%**	**0%**
CENTROPE share, as % of EU 27 total	**1.6%**	**1.6%**	**1.2%**	**1.9%**	**0.7%**
CENTROPE share, as % of EU 27 total (without Vienna)	**0.45%**	**0.50%**	**0.51%**	**0.28%**	**0.05%**

Source: Eurostat – Regional science and technology statistics. – *Note*: Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

In sum R&D expenditures as an important performance indicator of the R&D capacity of a region suggest that according to several absolute and relative regional statistics the only competitive regions of CENTROPE from a European perspective are Vienna and Lower Austria. The other regions are under-funded due to a number of reasons of which, however, the often low R&D expenditure of the business enterprise sector is an important aspect.

Furthermore due to this asymmetric allocation pattern also the entire region performs below average in terms of R&D expenditure.

Figure 2.14 Regional distribution of total intramural R&D expenditure (GERD) – % of CENTROPE total, 2007



Source: Eurostat – Regional science and technology statistics. – *Note*: The total expenditure is 3 647.8 million euro.

Table 2.5: Total intramural R&D expenditure (GERD) per inhabitant by sectors, as percent of EU 27 countries' average, %, 2007

Regions	Total GERD	Business enterprise sector	Government sector	Higher education sector	Private non-profit sector
AT13 – Vienna	340.5	315.3	218.2	488.3	187.2
AT12 – Niederösterreich	70.0	100.0	32.4	9.4	10.6
AT11 – Burgenland	28.9	40.2	-	-	0.0
SK01 - Bratislavský kraj	43.5	11.3	179.3	59.2	-
SK02 - Západné Slovensko	8.2	9.5	11.8	2.9	0.0
CZ06 – Jihovýchod	29.6	24.6	37.9	40.3	2.1
HU22 - Nyugat-Dunántúl	12.7	13.3	9.3	13.8	-
CENTROPE – average	**76.2**	**73.5**	**81.5**	**102.3**	**40.0**
CENTROPE - average (without Vienna)	**32.2**	**33.2**	**54.1**	**25.1**	**3.2**

Source: Eurostat – Regional science and technology statistics. – *Note*: EU 27 countries average is 462.8 euro per inhabitant,

Table 2.6: Total R&D personnel and researchers by region (head count and in % of total employment, 2007)

Region	Total R&D personnel, % of total employment	R&D personnel head count	Researchers, % of total employment	Researcher head count
EU 27 - European Union (27 countries)	1.57	3,445,298	0.99	2,158,540
AT13 - Vienna	4.73	36,593	3.07	23,791
AT12 - Niederösterreich	0.76	5,909	0.36	2,760
AT11 - Burgenland (AT)	0.47	639	0.24	327
CZ06 - Jihovýchod	1.57	12,260	0.98	7,674
SK01 - Bratislavský kraj	3.33	10,802	2.74	8,905
SK02 - Západné Slovensko	0.58	4,960	0.42	3,639
HU22 - Nyugat-Dunántúl	0.62	2,682	0.43	1,863
CENTROPE – average	**1.72**	**73,845**	**1.18**	**48,959**
CENTROPE - average (without Vienna)	**1.22**	**37,252**	**0.86**	**25,168**
CENTROPE share, as % of EU 27 total		**2.14**		**2.26**
CENTROPE share, as % of EU 27 total (without Vienna)		**1.08**		**1.16**

Source: Eurostat – Regional science and technology statistics. – *Note*: R&D personnel include all persons employed directly on R&D, plus persons supplying direct services to R&D, such as managers, administrative staff and office staff. The measure shown in this table is total R&D personnel in full time equivalents as a percentage of the economic active population.

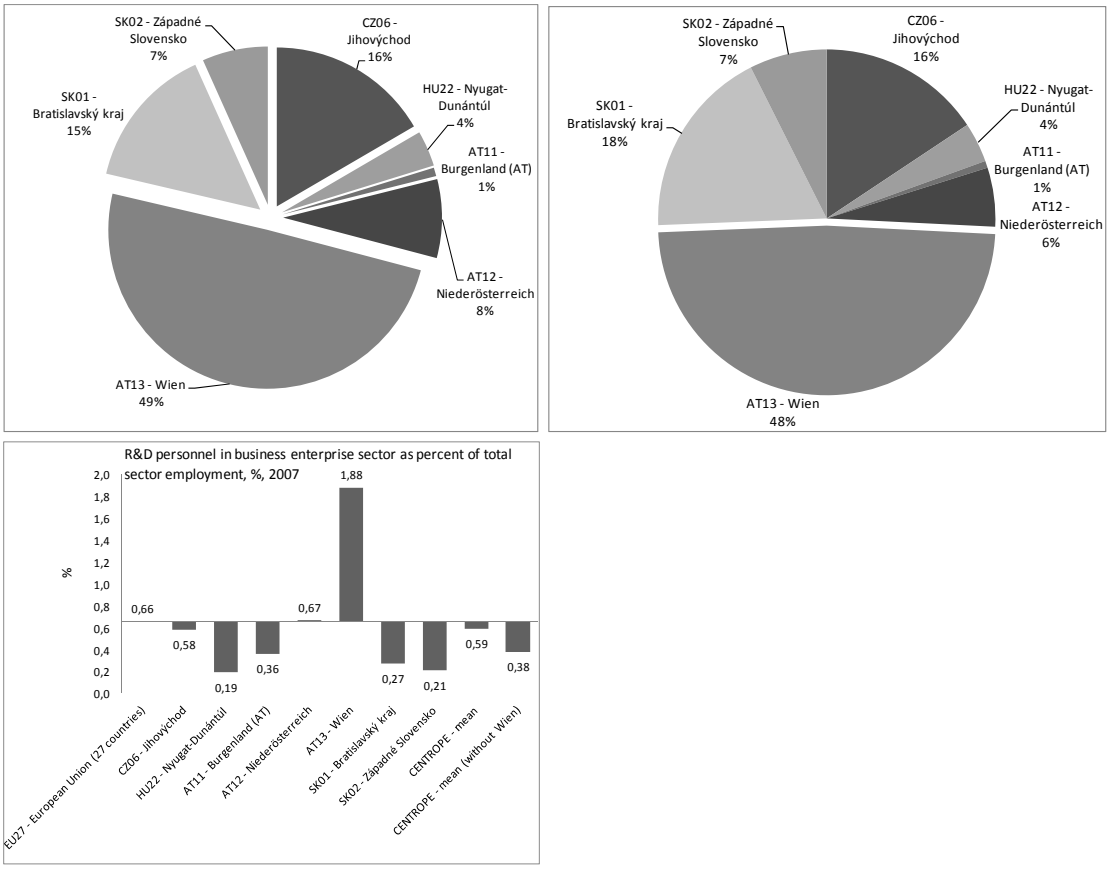
2.4.2. R&D personnel and researchers

Another important component (after R&D expenditure) of successful research and development and innovation processes is knowledge which depends heavily on human resources and personnel. In this subtopic the following indicators were used to measure the overall performance of CENTROPE region (external positioning on EU scale) and the differences among the partner regions (internal positioning): the total number of R&D personel and its share of total employment, the number of researchers and their share in total employment, the share of R&D personnel and researchers of a region in the total of the CENTROPE, the share of total R&D personnel by sectors of performance in 2007. These indicators show that:

- In contrast to funding, which is a weak point in the system of R&D and innovation of CENTROPE, the pool of human resources (in quantity but not necessarily in quality) is a strong component. For many of the indicators considered in this section the CENTROPE aggregate exceeds the EU average.
- Also the internal, interregional inequalities are lower in this dimension and there are also some signs of regional specialisation which generally follow the distribution of R&D

expenditure by sectors of performance. In the Hungarian and Slovak CENTROPE most of the R&D personnel is working in the higher education sector and in Vienna and the Czech Southeast (Jihovychod) the relative majority of the R&D personnel works in this sector. By contrast in the Austrian CENTROPE regions of Burgenland and Lower Austria, most of the research personnel works in the business enterprise sector, while the number of researchers in the business and enterprise sector is very low in most of the new member state regions of CENTROPE. In aggregate, however, the overall structure of the allocation of personnel by sector of performance reflects the EU 27 average. This is again due to the exceptionally good performance of Vienna, which strongly increases the mean values of the CENTROPE aggregate. Absolute R&D personnel and researcher numbers in the business and enterprise sector are, however, very low in most of partner regions (except Vienna).

Figure 2.15: Share of R&D personnel and researchers in CENTROPE total, %, 2007



Source: Eurostat – Regional science and technology statistics.

Table 2.7: Share of total R&D personnel by sectors of performance, 2007

Regions	Business enterprise sector, %	Government sector, %	Higher education sector, %
EU 27 - European Union (27 countries)	**42.3**	**12.2**	**44.4**
AT13 - Vienna	39.8	10.0	49.6
AT12 - Niederösterreich	87.1	5.9	6.4
AT11 - Burgenland (AT)	76.7	-	-
CZ06 - Jihovýchod	36.9	15.8	47.2
SK01 - Bratislavský kraj	8.0	31.3	60.7
SK02 - Západné Slovensko	36.5	12.5	50.9
HU22 - Nyugat-Dunántúl	31.2	9.7	59.2
CENTROPE - average	**45.2**	**14.2***	**45.6***

Source: Eurostat – Regional science and technology statistics. – *Note:* * Just estimation because of the missing data of Burgenland.

- The total number of R&D personnel working in CENTROPE was 73,845 (head count) and the number of researchers employed was 48,959 in 2007. This implies that R&D personnel accounts for 1.72 percent and researchers for 1.18 percent of the total employment of CENTROPE. Both these indicators are above the EU 27 averages (which is 1.57 and 0.99 percent, respectively).
- 2.1% of R&D the personnel and 2.3% of researchers of the EU work in CENTROPE although the population share of the Region in the EU average is only 1.6%.
- Despite the weaker regional concentration within CENTROPE in terms of human resources than in terms of R&D expenditure, human resources in R&D are also strongly concentrated on Vienna and Bratislava. In Vienna R&D personnel accounts for 4.7% of total employment and in Bratislava for 3.3%. The only other NUTS 2 CENTROPE region where the share of R&D personnel in total employment exceeds 1% is the Czech Southeast (Jihivychod), where the city of Brno once more increases this share substantially. By contrast in all other CENTROPE regions less than 1% of the employed are R&D personnel with the employment share in R&D being very low in Burgenland, Západné Slovensko and Nyugat-Dunántúl (where it ranges only between 0.47% and 0.62% of total employment).
- Similarly, in Vienna 3.1% of the employed work as researchers and in Bratislava region this applies to 2.7% of the employed. In all other regions this share is below 1%, with, however, again the Czech Southeast (Jihovychod) – on account of the Brno agglomeration – performing better than the other regions.

2.4.3. Higher education, human resources and employment in science and technology

In the last subtopic the key dimensions are employment and education. We will describe the education level of the active population and workforce, then the role and weight of technology and knowledge-intensive sectors in the economy of CENTROPE. In this subtopic the following indicators for 2009 were used to measure the overall performance of CENTROPE (external positioning on EU scale) and the differences among the partner regions (internal positioning): The number and share of students in tertiary education; The employment in high technology manufacturing; the employment in knowledge-intensive high-technology services; the share of HTC employment in total employment; the proportion of high-technology manufacturing and knowledge-intensive services; the number and share of human resources in science and technology and the allocation of human resources in science and technology by sector of economic activity (NACE categories). Again these indicators lead to a number of important quantitative conclusions, which suggest that:

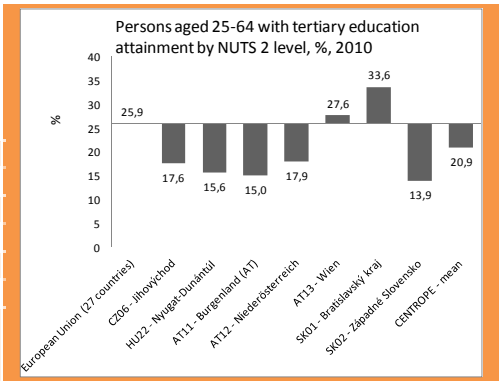
- The large number of students and tertiary education institutions in the CENTROPE is a strength of the regional innovation system. The total number of students in the CENTROPE region was 1,849,535, and the number of students in tertiary education was 422,895 in 2009. This means that 22.9% of the students studied in tertiary education. The centres of higher education are Vienna, Bratislava and Brno with 151,196, 77,355 and 80,000 students respectively[7] (table 2.8). Of these students in tertiary education in CENTROPE 33.6% (around 142,000) are studying in the social sciences, business or law, a further 14.6% (around 62,000) are studying engineering, manufacturing and construction. 12.7% (54,000) natural sciences, mathematics and computing and another 10.7% (45,000) respectively 10.2% (43,000) are studying humanities, arts and languages or are in teacher training, while the remaining 18.4% (78,000) are studying in other fields. Relative to the 18 EU countries for which the labour force provides data on the field of education this suggests a slightly higher share of students in engineering, manufacturing and construction (12,7% in the EU average) and teacher training (6.7% in the EU average) but a lower share in all other fields (figure 2.16).

[7] While according to the EUROSTAT Database the 87.144 students study in the Czech Southeast. According to national sources of these slightly more than 80.000 studied in Brno, however.

- The important role played by institutions of tertiary education in the CENTROPE is further underlined by the fact that a total of 61 institutions providing tertiary education exist in CENTROPE (see Appendix 1 for a list of universities identified) and the CENTROPE hosts 2.2% of the student population in the EU 27, although its share of the overall population is only 1.6%.

Table 2.8: Number and share of students in tertiary education, levels 5-6 (ISCED 1997), 2009

Region	Number of students all	Number of students in tertiary education	Share of students in tertiary education
AT13 - Vienna	417,035	151,196	36.3
AT12 - Niederösterreich	276,491	14,056	5.1
AT11 - Burgenland (AT)	45,410	1,840	4.1
SK01 - Bratislavský kraj	176,176	77,355	43.9
SK02 - Západné Slovensko	364,774	63,536	17.4
CZ06 - Jihovýchod	375,894	87,144	23.2
HU22 - Nyugat-Dunántúl	193,755	27,768	14.3
CENTROPE – total or average	**1,849,535**	**422,895**	**22.9**



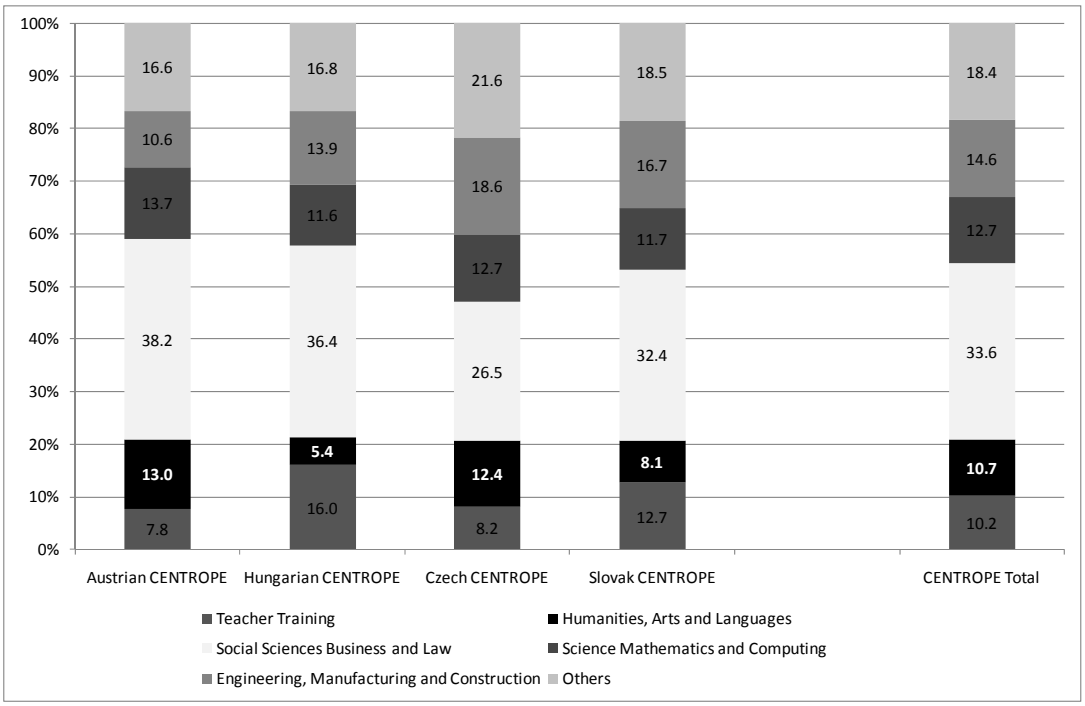
Source: Eurostat – Regional science and technology statistics.

- Finally, in terms of students also Bratislava region has a higher share of tertiary educated students in total students than Vienna. 44% of the students attended tertiary education in Bratislava, and Vienna had the second highest ratio with 36%. This suggests that these two centres of tertiary education are also attracting a very large number of students from their respective countries (or from abroad), while for the third centre of tertiary education in the region (Brno) the share of students in tertiary education in total students (with 23.2) is the third highest among all CENTROPE regions, but also somewhat lower than in Vienna and Bratislava. This suggests that for this centre of tertiary education, the function as a centre of education also for other regions is more weakly developed than in the capital city regions of CENTROPE.
- Despite the large number of students, however, the share of population with a tertiary education level in the total population aged 25-64 of CENTROPE is lower (20.9% with tertiary attainment) than the EU average (25.9%) although the two capital city regions increase the average value. In most of the other CENTROPE regions these shares only range between 13.9% and 17.9%. This therefore suggests that – as already noticed in earlier report (Römisch et al., 2011) many of the highly educated university students,

leave the region after receiving their education and characterizes the region as a brain drain region.

- Yet, despite this brain drain the workforce in the high-tech industry or knowledge-intensive service sector in CENTROPE amounts to roughly 180,902 people. This is 4.8% of the total employment in all NACE activities. 60,610 people (1.6%) are working in the high-technology manufacturing (HTC) sector and an additional 120,291 in the knowledge-intensive high technology service sector (KIS). Thus the employment pattern in high-tech sectors clearly follows the structural necessities of modern, global, post-industrial service economies. Furthermore following the structural prerequisites of post-industrial service economies in CENTROPE around one third of the employed in high-tech or knowledge intensive sectors work in high-tech manufacturing industries and two thirds in the knowledge intensive services.

Figure 2.16: Distribution of students in tertiary education (at ISCED level 5 or 6) by subjects in %, 2009



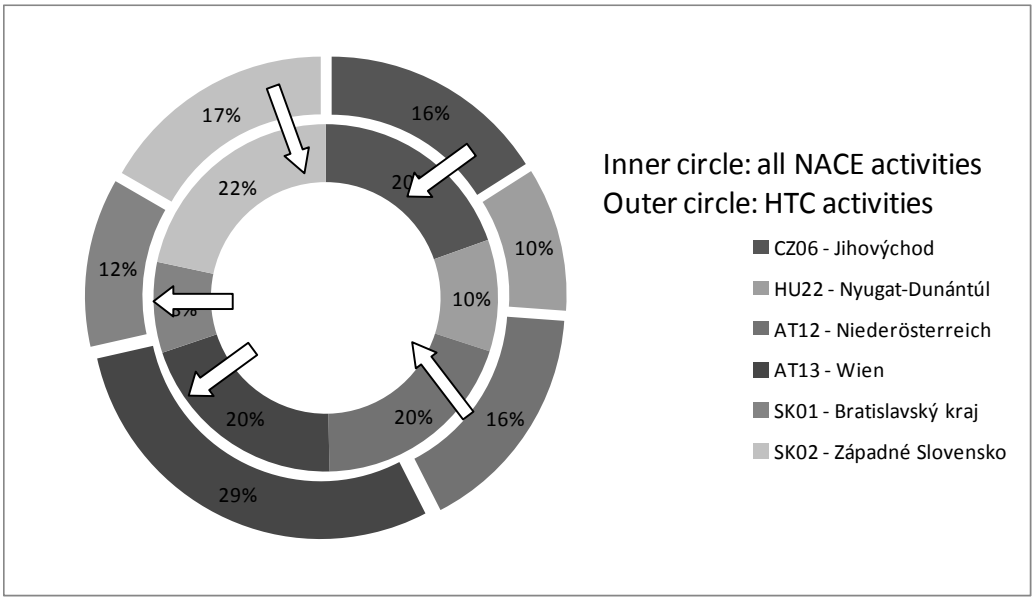
Source: Austrian, Hungarian and Slovak CENTROPE, estimates based on the European Labour Force survey, Czech CENTROPE estimates based on statistical yearbook of South Moravia, 2011. – *Notes:* Category Others includes unknown category.

Table 2.9: Employment in technology and knowledge-intensive sectors at regional level, 2009

Regions	All NACE activities, N	HTC N	HTC %	HTC-M N	HTC-M %	HTC-KIS N	HTC-KIS %
AT13 - Vienna	795,533	52,562	6.6	10,042	1.26	42,519	5.34
AT12 - Niederösterreich	773,330	29,525	3.8	6,398	0.83	23,127	2.99
AT11 - Burgenland (AT)	134,541	-	-	-	-	-	-
CZ06 - Jihovýchod	769,518	28,997	3.8	7,320	0.95	21,677	2.82
SK01 - Bratislavský kraj	331,247	21,304	6.4	2,555	0.77	18,749	5.66
SK02 - Západné Slovensko	851,910	30,260	3.6	20,609	2.42	9,651	1.13
HU22 - Nyugat-Dunántúl	408,467	18,254	4.5	13,686	3.35	4,568	1.12
*CENTROPE - sum (without Burgenland)	**4,064,546**	**180,902**	**4.8**	**60,610**	**1.60**	**120,291**	**3.18**

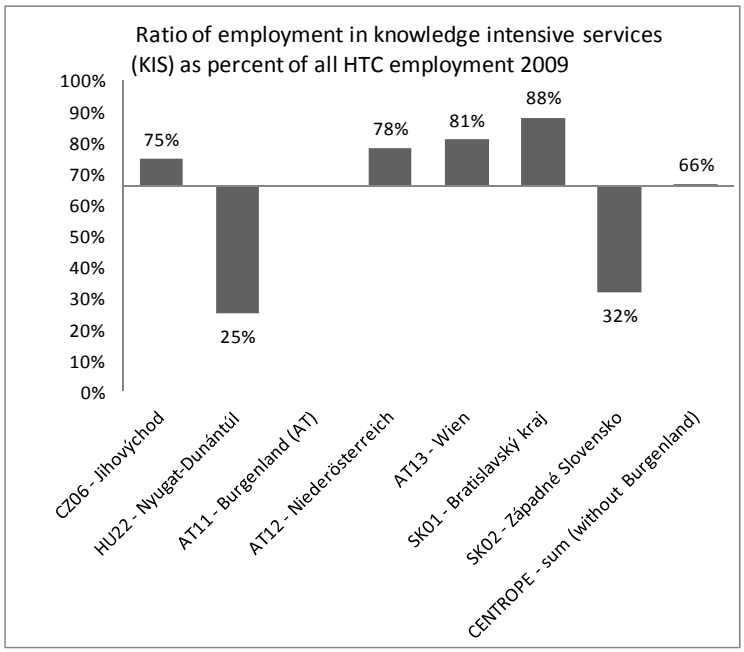
Source: Eurostat – Regional science and technology statistics. – *Note:* HTC: high-technology manufacturing and knowledge-intensive high-technology services HTC-M: high-technology manufacturing, HTC-KIS: knowledge-intensive high-technology services AT11 – Burgenland: unreliable data * Estimated due to missing data of Burgenland.

Figure 2.17: The relative distribution of total and HTC employment of the CENTROPE region by NUTS 2 regions, %, 2009



Source: Eurostat – Regional science and technology statistics. – *Note:* Inner circle: share of region in total CENTROPE employment in all NACE activities by regions Outer circle: share of region in total CENTROPE employment in HTC activities by regions.

Figure 2.18: Ratio of employment in KIS as %of all HTC employment, 2009



Source: Eurostat – Regional science and technology statistics. – *Note:* HTC: high-technology manufacturing and knowledge-intensive high-technology services, HTC-KIS: knowledge-intensive high-technology services, AT11-Burgenland: unreliable data.

Table 2.10: Human resources in science and technology (HRST), number, share of CENTROPE and % of active population, 2010

Regions	N in thousands	Share of CENTROPE %	% of active population
AT13 – Vienna	455	25	45.1
AT12 – Niederösterreich	335	18	37.0
AT11 - Burgenland (AT)	52	3	33.4
CZ06 – Jihovýchod	342	18	36.0
SK01 - Bratislavský kraj	221	12	56.6
SK02 - Západné Slovensko	306	17	28.4
HU22 - Nyugat-Dunántúl	143	8	26.5
CENTROPE - average or sum	**1,854**	**100**	**37.6**

Source: Eurostat – Regional science and technology statistics. – Note: Human resources in science and technology (HRST) as a share of the economically active population in the age group 25-64. This indicator gives the percentage of the total labour force in the age group 25-64, that is classified as HRST, i.e. having either successfully completed an education at the third level in an S&T field of study or is employed in an occupation where such an education is normally required. HRST are measured mainly using the concepts and definitions laid down in the Canberra Manual, OECD, Paris, 1995.

- Following the functional differences among the regions of CENTROPE, however, the centre of gravity of High-tech manufacturing employment is located in the more heavily industrialised regions of the Czech, Slovak and Hungarian CENTROPE, while the

employment in knowledge intensive services is concentrated in the urban regions such as Brno, Vienna and Bratislava region but in particular in the capital city regions of Vienna and Bratislava. In consequence there is a clear and obvious territorial/ regional division of labour in the field of high-tech activities, which follows the economic structure of the regions.

Finally, the last R&D and innovation performance indicator analysed in this chapter is human resources in science and technology (HRST) as a share of the economically active population in the age of 25 to 64. This indicator gives the percentage share of the total labour force in the age group 25-64, that is classified as HRST, i.e. either has a completed a tertiary education in an S&T field of study or is employed in an occupation where such an education is normally required. This share shows that:

- The number of human resources in science and technology was 1.854 million in 2009. This means that 37.6% of the active population (age group 25-64) is studied and/or employed in an occupation where such an education required. This in conjunction with the lower number of tertiary educated persons in CENTROPE suggests that a number of persons, who do not have a tertiary education, are working in occupations that formally require such an education, and are thus formally under-qualified for their job.
- Once more, however, the regional variation of this indicator in CENTROPE region is very high, Nyugat-Dunántúl (Hungary) has the lowest (26.5%) and Bratislava (Slovakia) has the highest share (56.6%) of persons working as HRST. In contrast to other indicators these differences, however, seem to be primarily a result of the different sizes of regions, since the regional distribution of human resources in science and technology closely follows the pattern of the distribution of the total workforce in the region.
- The concentration of science and technology related workforce in the CENTROPE region is not influenced by spatial factors or the different functional patterns of the regional economies. Much rather the regional variation in the share of the workforce with science and technology related education or occupation is primarily driven by sector differences. The highest shares are found in the field of information and communication, professional activities, education, and financial activities in all CENTROPE regions.

Table 2.11: Share of human resources in science and technology (HRST) by sector of economic activity (NUTS level 0 and 1), in decreasing order of the average of the CENTROPE countries %, 2009

Sector of economic activity	CZ - Czech Republic	HU - Hungary	AT - Austria	SK - Slovakia	Average
KIS_HTC- Knowledge-intensive high-technology serv.	**84.2**	**78.2**	**75.8**	**91.5**	**82.4**
J - Information and communication	84.9	75.9	72.5	89.9	80.8
M - Professional, scientific and technical activities	88.8	72.4	72.0	88.8	80.5
P – Education	78.6	75.6	82.6	74.4	77.8
K - Financial and insurance activities	81.6	85.9	49.8	78.8	74.0
KIS_MKT_OTH - Knowledge-intensive market services	**73.2**	**56.7**	**65.5**	**68.0**	**65.9**
KIS - Total knowledge-intensive services	**71.3**	**65.9**	**58.7**	**66.8**	**65.7**
HTC - High-technology sectors	**68.7**	**54.6**	**70.4**	**65.3**	**64.8**
KIS_OTH - Other knowledge-intensive services	**68.2**	**64.5**	**56.6**	**63.2**	**63.1**
R - Arts, entertainment and recreation	55.7	60.7	61.8	38.8	54.3
O_U - Public administration; activities of extraterritorial organisations and bodies	58.7	52.0	38.2	59.9	52.2
G-U – Services	49.4	44.6	43.2	44.8	45.5
Q - Human health and social work activities	48.2	45.7	44.7	26.4	41.3
C_HTC - High-technology manufacturing	39.6	34.1	56.8	29.0	39.9
Total - All NACE activities	**39.3**	**35.1**	**37.9**	**34.5**	**36.7**
HTC_MH - High and medium high-technology manuf.	**32.1**	**26.7**	**44.1**	**26.5**	**32.4**
HTC_M - Medium high-technology manufacturing	**30.9**	**23.3**	**40.7**	**26.0**	**30.2**
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	29.6	22.7	32.8	23.9	27.3
N - Administrative and support service activities	29.7	24.7	21.3	28.1	26.0
C – Manufacturing	25.5	19.5	30.8	21.4	24.3
LKIS_MKT - Less knowledge-intensive market services	**25.7**	**20.6**	**25.7**	**20.2**	**23.1**
S_T - Other service activities	19.0	23.2	32.1	17.4	22.9
LKIS - Total less knowledge-intensive services	**24.8**	**20.3**	**26.2**	**20.0**	**22.8**
C_LTC_M - Medium low-technology manufacturing	23.4	18.3	25.6	23.4	22.7
D-F - Electricity, gas, steam and air conditioning supply; water supply and construction	25.7	17.6	24.3	18.1	21.4
LKIS_OTH - Other less knowledge-intensive services	**15.9**	**17.8**	**32.1**	**19.1**	**21.2**
LTC_LM - Low and medium low-technology manuf.	**21.5**	**15.2**	**24.1**	**18.5**	**19.8**
H - Transportation and storage	19.6	15.8	19.7	16.2	17.8
C_LTC - Low-technology manufacturing	19.1	13.1	22.6	14.5	17.3
A_B - Agriculture, forestry and fishing; mining and quarrying	21.8	12.1	13.2	17.0	16.0
I - Accommodation and food service activities	6.6	12.0	11.6	6.6	9.2

Source: Eurostat – Regional science and technology statistics Table shows % of workforce in a given economic activity who fulfil at least one of the following conditions: 1) they have successfully completed education at the tertiary level or 2) they work in an S&T occupation where such a formal qualification is normally required.

2.5. Distribution and concentration – Common R&D&I indicators at NUTS 3-level

In addition to these NUTS2-level indicators we also collected the latest available NUTS 3-level R&D and innovation statistics of the CENTROPE regions in order to measure the performance of this territory at the most precise level of its definition. As mentioned above

the basic problem with this is the limited number of comparable official R&D and innovation indicators. As we go deeper down the hierarchy of the spatial-territorial system R&D personnel and expenditure are the only available commonly measured statistical dimensions of the national statistical offices of the CENTROPE countries. After reviewing the official statistics of each country the harmonisation of this kind of data is an urgent and useful aim for future development.[8]

Table 2.12: The most important R&D and innovation indicators of CENTROPE region

CENTROPE as a combination of NUTS 3 regions	
Indicators	**Statistics**
Number of R&D personnel (2009)	67,697
Number of researcher (2009)	45,403
Researcher as a percent of total R&D personnel (2009)	66.7%
R&D expenditure – million EUR (2009)	3,706
Average annual R&D expenditure per one R&D personnel – EUR (2009)	39,288
Relative share of CENTROPE region from the national total R&D expenditure (2009)	
- Vienna and Bratislava	44.8%
- Other CENTROPE regions (average) - (2009)	5.2%
Share of CENTROPE region from the national total R&D personnel (2009)	
- Vienna and Bratislava	44.5%
- Other CENTROPE regions (average) – (2009)	5.7%
Share of CENTROPE region from the national total researcher personnel (2009)	
- Vienna and Bratislava	51.6%
- Other CENTROPE regions (average) – (2009)	5.9%

Sources: EUROSTAT - Regional science and technology statistics (reg_sct) Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

At present only the following eleven latest (2009) officially published indicators are available for comparison at CENTROPE level:

1. Number and regional share of R&D personnel
2. Number and regional share of researchers
3. Researchers as percent of total R&D personnel
4. Amount and regional share of R&D expenditure

[8] In compiling these statistics the following sources were used: Austria, Eurostat, Regional database (http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database); Czech Republic, Statistical Yearbook of the Jihomoravský Region 2010, http://www.czso.cz/csu/2010edicniplan.nsf/engp/641011-10, Slovak Republic, Yearbook of science and technology in the Slovak Republic 2010, http://portal.statistics.sk/showdoc.do?docid=29419; Hungary: http://portal.ksh.hu/pls/ksh/docs/eng/xstadat/xstadat_annual/i_ohk007a.htm.

5. R&D expenditure per employed R&D personnel, EUR
6. Concentration of national R&D personnel in the CENTROPE partner region, %
7. Concentration of national researcher personnel in the CENTROPE partner region, %
8. Concentration of the total national R&D expenditure in the CENTROPE partner region, %

So at NUTS 3-level only R&D performance is measurable and indicators of innovation are missing completely.[9]

Table 2.13: Basic indicators of RDI, numbers and relative frequencies, 2009

Regions	Number of R&D personnel	%	Number of Researcher	%	Researcher as % of total R&D personnel	R&D expenditure (million EUR)	%	GERD per one R&D personnel, EUR
Vienna	*3,6593*	*54.1*	*23,791*	*52.4*	*65.0*	*2,618.0*	*70.6*	*71,543.7*
Lower Austria	5,909	8.7	2,760	6.1	46.7	514.9	13.9	87,138.3
Burgenland	639	0.9	327	0.7	51.2	37.5	1.0	58,685.4
South Moravia	8,387	12.4	5,136	11.3	61.2	325.1	8.8	38,762.4
Bratislava	*12,189*	*18.0*	*10,489*	*23.1*	*86.1*	*156.0*	*4.2*	*12,798.4*
Trnava	1,279	1.9	1,081	2.4	84.5	13.1	0.4	10,242.4
Győr-Moson-Sopron	2,110	3.1	1,405	3.1	66.6	30.1	0.8	14,244.7
Vas	573	0.8	414	0.9	72.3	12.0	0.3	20,886.0
CENTROPE (sum or average)	**67,679**	**100.0**	**45,403**	**100.0**	**66.7**	**3,706.7**	**100.0**	**39,287.7**
Vienna and Bratislava	**48,782**	**72.1**	**34,280**	**75.5**	**75.6**	**2,774.0**	**74.8**	
Other regions	**18,897**	**27.9**	**11,123**	**24.5**	**63.8**	**932.7**	**25.2**	

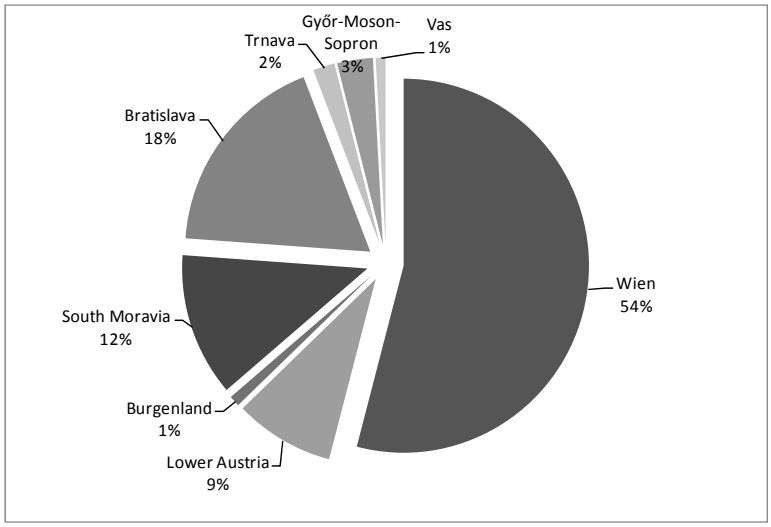
Sources: EUROSTAT – Regional science and technology statistics (reg_sct) Statistical Yearbook of the Jihomoravský Region 2010 Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

The results of this analysis at NUTS 3-level confirm many of the previous results with respect to the structure and distribution of R&D and innovation in CENTROPE already found in the previous chapter, where older (2007) data with a broader territorial extension were used. In addition these data, however, give a more precise estimate of the R&D and innovation resources used on the territory of CENTROPE. These figures suggest that:

[9] As will become apparent in the next chapter, however, this shortcoming can be dealt with by analysing individual level patent data.

- The total pool of R&D human resources of CENTROPE is around 67,679 persons, with 67% of these working as researchers (45,403).
- The total R&D expenditure was € 3,707 million in 2009, and dividing this by the R&D personnel the GERD/personnel volume of research and development in CENTROPE is approximately € 39,287.

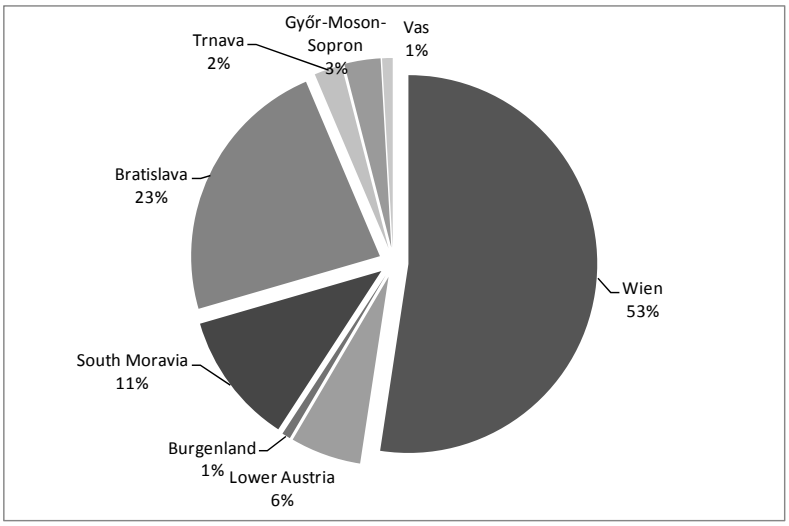
Figure 2.19: Shares of CENTROPE's total R&D personnel, by region, %, 2009



Sources: EUROSTAT - Regional science and technology statistics (reg_sct) Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

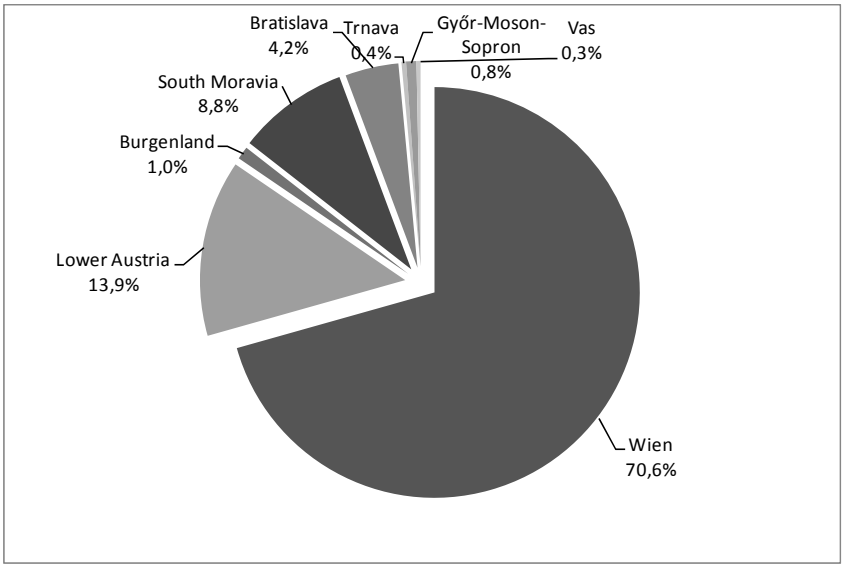
- Also when considering this more disaggregated level the spatial concentration (relative regional frequencies) of the indicators is very high. The key players of CENTROPE region's R&D system seem to be the two capital cities (but mainly Vienna) and their surroundings. Vienna's and Bratislava regions's combined shares of R&D expenditures and personnel are 72% and 76%, respectively. Focusing on the regionally more disaggregated level, however, also further highlights the role of Brno in the innovation system as the third most important centre of R&D and technology in CENTROPE, since South Moravia holds the third rank in the region in terms of R&D personnel and researchers.

Figure 2.20: Shares of CENTROPE's total researcher, by region, %, 2009



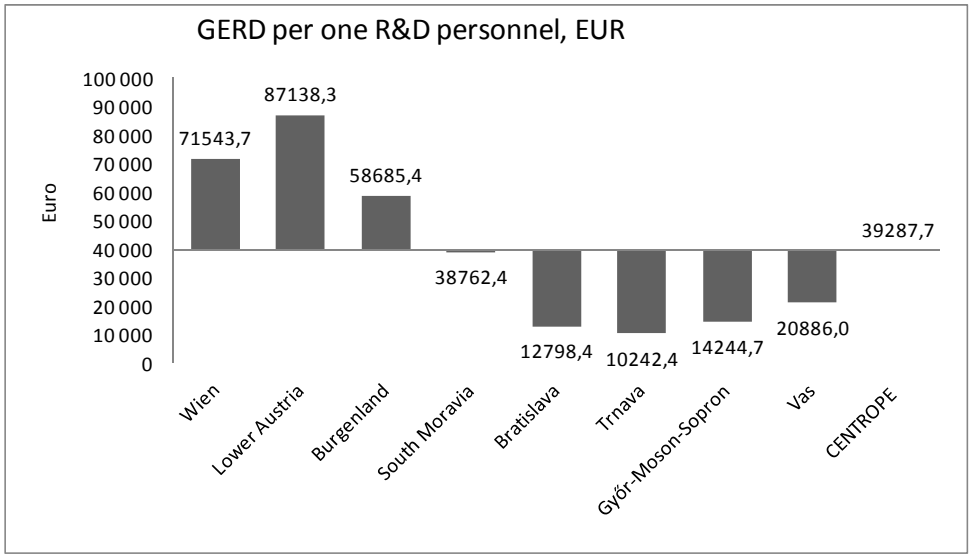
Sources: EUROSTAT – Regional science and technology statistics (reg_sct), Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

Figure 2.21: Shares of CENTROPE's total R&D expenditure, by region, %, 2009



Sources: EUROSTAT – Regional science and technology statistics (reg_sct), Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

Figure 2.22: Total R&D expenditure per one R&D personnel, €, 2009



Sources: EUROSTAT - Regional science and technology statistics (reg_sct), Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

- In terms of R&D expenditure, however, the Austrian region of Lower Austria takes the second rank among the CENTROPE regions. This underlines the low level of financing for R&D in many of the EU 10 regions of CENTROPE already found in the previous analysis and also leads to the fact that R&D expenditures per R&D personnel are almost incomparable between the Austrian CENTROPE and the other parts of the region. R&D expenditure per R&D personnel reaches from € 10,242 in Trnava to € 87,138 in Lower Austria. This therefore also suggests very sizeable differences in payment of R&D personnel in the two parts of the region.

CENTROPE can therefore be imagined as the focus point of the Austrian and Slovak national R&D resources (but not the Czech and Hungarian), because in these two regions approximately 45-50% of the total national expenditures and personnel are concentrated. Among the other six partner regions', by contrast only South Moravia on account of the city of Brno attains some importance in the CENTROPE, while all other regions have relative average share in their own country's total R&D expenditures and personnel of between 5 to 6%.

Table 2.14: Concentration of total national RDI resources in the CENTROPE regions

Regions	% of total national R&D personnel	% of total national researcher personnel	% of total national R&D expenditure
Vienna	*40.9*	*55.1*	*38.1*
Lower Austria	6.6	6.4	7.5
Burgenland	0.7	0.8	0.5
South Moravia	16.5	17.9	14.7
Bratislava	*48.0*	*48.0*	*51.5*
Trnava	5.0	5.0	4.3
Győr-Moson-Sopron	4.0	4.0	3.0
Vas	1.1	1.2	1.2
CENTROPE range (Max-Min)	**47.3**	**54.3**	**51.0**
Vienna and Bratislava (average)	**44.5**	**51.6**	**44.8**
Other regions (average)	**5.7**	**5.9**	**5.2**

Sources: EUROSTAT - Regional science and technology statistics (reg_sct) Statistical Yearbook of the Jihomoravský Region 2010 Yearbook of science and technology in the Slovak Republic 2010 Research and development 2009 - Hungary (Hungarian Central Statistical Office).

2.6. Conclusions

According to the Innovation Union Scoreboard 2010 the overall innovation performance of CENTROPE countries is very different. Austria is a member of the so-called 'innovation followers' with a position of 7th in the hierarchy while the Czech Republic (17th), Hungary (21th) and Slovakia (23th) are only the members of 'moderate innovators' with a significantly lower position in the ranking. Over a five-year period all European countries show an absolute improvement in innovation performance, but at very different speeds of growth. The annual growth rate of CENTROPE countries was between 1.2% (Hungary) and 2.8% (Czech Republic). The problem is that in the last five years the growth rate of Hungary and Slovakia was very slow in the group of moderate innovators.

The differences in the four countries' performance are smallest in the dimension of human resources (education) and finance and support (R&D expenditure, venture capital). Unfortunately in the other six dimensions (research system, investment, linkages, intellectual assets, innovators, economic effects) the gap between Austria and the other three, or Austria and Czech Republic and the other two countries is very wide which indicates a substantially different efficiency in the R&D system. So CENTROPE region is composed of national innovation and technology systems at very different stages of development.

The patterns of relative changes over time in the basic R&D and innovation statistics indicate a slow catch-up process (like R&D expenditures and personnel), or a consistent following-

the-global-international-trends-like process (employment and human resources in knowledge intensive science and technology sectors), where the initial internal regional differences and the lag of the CENTROPE states have remained. The third pattern is a mixture of increasing or decreasing performance indicators where the emphasis is on structural changes (like high-tech export) or on disadvantageous tendencies (like the low share of business enterprise sector R&D expenditure in the total amount of R&D expenditures).

Despite these differences, however, also some common weaknesses of the national R&D systems of the CENTROPE countries emerge. These apply in particular to the low share of population with tertiary education. This seems to be due to a substantial out migration of tertiary educated people from the region, and finance and support, which is due to the very low provisions of venture capital. This suggests that financing R&D and development of human resources are shared problems in the national R&D systems of the CENTROPE countries and could be a starting point for cross-border policies.

In particular the average growth rate of total intramural R&D expenditures (% of GDP) between 2000 and 2007 was 11% in CENTROPE which was higher than in the EU average. The problem is the low rate of total R&D expenditures in individual regions, in the CENTROPE average this is only 1.21% of the GDP (which is just 66 % of the EU 27 average expenditures). If we exclude Vienna this relative performance indicator drops to 44% of the EU average. The average growth rate of R&D personnel (RDP) indicator (12%) is also lower than the EU 27 average (20%) and the average of the four countries (27%). But the biggest problem is the unbalanced distribution of RDPs with a high concentration in the regions of the two capital cities. Without Vienna, the average ratio of total R&D personnel in the active population is only 52% of the EU 27 mean value among the CENTROPE regions.

The distribution of expenditures are thus very unbalanced with a high concentration rate in the capital regions. Only Vienna has a higher expenditure performance than the EU 27 average so the other regions are heavily underfunded.

If funding is the weak point in the system of R&D and innovation of CENTROPE then the pool of human resources (in quantity but not necessarily in quality) is a strong component. Each indicator is around or a little bit above the EU 27 counties' average and the internal regional inequalities are lower in this dimension. The internal distribution pattern of human resources is very different in the partner regions: in Hungary and Slovakia most of the R&D personnel work in the higher education sector, while in Austria, and mainly in Burgenland and Lower Austria most of them work in the business or enterprise sector. The number of

R&D personnel and researchers in the business and enterprise sector is very low in most of partner regions (except Vienna). Following the structural prerequisites of new, global, post-industrial service economies the average proportion of employment in high-tech manufacturing is about one third of all high-tech and knowledge intensive activities, while the share of knowledge intensive services is two thirds.

The biggest problem of a territorially reliable and precise statistical analysis is that at NUTS 3-level only the R&D performance (expenditure and personnel) is measurable and comparable; other indicators of innovation are missing. The results of the statistical analysis at NUTS 3-level using these indicators, however, confirm the same structural and distributional characteristics as on a NUTS 2-level. As before the two capital cities and their surroundings and the city of Brno emerge as most important players of CENTROPE's R&D system. The spatial concentration (relative regional frequencies) of the indicators is very high. Vienna's and Bratislava's combined relative share from all of the material and immaterial R&D resources (expenditures and personnel) of the whole macro region are between 72% and 76%.

Finally, there is also some evidence of different specialisations among the CENTROPE regions in the field of R&D and innovation. In particular the capital city regions of CENTROPE (Vienna and Bratislava) and to a slightly lesser extent Brno as the second largest Czech city are important centres of tertiary education in their respective countries and thus account for the high share of students living in the region. By contrast the more industrialized regions of the Hungarian and Slovak CENTROPE often have a stronger position in more applied research activities. This is also reflected in the fact that the centre of gravity of high-tech manufacturing employment is located in the Slovakian and Hungarian regions, while the knowledge intensive services are most strongly concentrated in Vienna and Bratislava.

To sum up: in the field of R&D and innovation CENTROPE is not a coherent and balanced region with equal spatial opportunities and potentials. The backbone of CENTROPE interregional R&D and innovation system is Vienna (expenditures, knowledge intensive services, high-tech employment), partially Bratislava (in terms of human resources) and also Brno, for which, however, we lack detailed data as a separate regional entity.

3. A relationship based analysis of the innovation system of CENTROPE

Authors: Peter Huber, Philipp Hergovich

3.1. Introduction

Aside from being characterized by a number of input and output indicators regional innovation systems are also marked by links and relationships between individual actors (inventors, firms and institutions conducting research) that are potentially located in different regions. These links have recently received high attention in the economic literature since a number of authors (e.g. Maggioni et al., 2011) have argued that their nature and structure are of importance to the performance of regional and sector innovation systems. As mentioned in the introduction of this study a number of studies have analysed linkages of universities and of research institutions participating in the 7th framework program in CENTROPE. In general the results of these studies seem to suggest that while the CENTROPE region is well linked with the EU27 and other parts of the world in terms of research co-operations, evidence of internal connectivity is somewhat weaker, with most of the links between capital cities of the CENTROPE countries serving as an indirect link to other actors of the CENTROPE region, but only few direct links. Therefore these studies seem to reflect many of the findings that also apply to cross-border trade, investment and labour flows.

In this chapter we therefore augment this information with respect to the innovation system of CENTROPE by using data on patenting activities with the European Patent Office (EPO) and thus focus on linkages in terms of more applied research than previous research on the CENTROPE. Our aim is to describe the relationships among both inventors and applicants within CENTROPE and of CENTROPE with other parts of the world. In particular we focus on three types of relationships that can be analyzed by means of our data:

1. Relationships between inventors (i.e. co-inventing relationships). As pointed out by Ejermo and Karlsson (2004) and Maggioni and Uberti (2009), amongst others, data on multiple inventors located in different regions can be considered to map a network of intentional knowledge exchange among regions. This can be assumed because the production of a patent by inventors located in different regions implies a flow of both

codified as well as tacit knowledge across these regions through different mechanisms (such as face-to-face contact, mail or others) to generate the knowledge embodied in a patent.

2. Relationships between inventors and applicants. – In contrast to the co-inventing relationships these relationships use the interaction between producers (inventors) and owners (applicants) of patents and can be seen as a proxy measure for the exchange or trade of knowledge between the creators (i.e. the inventors) and the owners (i.e. applicants) of a patent (see e.g. Breschi and Lissoni 2006 for a similar interpretation of inventor – applicant relationships). In addition such relationships also reflect the intra-company division of labour in multinational enterprises, which may potentially register patents in a different location than where the patent was developed (see Dettori et al., 2005). This may be of particular importance for the CENTROPE, because recent research on this region (Römisch et al., 2011, Huber and Römisch, 2011) suggests that CENTROPE is one of the top locations for foreign direct investments by multinational enterprises.
3. Relationships between applicants (i.e. co-applicant relationships) – These relationships, finally, can be considered a proxy for the interaction of owners of patents and the exchange of codified (in the form of patents) knowledge among them and will thus reflect inter- and intra-regional knowledge owner networks.

Thus the central objectives of this chapter are: first of all to find out how CENTROPE and its individual sub-regions are integrated into international and European inventor, applicant and inventor-applicant networks (i.e. the extent of external integration into different types of patenting relationships), second of all to analyze how strongly the individual sub-regions of CENTROPE are connected amongst each other in terms of these three types of networks (i.e. the extent of internal integration), third of all to compare CENTROPE to the EU 27 in terms of patenting activities and fourth of all to differentiate the structure of the different types of patenting networks both within the CENTROPE as well as to other countries by different types of technology (as measured by the ipc-code of the patent). Furthermore since our data also covers a rather long time span (of almost 20 years) we also aim to provide some evidence on the dynamics of patenting in the region.

3.2. Data

The data, we use for this purpose comes from the OECD REGPAT database[10] and contains detailed information on all of the inventors, applicants and technology fields of all patent applications registered with the EPO in the years 1975 to 2008. From this time period we, however, only use data from 1990 to 2008, because, given the dramatically different political situation in CENTROPE before 1990, it seems unlikely that (cross-border) co-operation in innovative activities in the CENTROPE is correctly proxied by data from the EPO before 1990.[11] These data report the ipc-code as well as the location (on a NUTS 3-level) of all inventors an all applicants to each and every patent registered with the EPO in this time period. Out of all these patents we select only those where at least one of the inventors or at least one of the applicants was located in the EU 27 at the time of registration.

3.2.1. Data on patenting according to region of residence of applicants

Thus within the framework of analysis chosen in this study we can analyze the data from two angles. The first of these is to look at European patenting activities from the point of view of applicants, as is also the case in official patenting statistics from EUROSTAT. In particular here we can count the number of EPO patents for which at least one applicant was located in CENTROPE (or for comparison reasons in one of the EU 27 regions).Table 3.1 reports some descriptive statistics of this data when analyzed from this perspective. As can be seen from this table our data cover a total of 763,880 patents registered at the EPO in the time period from 1990 to 2008 for which at least one applicant resided in the EU 27 at the time of registration. Furthermore, these patents had a total of 815,284 applicants, so that for the whole of the EU the average patent had 1.07 applicants. Among these patents 7,659 (or 1.0%) were registered by at least one applicant located in CENTROPE at the time of registration. These 7,659 patents involved 10.504 applicants (residing anywhere in the world) so that the average patent filed by an applicant from CENTROPE involved 1.37 applicants.

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[10] See Maraut et al. (2008),for a detailed description.

[11] In addition there is also some evidence that registration data in the last year of observation (2008) is still incomplete since a number of patents applied for in this year were still not granted at the time of drawing the data set (which was end of 2009). Nonetheless, we decided to include data from 2008 in our analysis, to also have access to recent data. This omission has rather little impact on our results given that we focus on data on 20 years of patenting activities.

The patents registered by applicants in CENTROPE are therefore less often multi-owner patents than patents registered in the remainder of the EU.

Furthermore, given that CENTROPE's share of total EU population is around 1.7%, but its share of patents registered by applicants residing in CENTROPE as well as its overall share of applicants ranges between 1.2% and 0.8% depending on the year of observation, with no sign of an upward trend, one would also conclude – at least from data on applicants – that CENTROPE contributes less than could be expected from population numbers to total patenting activities at the EPO.

Table 3.1: Patents and applicants to patents in the CENTROPE and the EU 1990-2008

	European Union			CENTROPE			Share of CENTROPE in EU	
	Patents	Applicants	Applicants per patent	Patents	Applicants	Applicant per patent	Patents	Applicants
1990	26,416	28,670	1.1	299	410	1.4	1.1	1.4
1991	26,271	28,631	1.1	309	560	1.8	1.2	2.0
1992	26,292	28,252	1.1	291	393	1.4	1.1	1.4
1993	27,427	29,678	1.1	321	423	1.3	1.2	1.4
1994	28,746	30,961	1.1	340	459	1.4	1.2	1.5
1995	30,269	32,510	1.1	306	439	1.4	1.0	1.4
1996	34,847	37,326	1.1	326	439	1.4	0.9	1.3
1997	39,364	41,817	1.1	314	394	1.3	0.8	0.9
1998	43,086	45,871	1.1	362	504	1.4	0.8	1.1
1999	47,188	50,113	1.1	408	555	1.4	0.9	1.1
2000	49,808	52,833	1.1	492	720	1.5	1.0	1.4
2001	49,445	52,488	1.1	499	718	1.4	1.0	1.3
2002	49,890	52,978	1.1	571	843	1.5	1.1	1.6
2003	51,052	54,283	1.1	575	826	1.4	1.1	1.5
2004	53,299	56,826	1.1	540	743	1.4	1.0	1.3
2005	54,528	58,002	1.1	513	669	1.3	0.9	1.2
2006	55,261	58,838	1.1	541	677	1.3	1.0	1.2
2007	48,699	51,954	1.1	409	471	1.2	0.8	0.9
2008	21,992	23,253	1.1	243	261	1.1	1.1	1.1
TOTAL	**763,880**	**815,284**	**1.1**	**7,659**	**10,504**	**1.4**	**1.0**	**1.3**

Source: EPO statistics, WIFO, own calculations. Note: table reports EPO patents with at least one applicant residing in the EU or CENTROPE, as well as the total number of applicants (irrespective of place of residence) involved in these patents.

3.2.2. Data on patenting according to region of residence of applicants

Table 3.2: Patents and inventors of patents in the CENTROPE and the EU 1990-2008

	European Union			CENTROPE			Share of CENTROPE in EU	
	Patents	Inventors	Inventors per patent	Patents	Inventors	Inventors per patent	Patents	Inventors
1990	27,428	59,520	2.2	361	593	1.6	1.3	1.0
1991	27,317	59,919	2.2	391	712	1.8	1.4	1.2
1992	27,523	59,846	2.2	333	647	1.9	1.2	1.1
1993	28,582	60,797	2.1	394	773	2.0	1.4	1.3
1994	30,312	65,388	2.2	403	761	1.9	1.3	1.2
1995	32,011	69,565	2.2	344	602	1.8	1.1	0.9
1996	37,118	81,298	2.2	464	896	1.9	1.3	1.1
1997	41,969	91,556	2.2	520	1019	2.0	1.2	1.1
1998	46,144	101,714	2.2	580	1199	2.1	1.3	1.2
1999	50,451	111,993	2.2	629	1244	2.0	1.2	1.1
2000	53,231	120,645	2.3	727	1605	2.2	1.4	1.3
2001	52,754	121,464	2.3	735	1609	2.2	1.4	1.3
2002	52,604	123,354	2.3	816	1,830	2.2	1.6	1.5
2003	53,898	125,693	2.3	899	1,927	2.1	1.7	1.5
2004	56,387	132,638	2.4	903	1,801	2.0	1.6	1.4
2005	57,750	135,390	2.3	932	1,937	2.1	1.6	1.4
2006	58,565	137,637	2.4	1,132	2,266	2.0	1.9	1.6
2007	51,640	120,357	2.3	910	1,923	2.1	1.8	1.6
2008	23,631	51,334	2.2	368	708	1.9	1.6	1.4
TOTAL	**781,887**	**1,770,588**	**2.3**	**11,480**	**24,052**	**2.1**	**1.5**	1.4

Source: EPO statistics, WIFO, own calculations. Note: table reports EPO patents with at least one inventor residing in the EU or CENTROPE, as well as the total number of inventors (irrespective of place of residence) involved in these patents.

Our data can, however, also be looked upon form the point of view of the inventors. In this approach we consider all patents for which at least one inventor is located in one of the regions of CENTROPE (or for comparison reasons of the EU 27). Table 3.2 considers our data from this point of view. It shows that in the period from 1990 to 2008 a total of 781,887 patents in our data involved at least one inventor from the EU and that a total 11,480 patents involved inventors from CENTROPE. In addition the 781,887 patents involving at least one EU inventor had a total of 1.8 million inventors (from all over the world) and the number of

inventors working on patents with at least one inventor from the CENTROPE was 24.052. The average number of inventors involved in one EU patent therefore was 2.3, among the CENTROPE patents this number was 2.1 inventors per patent. This thus suggests that patents originating from the CENTROPE (in terms of inventors) also involve fewer inventors than other EPO patents.

Looking at the data from this perspective, however, leads to different conclusions with respect to the position of CENTROPE in the European innovation system, since the share of patents involving at least one inventor in the CENTROPE is 1.5% of the EU 27 value, which is much closer to the CENTROPE's population share in the EU 27. Furthermore, this share has also trended upward in our observation period, so that towards the end of our period (i.e. the years 2006 and 2007) the CENTROPE's share in patents already exceeded its population share slightly. The share of inventors involved in CENTROPE patents is, however, also slightly less than 1%, so that here again the share is disproportionately low.

Taken together the low share of patents involving applicants from CENTROPE and the higher share of patents involving inventors, suggest that CENTROPE is a region where – relative to population size – a slightly above average number of patents is invented, but where also a below average number of owners of patents (i.e. applicants) are located. One explanation for this may be that the large number of multinational enterprises investing in the region, register the patents created in CENTROPE in other EU regions such as the location of the centre of the multinational enterprise.

Clearly, therefore, our data can generate new insights on the regional innovation system of the CENTROPE. Yet, there are also some drawbacks. The first of these is that they only capture certain parts of the links and relationships between individual actors that are characteristic of the regional innovation system. In particular we miss any links that arise between actors in innovative activities that do not result in a patent application or result in a patent application with other patent offices only. Although this limits the generality of our analysis, we still think that it has substantial value added. This is because, on the one hand, patenting activities have been uniformly considered as one of the most important output indicators of regional innovative performance in the innovation literature and because registration with the EPO guarantees a certain importance of patents from the point of view

of the applicant.[12] Furthermore, given the paucity of results with respect to the cross-border relationships in innovation activity, we think that the analysis of patenting activities, for which data is relatively easily available, is a natural starting point for an analysis of cross-border innovation system, which we hope can be extended upon in future research.

The second caveat with our data is that we know nothing about the importance of the patent in terms of its usability and about national differences in registration behaviour. This is a problem because as amply documented in the literature (see e.g. Czernitzki et al., 2011) some patents are of a rather limited value when considering citations and/or revenues and there are also substantial differences in patenting behaviour across industries and countries. While the latter will clearly lead to distortions in the evaluation of patenting behaviour, the former will lead to distortions only if the "quality" of patents differs systematically between patent registered from CENTROPE and EU inventors and applicants.

The third drawback of our data only reach to the year 2008 and are thus not very recent. This is, however, primarily due to the fact that patenting at the EPO is a rather complicated and time consuming process, with patents being granted only with a substantial time lag. Official data on patenting activities (on which this chapter is based) therefore only becomes available with a time lag of three to four years. Clearly this is an impediment to an analysis interested in the most recent developments. In this study we, however, analyse a rather long time period and find only little evidence of fundamental structural change over the last 20 years of our data. Given this finding (and the lack of alternatives) we, however, think that our analysis is highly likely to also capture the central tendencies of the current structure of patenting activities in CENTROPE.

Finally, our data also only cover patent applications and not registered patents. Our data thus are likely to more accurately capture innovative activity rather than protected innovations. This, however, arguably is also the more important indicator when it comes to evaluating the performance and interaction within a regional innovation system.

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[12] See Dettori et al. (2005) for a more detailed discussion of the advantages and disadvantages of using patent data to measure technological activity. In general one of the advantages of EPO data is that registration with EPO is costly and time consuming, which suggests that applicants are committed to the patent to some degree.

3.3. Extent of Patenting by NUTS 3 region and IPC class

Despite these drawbacks tables 3.3 to 3.6 present some descriptive statistics on to the extent of patenting activities in individual CENTROPE regions by different ipc-codes. In particular tables 3.3 and 3.4 show the number of patents for which there is at least one applicant residing in one of the CENTROPE regions as well as the ipc-codes under which these patents were registered for two sub-periods (the time period from 1990 to 1999 in table 3.3 and the time period 2000 to 2008 in table 3.4).[13]

Table 3.3: Number of patents by CENTROPE region of applicant and IPC class (1990-1999)

	Total	Total	A	B	C	D	E	F	G	H	Z
	Absolute	Per 1000 inhabitants									
Mittelburgenland	3	0.08	0.00	0.03	0.00	0.00	0.00	0.05	0.08	0.03	0.00
Nordburgenland	50	0.34	0.08	0.18	0.01	0.03	0.04	0.06	0.02	0.05	0.00
Südburgenland	5	0.05	0.01	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Mostviertel-Eisenwurzen	175	0.73	0.10	0.29	0.12	0.01	0.24	0.16	0.08	0.02	0.00
Niederösterreich-Süd	93	0.37	0.05	0.17	0.04	0.02	0.05	0.08	0.03	0.05	0.00
St. Pölten	83	0.56	0.09	0.20	0.09	0.01	0.14	0.13	0.06	0.01	0.00
Waldviertel	76	0.34	0.04	0.05	0.02	0.01	0.02	0.04	0.04	0.18	0.00
Weinviertel	10	0.08	0.02	0.03	0.02	0.01	0.01	0.02	0.00	0.00	0.00
Viennaer Umland/Nordteil	122	0.41	0.07	0.14	0.09	0.00	0.08	0.04	0.06	0.09	0.00
Viennaer Umland/Südteil	392	1.25	0.34	0.55	0.29	0.05	0.07	0.11	0.06	0.11	0.00
Vienna	2,192	1.31	0.53	0.30	0.43	0.01	0.14	0.15	0.21	0.13	0.00
South Moravia	33	0.03	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Györ-Moson-Sopron	9	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Vas	2	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bratislava region	21	0.03	0.01	0.01	0.02	0.00	0.00	0.01	0.01	0.00	0.00
Trnava region	10	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total	3,276	0.50	0.17	0.14	0.14	0.01	0.06	0.06	0.07	0.05	0.00
EU 27	**329,906**	**0.85**	**0.18**	**0.26**	**0.19**	**0.03**	**0.05**	**0.12**	**0.16**	**0.17**	**0.00**

Source: EPO statistics, WIFO, own calculations. Note table reports EPO patents with at least one applicant residing in the one of the CENTROPE regions. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others. Column sums do not add to total, because patents may be registered under more than one IPC-code.

[13] Note that patents may have more than one IPC-code.

3.3.1. Extent of patenting in CENTROPE according to region of residence of applicants

The first outstanding feature documented in these tables is the strong and persistent regional concentration of patenting activities in terms of applicants. In both time periods considered around two thirds of all patents, which had at least one applicant residing in CENTROPE were patents with an applicant from Vienna. The next most important region in both time periods was the southern environs of Vienna (Vienna Umland-Südteil) which held a share of between 12% (in the 1990 – 1999 period) and 7% (in the 2000-2008 period), all other regions held a share of patents of less than 5%.

Furthermore, despite substantial catching-up of the EU 10-country parts of CENTROPE in the last decade these regions still have a rather low number of patent applications per 1000 inhabitants. The cumulative share of the regions located in the Czech Republic, Hungary and Slovakia in total patenting according to residence of the applicant increased from just over 2% in the 1990 to 1999 period to over 4% in the period 2000 to 2008, but only the regions of South Moravia and the region of Bratislava account for a share of more than 1% of all patents according to residence of the applicant in the CENTROPE.

The second important feature shown in this table is that while the disadvantage of the EU 10-parts of CENTROPE with respect to patenting applies to almost all ipc-groups, the disadvantage of the CENTROPE relative to the European Union average does not. In particular in the later time period (i.e. from 2000 to 2008 – table 3.4) the number of patents per thousand inhabitant in the CENTROPE exceeded the EU average for patents in human necessities (IPC A) and fixed constructions (IPC E). These technology fields therefore seem to be the leading areas in terms of patenting activity, as measured by the number of applicants in CENTROPE. The most pronounced disadvantages for CENTROPE in this respect by contrast exist in patents performing operations, transporting (IPC B), physics (IPC G) and electricity (IPC H). In each of these fields the number of patents per 1000 inhabitants is by 0.1 patents per 1000 inhabitants lower in CENTROPE than in the EU average, when the residence of the applicant is taken as a criterion for assigning patents to regions.

Finally, a third stylised fact that arises from a comparison of tables 3.3 and 3.4 is that when considering all patents, the CENTROPE actually fell behind in terms of the number of EPO patents per 1000 inhabitants relative to the EU in the two time periods considered. While in the period 1990 to 1999 the number of patents in CENTROPE was by 0.35 patents per 1000 inhabitants lower than in the EU 27 average, it was by 0.45 patents per 1000 inhabitants

lower in the time period from 2000 to 2008. This finding, however, hinges on an adverse development in patents in the fields of performing operations and transporting, (IPC B), physics (PC G) and electricity (IPC H), while in all other fields the disadvantage in terms of patents per 1000 inhabitants of CENTROPE relative to the EU stagnated or even reduced between these two time periods.

Table 3.4: Number of patents by region of applicant and IPC class (2000-2009)

	Total	Total	A	B	C	D	E	F	G	H	Z
	Absolute	Per 1000 inhabitants									
Mittelburgenland	7	0.19	0.05	0.05	0.00	0.00	0.05	0.08	0.03	0.00	0.00
Nordburgenland	94	0.64	0.06	0.22	0.05	0.02	0.08	0.14	0.08	0.25	0.00
Südburgenland	61	0.63	0.03	0.05	0.10	0.00	0.05	0.12	0.04	0.36	0.00
Mostviertel-Eisenwurzen	182	0.75	0.10	0.32	0.08	0.02	0.21	0.14	0.04	0.02	0.00
Niederösterreich-Süd	154	0.61	0.12	0.23	0.06	0.02	0.12	0.16	0.06	0.03	0.00
St. Pölten	167	1.13	0.20	0.52	0.17	0.03	0.38	0.12	0.11	0.04	0.00
Waldviertel	140	0.63	0.05	0.12	0.09	0.04	0.09	0.10	0.07	0.23	0.00
Weinviertel	18	0.15	0.03	0.02	0.01	0.00	0.02	0.02	0.01	0.06	0.00
Viennaer Umland/Nordteil	210	0.70	0.24	0.14	0.12	0.01	0.09	0.10	0.09	0.13	0.00
Viennaer Umland/Südteil	292	0.93	0.27	0.27	0.13	0.02	0.15	0.08	0.17	0.10	0.00
Vienna	2,866	1.71	0.75	0.28	0.60	0.01	0.16	0.11	0.31	0.17	0.01
South Moravia	105	0.09	0.03	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.00
Györ-Moson-Sopron	15	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vas	5	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Bratislava region	52	0.09	0.01	0.01	0.03	0.00	0.00	0.02	0.02	0.01	0.00
Trnava region	15	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Total	4,383	0.67	0.24	0.14	0.19	0.01	0.08	0.07	0.11	0.08	0.00
EU 27	**433,974**	**1.12**	**0.23**	**0.29**	**0.20**	**0.03**	**0.06**	**0.16**	**0.22**	**0.23**	**0.00**

S: EPO statistics, WIFO, own calculations. Note table reports EPO patents with at least one applicant residing in the one of the CENTROPE regions. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others. Column sums do not add to total, because patents may be registered under more than one IPC-code.

3.3.2. Extent of patenting in CENTROPE according to the region of residence of inventors

In sum therefore our findings with respect to the number of EPO patents by the location of applicants suggest a strong concentration of the patenting activities in CENTROPE on the city of Vienna with the CENTROPE regions of the EU 10-countries lagging behind despite a catch-up process in the last two decades. Also they suggest that CENTROPE in aggregate has an advantage relative to other EU regions in terms of patents in the fields of human necessities (IPC A) and fixed constructions (IPC E), while it has an increasing disadvantage in the fields of performing operations, transporting (IPC B), physics (IPC G) and electricity (IPC H).

Table 3.5: Number of patents by region of inventor and IPC class (1990-1999)

	Total	Total	A	B	C	D	E	F	G	H	Z
	Absolute	Per 1000 inhabitants									
Mittelburgenland	8	0.21	0.08	0.08	0.00	0.00	0.03	0.00	0.11	0.00	0.00
Nordburgenland	127	0.87	0.20	0.40	0.11	0.02	0.08	0.12	0.02	0.12	0.00
Südburgenland	43	0.44	0.01	0.23	0.05	0.05	0.02	0.10	0.08	0.09	0.00
Mostviertel-Eisenwurzen	353	1.46	0.13	0.66	0.23	0.04	0.33	0.42	0.08	0.08	0.00
Niederösterreich-Süd	275	1.09	0.22	0.48	0.21	0.09	0.07	0.14	0.11	0.15	0.00
St. Pölten	180	1.22	0.19	0.35	0.22	0.18	0.25	0.17	0.15	0.11	0.00
Waldviertel	120	0.54	0.05	0.09	0.06	0.10	0.05	0.12	0.05	0.11	0.00
Weinviertel	50	0.40	0.06	0.10	0.09	0.01	0.03	0.10	0.06	0.11	0.00
Viennaer Umland/Nordteil	434	1.45	0.52	0.34	0.56	0.03	0.09	0.16	0.31	0.21	0.00
Viennaer Umland/Südteil	632	2.02	0.49	0.59	0.54	0.07	0.12	0.20	0.28	0.42	0.00
Vienna	2,042	1.22	0.40	0.28	0.31	0.02	0.12	0.11	0.22	0.21	0.00
South Moravia	71	0.06	0.02	0.01	0.03	0.00	0.01	0.01	0.01	0.01	0.00
Györ-Moson-Sopron	20	0.05	0.01	0.01	0.02	0.00	0.00	0.01	0.01	0.00	0.00
Vas	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bratislava region	55	0.09	0.04	0.02	0.04	0.00	0.00	0.01	0.02	0.00	0.00
Trnava region	8	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4,419	0.67	0.18	0.19	0.17	0.02	0.07	0.08	0.10	0.10	0.00
EU 27	**348,855**	**0.90**	**0.19**	**0.27**	**0.21**	**0.03**	**0.05**	**0.12**	**0.17**	**0.17**	**0.00**

Source: EPO statistics, WIFO, own calculations. Note table reports EPO patents with at least one inventor residing in the one of the CENTROPE regions. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others. Column sums do not add to total, because patents may be registered under more than one IPC-code.

These results, however, apply only to the patenting activities, when patents are allocated to regions according to the region of residence of the applicant (or patent owners). As shown above these results may change when the region of residence of the inventor is considered. For this reason tables 3.5 and 3.6 repeat tables 3.3 and 3.4 using this alternative method of allocating patents to regions. As can be seen from these tables this change leaves the result of a strong concentration of the EPO patenting activities in CENTROPE on Vienna unchanged. Concentration is only slightly reduced when patenting activities according to the residence of the inventor are considered. In this case Vienna accounted for around 45% of all patents in the CENTROPE and only three regions (the two Vienna environs regions Vienna Umland/Nordteil and Vienna Umland/Südteil as well as Mostviertel-Eisenwurzen) attain shares in patents that exceeded the 5% mark.

Table 3.6: Number of patents by region of inventor and IPC class (2000-2008)

	Total	Total	A	B	C	D	E	F	G	H	Z
	Absolute	Per 1000 inhabitants									
Mittelburgenland	13	0.35	0.05	0.16	0.03	0.03	0.03	0.08	0.03	0.08	0.03
Nordburgenland	228	1.56	0.41	0.51	0.36	0.03	0.10	0.33	0.09	0.19	0.01
Südburgenland	103	1.06	0.09	0.26	0.15	0.05	0.05	0.34	0.11	0.28	0.00
Mostviertel-Eisenwurzen	467	1.94	0.18	0.75	0.22	0.19	0.29	0.51	0.11	0.12	0.01
Niederösterreich-Süd	404	1.60	0.41	0.56	0.36	0.17	0.08	0.23	0.16	0.19	0.01
St. Pölten	314	2.13	0.21	0.53	0.20	0.71	0.24	0.24	0.31	0.23	0.00
Waldviertel	289	1.31	0.14	0.25	0.16	0.22	0.19	0.18	0.15	0.31	0.00
Weinviertel	173	1.40	0.23	0.20	0.19	0.02	0.10	0.13	0.31	0.52	0.00
Viennaer	698	2.34	0.57	0.45	0.60	0.07	0.19	0.28	0.40	0.48	0.02
Viennaer Umland/Südteil	869	2.78	0.81	0.69	0.72	0.04	0.18	0.31	0.56	0.46	0.01
Vienna	3,370	2.01	0.50	0.29	0.43	0.04	0.12	0.14	0.46	0.56	0.02
South Moravia	239	0.21	0.05	0.03	0.07	0.01	0.01	0.03	0.03	0.04	0.00
Györ-Moson-Sopron	37	0.08	0.02	0.03	0.03	0.00	0.01	0.00	0.00	0.01	0.00
Vas	14	0.05	0.03	0.01	0.02	0.00	0.00	0.01	0.01	0.00	0.00
Bratislava region	166	0.27	0.06	0.04	0.11	0.01	0.01	0.01	0.05	0.07	0.00
Trnava region	38	0.07	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Total	7,422	1.13	0.26	0.23	0.24	0.06	0.08	0.12	0.21	0.25	0.01
EU 27	**460,460**	**1.19**	**0.25**	**0.31**	**0.21**	**0.03**	**0.07**	**0.17**	**0.24**	**0.24**	**0.01**

Source: EPO statistics, WIFO, own calculations. Note table reports EPO patents with at least one inventor residing in the one of the CENTROPE regions. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others. Column sums do not add to total, because patents may be registered under more than one IPC-code.

Furthermore, also the impression of substantially lower EPO-patent registration rates in the CENTROPE regions of the EU 10 countries remains, although the disadvantages here are somewhat smaller. The cumulative share of all patents registered in the EU 10-country regions of CENTROPE attains almost 7% of all CENTROPE patents in the 2000 to 2008 period and South Moravia holds a share of more than 3% and Bratislava of more than 2%, when the location of the inventor is taken as a criterion for assigning patents to regions.

More importantly, however, this view on patent data dramatically changes both the findings on the technological areas in which CENTROPE has an advantage relative to the EU average and the findings on the dynamics of the innovation rate in CENTROPE relative to the EU. If patents are considered by the region of residence of the inventor, we find that in the 2000 to 2008 period the number of the patents per 1,000 inhabitants in CENTROPE exceeded the EU-level in human necessities (IPC A), chemistry, metallurgy (IPC C), textiles, paper (IPC D), fixed constructions (IPC E) as well as electricity (IPC H) and that the slight disadvantage of CENTROPE in the aggregate number of patents per 1000 inhabitants is exclusively due to a below average performance in performing operations, transporting (IPC B), mechanical engineering, lighting, heating, weapons, blasting (IPC F) and physics (IPC G).

Furthermore, when considering the changes in the number of patents per 1000 inhabitants over time periods, CENTROPE caught up relative to EU-levels not only in aggregate but also in each and every technology group but mechanical engineering, lighting, heating, weapons, blasting (IPC F). In particular in the period 2000 to 2008 the aggregate number of patents per 1,000 inhabitant in CENTROPE was only by 0.06 lower than in the EU average after having been by 0.33 patents per 1000 inhabitants lower in the 1990 to 1999 period, and in a number of technology groups (human necessities (IPC A), chemistry metallurgy (IPC C), textiles, paper (IPC D) and electricity (IPC H)) even overtook the EU average.

In sum therefore focusing on patenting data from the perspective of owners (i.e. applicants) and the perspective of creators (i.e. inventors) provides only modestly different results with respect to the internal structure of the innovation system in CENTROPE: According to both views EPO patents are strongly concentrated in Vienna (although less so when focusing on inventors) and in general patenting is less common in many of the EU 10-parts of CENTROPE than in the Austrian part (although this difference too is less dramatic when inventor data is considered).

By contrast, these two views of the data provide very different results on the technological performance of the CENTROPE-region relative to other EU-regions. Focusing on applicants suggests that the CENTROPE as an aggregate is a region with substantially lower patenting than other regions, has fallen behind in terms of patent applications relative to other EU regions in the last decade and has a revealed comparative advantage in patenting in only a few technology fields. By contrast when considering inventor data CENTROPE emerges as a region, which as an aggregate patents about as much as other regions of the EU, has substantially caught up in terms of patenting activities relative to other EU-regions in the last decade and has a revealed comparative advantage in patenting in most technology fields except for three (performing operations, transporting - IPC B, mechanical engineering, lighting, heating, weapons, blasting - IPC F and physics - IPC G).

3.4. Patenting Networks in CENTROPE

Taken together these results therefore suggest that CENTROPE is a region that takes a role in European patenting that differs somewhat from that of other regions. In particular it seems to be a region where there are a lot of producers of patents (i.e. inventors) but only few owners (i.e. applicants). Given this situation we would therefore also expect the patenting network structure (in terms of owner, inventor and inventor-applicant relationships) of the CENTROPE to differ quite substantially from that of other EU regions.

3.4.1. Owner networks

In table 3.7 we therefore provide some evidence on the structure of owner (or equivalently applicant) networks in CENTROPE. In particular in the first row of this table we report the number of patents registered at the EPO in which at least one of the applicants to the patent resides in the CENTROPE region, the second row of the table, by contrast, reports the total number of applicants that were applying to these patents. Thus for instance the first row of the first column of table 3.7 indicates that in the time period 2000 to 2008 7 patents, where one of the applicants resided in Mittelburgenland, were filed at the EPO, while the second row states that these 7 patents had a total of 8 applicants (that could potentially reside anywhere in the world). The third row finally states the total number of partners (excluding the original number of applicants in the region) for the patents, while the rows below this show the share of partners coming from a) the same region, b) another CENTROPE region of the same country c) another region in the country d) another CENTROPE region in a

different country e) a non-CENTROPE region in another CENTROPE country f) another EU 27 country g) another (Non-EU 27) European country and h) a country outside Europe. Finally, the last row shows the number of patents per applicant as an indicator of the overall applicant network size in patents.

Table 3.7 therefore shows the rather different structure of applicant networks for patents in the Austrian part of CENTROPE and the EU 10-part. In the Austrian CENTROPE patent applicants co-apply either with other applicants located in the same country or with an applicant from another EU 27 country outside the set of CENTROPE countries, all other regions but in particular the other CENTROPE countries, and regions, are rather unimportant co-operation partners.

Depending on the Austrian region considered between 20% to up to 100% of the co-applicants of patents from one of the Austrian CENTROPE regions are located in another Austrian region and up to almost 70% (in Vienna) of these partners are located in other EU 27 countries. Partners other than that have a share in excess of 15% only in a number of exceptional regions such as Südburgenland and Vienna. Most importantly, however, in the whole time period from 2000 to 2008 there was not a single case in which an applicant from the Austrian CENTROPE co-applied for a patent together with a partner from the EU 10-CENTROPE-regions and there are only 4 such partners that are located in one of the other CENTROPE-countries.

By contrast, for the EU 10-parts of CENTROPE although co-applicant networks are also strongly focused on national partners, – in particular when the region considered is not a capital city as is the case for South Moravia, the Hungarian regions and Trnava region, – or on EU partners (in particular for Bratislava region and Györ-Moson-Sopron) there is at least some evidence of cross-border co-operation in patent applications among the CENTROPE regions in Vas, South Moravia and Bratislava. None of these co-operations, however, is with an Austrian partner.

Table 3.7: Applicant networks for patents by region of applicant (2000-2008)

	AT111	AT112	AT113	AT121	AT122	AT123	AT124	AT125	AT126	AT127	AT130	CZ064	HU221	HU222	SK010	SK021
Patents (applicants)	7	94	61	182	154	167	140	18	210	292	2,866	105	15	5	52	**15**
Total Applicants	8	106	94	204	174	179	150	24	247	350	4,252	129	23	7	79	**29**
Partners	1	12	33	22	20	12	10	6	37	58	1,386	24	8	2	27	**14**
of this in %																
- Same country																
-- same region	*0.0*	*16.7*	*12.1*	*36.4*	*20.0*	*50.0*	*0.0*	*0.0*	*5.4*	*3.4*	*8.4*	*25.0*	*0.0*	*0.0*	*37.0*	***7.1***
-- CENTROPE region.	*0.0*	*25.0*	*0.0*	*13.6*	*0.0*	*41.7*	*20.0*	*33.3*	*51.4*	*53.4*	*2.9*	*-*	*0.0*	*0.0*	*11.1*	***21.4***
-- Other region	*100.0*	*8.3*	*21.2*	*40.9*	*20.0*	*0.0*	*10.0*	*50.0*	*18.9*	*8.6*	*5.4*	*54.2*	*62.5*	*50.0*	*11.1*	***57.1***
- Other country																
-- CENTROPE region.	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*4.2*	*0.0*	*50.0*	*11.1*	***0.0***
-- CENTROPE country	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	*7.4*	***7.1***
-- EU 27 country	*0.0*	*50.0*	*42.4*	*4.5*	*50.0*	*8.3*	*60.0*	*16.7*	*13.5*	*31.0*	*69.8*	*8.3*	*37.5*	*0.0*	*18.5*	***0.0***
-- other European	*0.0*	*0.0*	*9.1*	*4.5*	*5.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.7*	*8.2*	*8.3*	*0.0*	*0.0*	*3.7*	***7.1***
-- ROW	*0.0*	*0.0*	*15.2*	*0.0*	*5.0*	*0.0*	*10.0*	*0.0*	*10.8*	*1.7*	*5.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.0***
Memorandum Item																
Patent per Applicant	87.5	88.7	64.9	89.2	88.5	93.3	93.3	75.0	85.0	83.4	67.4	81.4	65.2	71.4	65.8	**51.7**

Source: EPO statistics, WIFO, own calculations. Note table reports EPO patents and applicant structure for patents with at least one applicant residing in the one of the CENTROPE regions. AT111 = Mittelburgenland, AT112 = Nordburgenland, AT113 = Südburgenland, AT121 = Mostviertel-Eisenwurzen, AT122 = Niederösterreich-Süd, AT123 = St. Pölten, AT124 = Waldviertel, AT125 = Weinviertel, AT126 = Viennaer Umland/Nordteil, AT127 = Viennaer Umland/Südteil, AT130 = Vienna, CZ064 = South Moravia, HU221 = Györ-Moson-Sopron, HU222 = Vas, SK010 = Bratislava region, SK021 = Trnava region.

In sum therefore cross-border co-operation among patent applicants located in CENTROPE seems to be a rather rare phenomenon altogether and whatever co-operation there is also seems to be limited to co-operation among partners located in the EU 10-parts of CENTROPE, while in terms of patent co-application Austrian partners literally never co-operated with a partner located in another CENTROPE region outside Austria in the eight years from 2000 to 2008.[14]

3.4.2. Co-inventor networks

The situation is slightly different with respect to co-inventor or patent creator networks (see Table 3.8). However, here too the low number of co-operations of Austrian inventors with inventors from one of the EU 10-CENTROPE-regions is striking. Even in the Austrian region, where cross-border co-operation with co-inventors for EPO patents from other CENTROPE regions is most important (Nordburgenland) only 0.7% of all partners come from the CENTROPE regions of EU 10-countries, and in total in the period from 2000 to 2008 Austrian inventors of EPO patents only had 42 co-inventors from the EU 10-regions of CENTROPE[15]. In the EU 10-country parts of CENTROPE, by contrast, cross-border co-operation from other CENTROPE-regions seems to be more common. In these regions the share of co-inventors from CENTROPE-regions in other countries exceeds 1% of all inventors. The only exception to this is the region of Vas, which in many ways resembles an archetypical rural-peripheral region in terms of co-invention relationships, since over 90% of the co-inventor relationships in this region are with other regions within Hungary.

In contrast to or instance results with respect to the 7 framework program (see ÖAR and CONVELOP 2011) we therefore find only little evidence of cross-border networks in inventing in within the CENTROPE, but rather an asymmetric pattern, in which the Austrian and EU 10-parts of CENTROPE stand apart, while there is more cross-border co-operation between the different EU 10-parts of CENTROPE. Furthermore in contrast to these results we also find no evidence that these networks for Austrian inventors are often mediated through the capital city regions of CENTROPE countries located outside the CENTROPE-region. Co-operation of Austrian inventors with other parts of the

[14] This also applies to the period from 1990 to 1999.

[15] For the 1990 to 1999 period this applies to 4 co-inventors from these regions.

CENTROPE-countries is also very rare and also here at most 0.7% of the co-operation partners of Austrian inventors come from other CENTROPE-countries. This therefore suggests that cross-border inventor networks, which are more strongly focused on applied research than the more basic research oriented 7th framework program co-operations, are even less developed in CENTROPE than cross-border basic research networks.

One consequence of the low share of co-operation partners from other CENTROPE-countries in Austria is that the share of co-inventors from the home country is much higher in most of the Austrian CENTROPE-regions than in the CENTROPE-regions located in the EU 10-countries. While among all of the Czech, Slovak and Hungarian CENTROPE-regions except for Vas the share of national co-inventors of EPO patents is around 60%, in the Austrian CENTROPE regions this share is above or round 80% in all regions but Vienna (where it amounts to 64%) and the southern Viennese environs (Wiener Umland-Südteil), where this share is 69.6%.

At the same time the low share of co-inventors from other CENTROPE-countries does not lead to a higher share of co-inventors from other countries. If anything co-inventors from countries outside the CENTROPE countries are also more rare among the Austrian CENTROPE regions than among the EU 10-CENTROPE-regions. Leaving aside the outlier of Vas, in the EU 10-CENTROPE-regions between 19.8% and 54.0% of the co-inventors come from a country other than the CENTROPE-countries. Among the Austrian CENTROPE regions this share is only higher in Südburgenland. Niederösterreich-Süd, St. Pölten, Viennaer Umland Süd and Vienna (i.e. 5 of 11 Austrian NUTS 3-regions in CENTROPE). In sum therefore co-inventor networks of inventors located in the Austrian CENTROPE – aside from not involving any inventors form other CENTROPE regions outside Austria are also in general less international than co-inventor networks in the EU 10-regions of CENTROPE.

Table 3.8: Applicant networks for patents by region of inventor (2000-2008)

	AT111	AT112	AT113	AT121	AT122	AT123	AT124	AT125	AT126	AT127	AT130	CZ064	HU221	HU222	SK010	SK021
Patents (inventors)	13	228	103	467	404	314	289	173	698	869	3,370	239	37	14	166	38
Inventors Involved	31	795	345	1,385	1,165	1,177	910	625	2,327	2,966	9,557	707	138	59	570	172
Partners	18	567	242	918	761	863	621	452	1,629	2,097	6,187	468	101	45	404	134
of this in %																
- Same Country																
--same region	*0.0*	*7.2*	*4.1*	*8.6*	*12.9*	*17.8*	*9.7*	*2.7*	*4.7*	*8.0*	*30.5*	*25.2*	*18.8*	*8.9*	*19.1*	*17.9*
-- CENTROPE region	*50.0*	*65.4*	*21.9*	*33.1*	*45.9*	*52.1*	*62.2*	*78.8*	*68.8*	*54.5*	*23.6*	-	*0.0*	*0.0*	*4.2*	*14.2*
-- other region	*38.9*	*15.0*	*52.1*	*38.6*	*15.5*	*9.5*	*13.0*	*6.0*	*6.9*	*7.1*	*9.7*	*18.8*	*42.6*	*84.4*	*10.4*	*17.2*
- Other Country																
-- CENTROPE region	*0.0*	*0.7*	*0.4*	*0.0*	*0.1*	*0.0*	*0.2*	*0.2*	*0.4*	*0.3*	*0.3*	*2.6*	*17.8*	*0.0*	*8.9*	*6.0*
-- CENTR Country	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	*0.0*	*0.0*	*0.2*	*0.2*	*0.1*	*0.3*	*0.0*	*1.0*	*0.0*	*7.9*	*19.4*
-- EU 27 Country	*0.0*	*7.2*	*16.9*	*17.1*	*19.8*	*16.8*	*12.4*	*10.4*	*15.0*	*23.7*	*27.3*	*34.0*	*16.8*	*2.2*	*36.6*	*20.1*
-- Other European	*11.1*	*0.9*	*3.3*	*1.2*	*0.9*	*0.7*	*0.8*	*0.9*	*0.7*	*1.8*	*2.3*	*5.6*	*0.0*	*0.0*	*8.4*	*3.7*
-- ROW	*0.0*	*3.5*	*1.2*	*1.4*	*4.2*	*3.0*	*1.8*	*0.9*	*3.4*	*4.5*	*5.9*	*13.9*	*3.0*	*4.4*	*4.5*	*1.5*

Source: EPO statistics, WIFO, own calculations. Note table reports EPO patents and inventor structure for patents with at least one inventor residing in the one of the CENTROPE regions. AT111 = Mittelburgenland, AT112 = Nordburgenland, AT113 = Südburgenland, AT121 = Mostviertel-Eisenwurzen, AT122 = Niederösterreich-Süd, AT123 = St. Pölten, AT124 = Waldviertel, AT125 = Weinviertel, AT126 = Viennaer Umland/Nordteil, AT127 = Viennaer Umland/Südteil, AT130 = Vienna, CZ064 = South Moravia, HU221 = Györ-Moson-Sopron, HU222 = Vas, SK010 = Bratislava region, SK021 = Trnava region.

3.4.3. Inventor-applicant networks

This finding also applies to inventor – applicant networks. In table 3.9 we report the location of the applicants of patents invented by CENTROPE inventors. This is particularly interesting because, as shown above, CENTROPE (in particular in the EU 10-parts) is a region in which there are relatively many inventors of EPO patents but only few applicants, so that many EPO patents invented in CENTROPE are registered at the EPO by applicants outside CENTROPE. Table 3.9 suggests that many of these applicants registering patents invented in the CENTROPE are located in EU 27-countries other than the CENTROPE-countries. In particular in all of the Austrian CENTROPE regions except for Mittelburgenland and Waldviertel more than 10% of the inventors of EPO patents are connected to applicants residing in other countries. In the EU 10-parts of the CENTROPE this share is even slightly higher in South Moravia and Bratislava and lower only in Vas.

Furthermore, the share of applicants of patents invented in CENTROPE residing outside Europe mostly ranges between 2% to 4% but exceeds the 10% mark in South Moravia. This therefore suggests that many of the patents invented in CENTROPE are registered by applicants residing in one of the EU 27 countries, which are also the main source countries for foreign direct investments in the CENTROPE (see Römisch and Huber, 2011).

Aside from this, however, the patterns of inventor-applicant networks in CENTROPE corroborate many of the previous findings. In particular, as with co-inventor and co-applicant networks – links of inventors from the Austrian CENTROPE-regions with applicants from the EU 10-parts are rare and Austrian inventor-applicant networks are less international than the inventor-applicant networks in the EU 10-parts of CENTROPE. In total in the time period 2000 to 2008 only 44 cases in which an applicant to a patent invented in the Austrian part of CENTROPE resided in one of the EU 10-parts of CENTROPE and in the Austrian CENTROPE the share of national applicants is above 80% in all regions but Vienna and Niederösterreich Süd, while it is 70% or lower in all of the EU 10-CENTROPE regions except for Vas.

Table 3.9: Inventor-Applicant networks for patents by region of inventor (2000-2008)

	AT111	AT112	AT113	AT121	AT122	AT123	AT124	AT125	AT126	AT127	AT130	CZ064	HU221	HU222	SK010	SK021
Patents (inventors)	13	228	103	467	404	314	289	173	698	869	3370	239	37	14	166	38
Applicants Involved	15	287	139	610	531	492	363	203	870	1179	6024	413	65	19	308	89
of this in %																
- Same Country																
-- same region	37.5	33.3	29.6	37.4	41.8	38.7	37.9	28.6	32.7	34.5	53.5	46.4	39.3	31.1	42.5	33.6
-- CENTROPE region	27.5	45.3	11.8	20.7	28.9	38.5	42.3	55.0	48.2	38.0	15.2		0.0	0.0	3.7	16.6
-- Other region	27.5	12.0	32.9	26.7	10.6	7.4	9.4	4.9	4.8	4.8	6.2	13.2	34.4	63.9	7.0	13.3
Other Country																
-- CENTROPE region	0.0	0.5	0.2	0.0	0.1	0.0	0.1	0.1	0.2	0.2	0.2		11.7	0.0	6.0	3.8
-- CENTROPE Country	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.1	0.1	0.3	0.0	0.6	0.0	8.4	15.2
-- EU 27	0.0	6.0	19.8	13.2	14.6	12.4	8.2	10.0	10.4	17.3	18.6	23.2	11.7	1.6	24.0	13.3
-- Other Europe	7.5	0.6	3.1	1.0	0.6	0.6	0.5	0.7	0.4	1.5	1.6	3.6	0.0	0.0	5.6	3.3
-- ROW	0.0	2.4	2.7	1.1	3.0	2.4	1.6	0.6	3.2	3.6	4.4	12.1	2.5	3.3	2.8	0.9

Source: EPO statistics, WIFO, own calculations. Note table reports the location of the inventors of patents invented by CENTROPE inventors. AT111 = Mittelburgenland, AT112 = Nordburgenland, AT113 = Südburgenland, AT121 = Mostviertel-Eisenwurzen, AT122 = Niederösterreich-Süd, AT123 = St. Pölten, AT124 = Waldviertel, AT125 = Weinviertel, AT126 = Viennaer Umland/Nordteil, AT127 = Viennaer Umland/Südteil, AT130 = Vienna, CZ064 = South Moravia, HU221 = Györ-Moson-Sopron, HU222 = Vas, SK010 = Bratislava region, SK021 = Trnava region.

Table 3.10: Applicant-Inventor networks for patents by region of applicant (2000-2008)

	AT111	AT112	AT113	AT121	AT122	AT123	AT124	AT125	AT126	AT127	AT130	CZ064	HU221	HU222	SK010	SK021
Patents (applicants)	7	94	61	182	154	167	140	18	210	292	2866	105	15	5	52	15
Inventors Involved	10	144	176	303	297	389	238	30	344	611	8325	245	40	7	144	69
of this in %																
- Same country																
--same region	80.0	84.5	57.0	82.8	82.4	94.5	89.0	62.8	76.5	80.0	64.0	74.6	47.7	66.7	69.8	52.9
--other CENTROPE	0.0	5.0	0.0	1.7	0.0	4.8	1.3	11.6	13.2	10.6	1.0	-	0.0	0.0	7.1	13.2
--Other region	20.0	1.9	8.2	12.8	3.1	0.0	0.9	20.9	3.5	1.7	1.6	19.7	40.9	22.2	3.2	23.5
- Other country																
-- CENTROPE region	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	11.1	4.0	0.0
-- CENTROPE Country	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	4.8	5.9
--EU 27	0.0	8.7	23.4	2.0	12.5	0.6	5.3	4.7	2.8	6.8	3.7	2.8	11.4	0.0	8.7	0.0
--other Europe	0.0	0.0	2.5	0.7	1.0	0.0	0.0	0.0	0.0	0.5	27.8	1.9	0.0	0.0	2.4	4.4
--ROW	0.0	0.0	9.0	0.0	1.0	0.0	3.5	0.0	4.1	0.3	1.7	0.0	0.0	0.0	0.0	0.0

Source: EPO statistics, WIFO, own calculations. Note table reports the location of the inventor of patents applied for by CENTROPE applicants. AT111 = Mittelburgenland, AT112 = Nordburgenland, AT113 = Südburgenland, AT121 = Mostviertel-Eisenwurzen, AT122 = Niederösterreich-Süd, AT123 = St. Pölten, AT124 = Waldviertel, AT125 = Weinviertel, AT126 = Viennaer Umland/Nordteil, AT127 = Viennaer Umland/Südteil, AT130 = Vienna, CZ064 = South Moravia, HU221 = Györ-Moson-Sopron, HU222 = Vas, SK010 = Bratislava region, SK021 = Trnava region.

3.4.4. Applicant-inventor networks

Table 3.11: Co-applicant and co-inventor networks for patents in CENTROPE by ipc-code (2000-2008)

	A	B	C	D	E	F	G	H	Z
					Co-applicant Networks				
- Same Country									
--same region	62.3	88.0	62.9	76.5	86.1	90.1	78.2	90.6	83.3
-- CENTROPE region	1.4	2.2	0.8	0.0	1.4	1.6	4.1	1.3	8.3
-- Other region	1.4	3.1	2.2	7.4	4.7	3.4	1.4	1.2	0.0
- Other country									
-- CENTROPE region	0.0	0.3	0.1	0.0	0.0	0.4	0.0	0.0	0.0
-- CENTROPE Country	0.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	0.0
-- EU country	1.5	3.3	2.6	9.9	7.4	3.2	2.0	4.7	0.0
-- Other European	31.0	2.7	28.9	6.2	0.3	1.0	13.3	0.8	8.3
-- ROW	2.5	0.4	2.0	0.0	0.0	0.0	1.1	1.3	0.0
Total Applicants	2,610	1,051	2,006	81	635	497	958	597	12
					Co-inventor networks				
- Same Country									
--same region	40.1	45.5	37.2	31.6	57.1	48.2	50.5	52.2	40.6
-- CENTROPE region	30.3	28.0	26.5	36.3	23.4	21.5	26.0	19.6	30.1
-- Other region	5.7	12.2	9.7	10.5	13.3	15.3	4.8	4.8	1.8
- Other country									
-- CENTROPE region	0.2	0.4	0.8	0.0	0.0	0.1	0.0	1.3	0.0
-- CENTROPE Country	0.5	0.2	0.7	0.2	0.1	0.2	0.4	0.3	0.0
-- EU country	15.1	11.5	18.7	19.8	4.9	13.0	12.1	19.1	25.6
-- Other European	2.2	0.7	2.4	1.0	0.5	0.8	1.2	0.6	0.5
-- ROW	6.0	1.6	4.2	0.6	0.7	0.8	4.9	2.1	1.4
Total inventors	6,576	4,154	7,050	1,615	1,064	2,062	3,881	4,084	219

Source: EPO statistics, WIFO, own calculations. – Note table reports EPO patents with at least one inventor residing in the one of the CENTROPE regions in the case of co-inventor networks and patents with at least one applicant located in the region for co-applicant networks. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others.

Finally looking at applicant – inventor networks (i.e. the location of inventors associated with an applicant for an EPO patent residing in one of the CENTROPE regions) in table 3.9, suggests that these networks are more strongly focused on national partners than

the inventor-applicant networks, which means that only few of the applicants for EPO patents in the CENTROPE are registering patents that were invented in other parts of the world. The only exceptions to this are the capital cities of Vienna and Bratislava and Südburgenland. In these regions the share of inventors from outside the own country that produce patents for which the applicant resides in CENTROPE is above 30% (for Vienna and Südburgenland) and 15.9% in Bratislava. For all other regions this share is (very often substantially) lower than 15%.

Furthermore, as already found previously for co-applicant networks, applicants located in the Austrian CENTROPE very rarely make use of inventors located in the EU 10-parts of CENTROPE. In our data we could not identify one such case in the time period 2000 to 2008. There is, however, some evidence of slightly more co-operation in the applicant-inventor networks among the EU 10-CENTROPE regions. Here in particular applicants from Györ-Sopron-Moson and Bratislava and to a much lesser extent South Moravia seem to co-operate with inventors from CENTROPE regions located in other countries than their own.

3.5. Sectoral Patenting Networks in CENTROPE

Aside from national and regional differences in the patenting network structure there are also relevant differences across different IPC (or technology) groups. In tables 3.10 and 3.11 we therefore plot the structure of co-inventing and co-patenting relationships (table 3.10) as well as the applicant-inventor and inventor-applicant relationships (table 3.11) of patents in CENTROPE. These tables suggest that the low intensity of cross-border patenting co-operation within CENTROPE found so far also applies to all IPC-groups of patents in all types of networks.

The share of partners from CENTROPE regions located in other CENTROPE countries is mostly below 1% of all partners in all types of networks and for all IPC-groups. The only exceptions are co-inventor networks and inventor applicant networks in electricity where, however, only 1.3% of the relationships are among partners located in CENTROPE regions of different countries. [16]

[16] Note that in these tables for the a co-inventor and inventor-applicant relationships we focus on patents for which at least one of the inventors is located in a CENTROPE region, while for the co-applicant and applicant-inventor relationships we consider patents for which one of the applicants is located in a CENTROPE region. Furthermore, also note that since patents can have more than one IPC code some patents may be considered more than once in these tables.

The important connections of both patent applicants and inventors in CENTROPE therefore are either located in the same country or in countries other than the CENTROPE countries. In this respect in particular the co-applicant as well as the applicant-inventor networks in the fields of human necessities (IPC A), chemistry and metallurgy (IPC C) have particularly numerous links to European countries outside the EU 27, since over a quarter of the relationships in these networks are with these countries. This also applies to co-applicant and applicant-inventor networks in the field of physics.

Table 3.12: Inventor-applicant and applicant-inventor networks for patents in CENTROPE by ipc-code (2000-2008)

	A	B	C	D	E	F	G	H	Z
					Applicant-Inventor				
- Same Country									
--same region	58.2	83.6	59.3	61.5	78.9	84.5	71.1	80.3	90.9
-- CENTROPE region	1.4	3.0	0.9	0.0	1.8	2.6	5.6	1.8	0.0
-- Other region	1.2	3.4	2.0	19.8	5.8	6.1	2.0	1.6	0.0
- Other country									
-- CENTROPE region	0.0	0.3	0.1	0.0	0.0	0.3	0.0	0.0	0.0
-- CENTROPE Country	0.0	0.0	0.5	0.0	0.0	0.3	0.0	0.0	0.0
-- EU country	1.6	5.3	3.4	13.7	13.1	4.9	2.5	11.3	0.0
-- Other European	35.4	3.7	31.8	4.9	0.4	1.3	17.2	1.1	9.1
-- ROW	2.3	0.7	2.0	0.0	0.0	0.0	1.7	3.8	0.0
Total relationships	6,099	1,748	4,958	182	1,026	757	1,792	1,043	22
					Inventor-Applicant				
- Same Country									
--same region	39.5	43.8	36.5	30.9	55.5	46.4	49.6	50.0	38.8
-- CENTROPE region	29.9	27.4	25.8	35.0	22.4	21.0	26.4	18.6	27.5
-- Other region	5.8	12.2	9.2	12.8	13.7	15.8	5.0	5.2	1.7
- Other country									
-- CENTROPE region	0.1	0.4	0.7	0.0	0.0	0.1	0.0	1.3	0.0
-- CENTROPE Country	0.5	0.2	1.1	0.2	0.1	0.6	0.4	0.3	0.0
-- EU country	14.9	13.4	19.5	19.4	7.1	14.2	12.3	21.4	30.4
-- Other European	2.4	0.7	2.2	1.2	0.7	1.1	1.3	0.7	0.4
-- ROW	7.0	2.0	4.9	0.5	0.6	0.7	5.0	2.5	1.3
Total relationships	7,522	4,550	8,251	1,693	1,163	2,276	4,262	4,388	240

Source: EPO statistics, WIFO, own calculations. – Note table reports EPO patents with at least one inventor residing in the one of the CENTROPE regions in the case of inventor-applicant networks and patents with at least one applicant located in the region for applicant-inventor networks. A = human necessities, B = Performing operations, transporting, C = Chemistry Metallurgy, D = Textiles, Paper, E = Fixed Constructions, F = Mechanical Engineering, Lighting, Heating, Weapons, Blasting, G = Physics, H = Electricity, Z = Others.

In the field of textiles and paper by contrast the EU 27 countries are an important co-operation partner in co-applicant and applicant-inventor networks, while in the field of fixed construction the same applies only to the applicant-inventor relationships. Finally, for both co-inventor and inventor-applicant relationships EU 27 countries outside the CENTROPE are an important partner in all fields except for fixed constructions.

3.6. Conclusions

In sum therefore focusing on patenting data of CENTROPE from the perspective of owners (i.e. applicants) and the perspective of creators (i.e. inventors) suggests that in CENTROPE EPO patents are strongly concentrated in Vienna (although less so when focusing on inventors) and in general patenting is less common in many of the EU 10-parts of CENTROPE than in the Austrian part (although this difference too is less dramatic when inventor data is considered). These two views of the data, however, also provide very different results on the technological performance of CENTROPE relative to other EU regions.

Focusing on patent applicants suggests that the CENTROPE as an aggregate is a region with substantially lower patenting than other regions, has fallen behind in terms of patent applications relative to other EU-regions in the last decade and has a revealed comparative advantage in patenting in only a few technology fields. By contrast, when considering inventor data CENTROPE emerges as a region, which as an aggregate patents about as much as other regions of the EU, has substantially caught up in terms of patenting activities relative to other EU regions in the last decade and has a revealed comparative advantage in patenting in most technology fields except for three.

Taken together these results therefore suggest that CENTROPE is a region where there are a lot of producers of patents (i.e. inventors) but only few owners (i.e. applicants). This situation is also reflected in the structure of cross-border patenting networks. In particular:

- Cross-border co-operation among patent applicants in CENTROPE is a rather rare phenomenon and whatever co-operation there, is also limited to co-operation among applicants located in the EU 10-parts of CENTROPE. In terms of patent co-application Austrian partners never co-operated with a partner located in another CENTROPE region outside Austria in the eight years from 2000 to 2008.

- Similarly co-inventor networks among CENTROPE partners also largely by pass the Austrian CENTROPE, while there is slightly more evidence of cross-border co-operation among partners from the EU 10-parts of CENTROPE. Aside from this, however, co-inventor networks are also in general more international in the EU 10 regions of CENTROPE than in the Austrian parts.
- Furthermore, applicants of patents invented in CENTROPE located outside CENTROPE are often located in the EU 27. Many of the patents invented in CENTROPE are therefore registered by applicants residing in one of the EU 27 countries, which are also the main source countries for foreign direct investments in CENTROPE.

4. Summary

4.1. Introduction

Regional competitiveness increasingly depends on the efficiency of businesses of a region and the regional innovative milieu determined by local externalities. While efficiency often has a strong connection to the innovativeness of a region's enterprises and their research and development activities, the innovative milieu is shaped by policy interventions at local and regional level, which target science and technological background, cluster processes and networks as well as other areas of knowledge transfer (although it is of course also affected by national policy).

The thematic focus report on technology policy, R&D and innovation of the CENTROPE Regional Development Report project monitored, took stock of and analysed the current R&D efforts and linkages (clusters/networks) within CENTROPE, with the aim of comparing the competitive position of the CENTROPE partner regions in a European context. A further focus was on how innovation is generated in CENTROPE, e.g. considering R&D conducted at company level or in co-operation with public institutions such as universities or in clusters/networks. Finally, the role of policy, both from a strategic and implementation point of view, was analysed. The central questions guiding the research were thus: How competitive is CENTROPE on the map of the EU wide science and innovation system? How can we describe the long term development of these performance indicators? Are there structural differences, regional concentrations and imbalances among the partner regions? What are the most significant strengths and weaknesses of the whole region and its territorial components in the field of R&D, science and innovation? What are the special R&D and innovation characteristics of the partner regions?

In consequence the elaboration of the thematic focus report on technology policy, R&D and innovation was based both on primary as well as secondary inputs, with secondary inputs coming from the available statistics, while primary inputs came from a series of country studies provided by each of the partners to the project. This report summarizes the results of our data analysis. Based on the available regional science and innovation statistics, it therefore first of all compares R&D expenditures and personnel, human resources in science and technology, employment in high technology sectors, and second of all European patent application to allow for a comparison of the R&D and innovation performance of CENTROPE regions amongst each other and CENTROPE to EU 27 averages.

4.2. The CENTROPE in the light of innovation indicators

Despite the somewhat strained data situation already a first analysis of the innovation systems of CENTROPE highlights a number of important stylised facts. The first of these is the vast heterogeneity among different parts of CENTROPE. This heterogeneity among regions applies in particular to the technological capacity in CENTROPE. This is already evident at the national level: According to the Innovation Union Scoreboard 2010 the overall innovation performance of CENTROPE countries is very different. Austria is considered to be a so called 'innovation follower' among the EU 27 countries and is ranked on 7th position in the EU by this source. The Czech Republic (17th), Hungary (21st) and Slovakia (23rd), by contrast, are only considered to be 'moderate innovators' with a significantly lower position in the ranking. At the same time also changes in technological capacity among CENTROPE countries – although indicating a catching up with respect to some indicators – have been very heterogeneous with in particular Hungary and Slovakia showing a weaker performance and Austria and the Czech Republic a better one. So even before moving to a regional analysis one has to acknowledge that the individual regions of CENTROPE are embedded in national innovation and technology systems at different stages of development.

Despite these differences, however, also some common weaknesses of the national R&D systems of the CENTROPE countries emerge. These apply in particular to the low share of population with tertiary education, which seems to be due to a substantial out migration of tertiary educated people from the region, and finance and support, which is due to the very low provisions of venture capital. This suggests that financing R&D and development of human resources are shared problems in the national R&D systems of the CENTROPE countries and could be a starting point for cross-border policies.

When moving to the regional level this heterogeneity is hardly removed, but is rather increased by the dominant position of the capital cities of Bratislava and Vienna in the region. These capital city regions obviously play quite a different role in their respective national innovation systems and in average host between 40% and 50% of CENTROPE's research personnel and also of the researchers. Aside from these two centres, however, also the city of Brno is a third – although perhaps somewhat smaller but rapidly developing - centre of R&D in the region. Although we lack data on Brno as a separate geographic entity in this study, many of our indicators suggest a strong position of South Moravia in the CENTROPE which can be traced back to the large number of universities and research institutions in Brno. Furthermore the primary inputs

collected in the stock taking report to this study document the ambitious development goals of Brno in the field of R&D and innovation.

A second stylized fact that emerges from the analysis of this data is, however, that despite this heterogeneity and thanks to the two capital cities, CENTROPE performs above EU 27 average with respect to many indicators. This applies in particular to measures of human resources devoted to research and development. Here with respect to each of the indicators, CENTROPE is around or a little bit above the EU 27 average and the regional inequalities are also lower in this dimension. In the Hungarian and Slovak CENTROPE most of the R&D personnel is working in the higher education sector, while in the Austrian CENTROPE, and mainly in Burgenland and Lower Austria most of the research personnel works in the business enterprise sector, while the number of researchers in the business and enterprise sector is very low in most the EU 10 CENTROPE regions.

Furthermore, while CENTROPE in aggregate has a share of R&D personnel in total employment which is higher than in the EU average, once Vienna is excluded from this statistic the average ratio of total R&D personnel in the active population is only 52% of the EU 27 average value. Similar observations also apply to other indicators at the NUTS 2-level. Similarly, the average proportion of employment in high-tech manufacturing (HTC) and high-tech knowledge intensive services (KIS) is approximately 4.8% relative to 3.7% in the EU and thus follows the structural necessities of modern, global, post-industrial service economies.

Another common feature shared by almost all of the CENTROPE regions (except for Vienna) is, however, the relatively low spending on R&D. Thus when total general R&D expenditure (GERD) as a % of GDP is considered Vienna is the only region with an above EU-average share among the CENTROPE regions and despite an average growth rate of total intramural R&D expenditures (in % of GDP) of 11% in CENTROPE between 2000 and 2007 – which was substantially higher than in the EU 27 – these growth rates of total R&D expenditures in the individual regions vary widely. Funding thus is definitely a weak point in the system of R&D and innovation of CENTROPE.

Finally, there is also some evidence of different specialisations among the CENTROPE regions in the field of R&D and innovation. In particular the capital city regions of CENTROPE (Vienna and Bratislava) and to a slightly lesser extent Brno as the second largest Czech city are important centres of tertiary education in their respective countries and thus account for the high share of students living in the region. By contrast the more industrialized regions of the Slovak and Hungarian CENTROPE often have a stronger position in more applied research activities. This is also reflected

in the fact that the centre of gravity of high-tech manufacturing employment is located in the Slovakian and Hungarian regions, while the knowledge intensive services are most strongly concentrated in Vienna and Bratislava.

To sum up therefore in the field of R&D and innovation CENTROPE is definitely not a coherent and balanced region with equal spatial opportunities and potentials. The backbone of CENTROPE interregional R&D and innovation system are the capital cities of Vienna and Bratislava as well as Brno, for which we, however, lack data as a separate regional entity. The other – often more industrialised regions – of the region in – by contrast are mostly involved in more practically oriented innovation activities.

4.3. Cross-border patenting networks

Aside from being characterized by a number of input and output indicators regional innovation systems are, however, also marked by a number of links and relationships between individual actors (inventors, firms and institutions conducting research) that are potentially located in different regions. These links have recently received high attention in the economic literature since a number of authors have argued that their nature and structure are of importance to the performance of regional and sectoral innovation systems.

Thus one of the central objectives of the focus report on technology policy, research, development and innovation in CENTROPE was also first of all to find out how CENTROPE and its individual sub-regions are integrated into international and European inventor, applicant and inventor-applicant networks (i.e. the extent of external integration into different types of patenting relationships), second of all to analyze how strongly the individual sub-regions of CENTROPE are connected amongst each other in terms of these three types of networks (i.e. the extent of internal integration), third of all to compare CENTROPE to the EU 27 in terms of patenting activities and fourth of all to differentiate the structure of the different types of patenting networks both within CENTROPE as well as to other countries by different types of technology (as measured by the ipc-code of the patent).

The data, used for this purpose came from the OECD REGPAT database and contained detailed information on all of the inventors, applicants and technology fields of all patent applications registered with the EPO in the years 1975 to 2008, with more recent data being unavailable due to the long time patents require for licensing. From this time period we, however, only use data from 2000 to 2008. These data report the ipc-code as well as the location (on a NUTS 3-level) of all inventors and all applicants

to each and every patent registered with the EPO in this time period. Out of all these patents we select only those where at least one of the inventors or at least one of the applicants was located in the EU 27 at the time of registration.

Therefore, within the framework of analysis chosen in this study we can analyze the data from the angle of applicants (or owners of patents), as is also the case in official patenting statistics from EUROSTAT, or from the point of view inventors (or actual creators of patents) from the CENTROPE region. One important result of this report is that these two views of the data provide rather different results:

- Focusing on patent applicants suggests that the CENTROPE as an aggregate is a region with substantially lower patenting than other regions, has fallen behind in terms of patent applications relative to other EU regions in the last decade and has a revealed comparative advantage in patenting in only a few technology fields. Furthermore from this perspective in CENTROPE EPO patents are strongly concentrated in Vienna.
- By contrast, when considering inventor data CENTROPE emerges as a region, which in aggregate patents about as much as other regions of the EU, has substantially caught up in terms of patenting activities relative to other EU regions in the last decade and has a revealed comparative advantage in patenting in most technology fields except for three.

Taken together these results therefore suggest that CENTROPE is a region where there are a lot of producers of patents (i.e. inventors) but only few owners (i.e. applicants). This thus reflects the structure of the region as a central location of FDI's in Europe. These foreign direct investors obviously often perform research leading to patents in CENTROPE, but register their patents elsewhere.

With respect to cross-border co-operation in patent applications we, however, find that this is rather rare both for applicants as well as inventors. In particular here co-operation between the Austrian CENTROPE and the other parts of CENTROPE is clearly below the levels that could be expected of a deeply integrated cross-border region. Here in particular:

- With respect to cross-border co-operation among patent applicants, whatever co-operation there is, is limited to co-operation among applicants located in the EU 10-parts of CENTROPE. In terms of patent co-application Austrian partners never co-operated with a partner located in another CENTROPE region outside Austria in the eight years from 2000 to 2008.

- Similarly co-inventor networks among CENTROPE partners also largely by pass the Austrian CENTROPE, while there is slightly more evidence of cross-border co-operation among partners from the EU 10-parts of CENTROPE. Aside from this, however, co-inventor networks are also in general more international in the EU 10 regions of CENTROPE than in the Austrian parts.
- Furthermore, applicants of patents invented in CENTROPE located outside CENTROPE are often located in the EU 27. Many of the patents invented in CENTROPE are therefore registered by applicants residing in one of the EU 27 countries, which are also the main source countries for foreign direct investments in CENTROPE.

4.4. Policy conclusions: Shaping the Nuclei of a cross-border innovation system

In sum, therefore, it would be premature to refer to the innovation systems of CENTROPE as a coherent and integrated cross-border innovation system. Much rather the emergence of such a system is in its infancy, and is likely to be confronted by repeated set-backs stemming from the rather different starting conditions and institutional background of the respective national innovation systems of the CENTROPE-countries. From a policy perspective, this implies that cross-border co-operation in the R&D field in the region is likely to be most beneficial to the individual regions if it focuses on individual sub-systems of the innovation system, and on concrete policies to be followed.

4.4.1. A more strategic approach to cross border co-operation is needed

Irrespective of the concrete policy field of co-operation, however, such co-operation – in particular in a field such as technology policy, where results of measures can often only be seen after a longer period of time – is likely to need a more strategic and long term approach to cross-border co-operation.

One striking feature of R&D and innovation policy in CENTROPE is that only very few of the regional innovation strategies consider co-ordinating or even exploiting the R&D resources of their neighboring regions: During its work on this report the research team could identify only one strategy document (in Lower Austria) which mentions the research and innovation potentials in the regions of other CENTROPE countries. Furthermore, also our finding that most of the existing cross-border co-operations in R&D and innovation policy are based on a project level and thus of a temporary nature

only, suggests that the idea of a more strategic approach to cross border co-operation in R&D and innovation policy is still in its infancy.

Nonetheless, several common goals, which may represent potential areas of cross-border co-operation, exist in the CENTROPE regions' strategy documents on technology policy. These are: the development of human resources (i.e. developing education and the improving the quality of the work force), the development of the technology transfer, the increase of cooperation between the science, education and business.

This suggest that attempts at a more strategic level long-term cross-border co-operation – as opposed to the current project based short term cross-border co-operation – could potentially yield substantial returns for all of the regions of the CENTROPE. Following such a more strategic approach would, however, also have to entail a major effort of concretization of what can be achieved through cross-border initiatives in these broad based priority topics. In this respect the current study can highlight some fields, which according to the analysis could become the nuclei of a cross-border innovation system.

4.4.2. University system and students could be nuclei for the development of cross-border innovation systems

In particular the university system in CENTROPE may be an area of joint co-operation from which all regions of CENTROPE could potentially profit. With a total of 61 institutions providing tertiary education CENTROPE (see Annex 1 for a list) and a total of almost 423.000 students in tertiary education, the CENTROPE hosts 2.2% of the student population residing in the EU 27, although its share of the overall population is only 1.6%. Thus the many students and universities of the region represent a valuable but still underutilized resource for regional development. In this area increased exchange of students and faculty as well as deepened co-operation in joint projects – which could in the long run potentially include very deep forms of integration such as the development of joint curricula – could be looked for.

This said it, however, also has to be acknowledged that while there are a large number of universities in the region only few of these rank high in international university rankings. Thus recent research on the mobility of students and co-operation intentions among the universities in CENTROPE finds that actors often prefer co-operation with more prestigious institutions located in other parts of the world. Any policy aiming at deeper integration of the institutions of tertiary education in CENTROPE is unlikely to yield substantial results, without efforts to also improve the performance of national

universities in the international arena, so that here there may be complementarities between developing international reputation and increasing regional co-operation.

4.4.3. Co-operation between the many clusters of the region could present another starting point for co-operation in more applied technology fields

A further area in which nuclei of co-operation could develop may be cluster policies. Each of the CENTROPE-regions has a number of clusters operating in the region and the current study has identified some 50 such clusters (see Annex 2 for a list) on the territory of CENTROPE, which are often focused on rather similar topics and follow comparable objectives. Again, however, increasing cross-border co-operation among clusters is not without challenge. Here in particular experiences in Austria have shown that even integrating clusters of different regions within one country can be a time consuming endeavour, given their differences in organisational structure and objectives. It is to be expected that in a cross-border context such co-operation is likely to be even more challenging and requires clear long term goals that would have to be formulated.

4.4.4. Reducing dependence on external patent applicants could be a joint goal of policy

A third potential common starting ground for cross-border initiatives could also be cross-border innovation and patenting networks. Here in particular the limited co-operation among the Austrian and EU 10-CENTROPE-regions is rather surprising, in particular since this lack of internal co-operation is accompanied by a relatively strong cooperation with international and EU partners. Depending on the form of co-operation and region considered between 10% and 20% of all co-operation partners for patenting network coming from other EU-regions. Furthermore these results suggest that patenting activities are more weakly linked than more basic research oriented activities (such as co-operation in the the 7th Framework Program). Here a recent study finds that the research institutions of the CENTROPE countries are well integrated into European research networks and that the institutions of the CENTROPE countries often co-operate with each other although some of the central actors (such as the Czech Academy of Sciences and the Hungarian academy of sciences as well as the Budapest University of Technology and Economics) are often located outside the actual CENTROPE region.

On the one hand side this may reflect the structure of the region, in which many FDI's – which are doing research in the region but are patenting in other regions. On the other

hand side this strong co-operation with other EU-regions also implies that many patents invented in the CENTROPE are registered somewhere else and therefore that the ownership (and economic value) of many innovations invented in CENTROPE accrues somewhere else. Thus one strategy of the CENTROPE could be to increase not only the numbers of inventors in the region but also the number of patent applicants. This could potentially also be done by increasing co-operation in the region. Among the instruments that could be used for this in the short run financial incentives (such as for instance the cross-border research voucher scheme developed and implemented in the CENTROPE-project) and increased awareness building (e.g. through information activities etc.) could be used.

Yet again these instruments – as valuable as they are – are likely to only alleviate but not solve the problem. In particular funds provided in a cross-border context are unlikely to become very large in the near future, given that national governments are mostly interested in financing their respective national innovation systems, and provision of information is unlikely to generate the large number of projects one would like to see developed in the region. These short run measures therefore should also be accompanied by more long run indirect measures (e.g. student exchange, English language training) which are complementary to integration in international networks.

4.5. Literature

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Annex 1 Factsheet – A numerical summary

CENTROPE as a combination of NUTS 3 regions	
Indicators	**Statistics**
Number of R&D personnel (2009)	67,697
Number of researcher (2009)	45,403
Researcher as a percent of total R&D personnel (2009)	66.7%
R&D expenditure – million EUR (2009)	3,706
Average annual R&D expenditure per one R&D personnel – EUR (2009)	39,288
Relative share of CENTROPE region from the national total R&D expenditure (2009)	
- Vienna and Bratislava	44.8%
- Other CENTROPE regions (average) - (2009)	5.2%
Share of CENTROPE region from the national total R&D personnel (2009)	
- Vienna and Bratislava	44.5%
- Other CENTROPE regions (average) – (2009)	5.7%
Share of CENTROPE region from the national total researcher personnel (2009)	
- Vienna and Bratislava	51.6%
- Other CENTROPE regions (average) – (2009)	5.9%
CENTROPE as a combination of NUTS 2 regions	
Indicators	**Statistics**
Total GERD – million EUR (2007)	3,648
CENTROPE relative share as % of EU 27 total GERD (2007)	1.6%
Total GERD as % of GDP (2007)	1.21%
CENTROPE average regional GERD as percent of EU 27 average GERD (2007)	65%
CENTROPE average regional GERD as percent of EU 27 average GERD – without Vienna (2007)	44%
Total GERD, EUR per inhabitant (2007)	353,euro
Total GERD in business enterprise sector as % of GDP (2007)	0.75%
Relative share of business enterprise sector in the total GERD (2007)	64%
Relative share of Vienna from the total GERD of CENTROPE (2007)	72%
R&D personnel – head count (2007)	73,845
R&D personnel as percent of active population (2007)	1.6%
CENTROPE average R&D personnel ratio as percent of EU 27 average (2007)	111%
Relative share of Vienna from the total R&D personnel of CENTROPE (2007)	49%
Relative share of business enterprise sector in the total number of R&D personals (2007)	45,2%
Number of students in tertiary education (2009)	422,895
Ratio of students in tertiary education (2009)	22.9%
Person aged 25-64 with tertiary education (2010)	20.9%
Employment in (HTC) high-technology and knowledge-intensive sectors (2009)	180,902
Ratio of HTC employment in all of the NACE activities (2009)	4.8%
Employment in (KIS) knowledge-intensive sectors (2009)	120,291
Ratio of KIS employment in all of the NACE activities (2009)	3.2%
Ratio of KIS as % of all HTC employment (2009)	66%
Number of human resources in science and technology (HRST) – thousand (2010)	1,854
Human resource as % of active population (2010)	37.6%

Sources: EUROSTAT - Regional science and technology statistics (reg_sct), Statistical Yearbook of the Jihomoravský Region 2010, Yearbook of science and technology in the Slovak Republic 2010, Research and development 2009 - Hungary (Hungarian Central Statistical Office).

Annex 2: Universities in CENTROPE

	Name	Location	Students
Slovak CENTROPE	Comenius University in Bratislava	Bratislava	24,292
	University of Cyril and Method in Trnava	Trnava	5,910
	Bratislava International School of Liberal Arts	Bratislava	57
	Paneuropean University	Bratislava	4,214
	Slovak Medical University in Bratislava	Bratislava	2,653
	University of health and Social Work Sv. Alžbety	Bratislava	11,745
	Trnava University in Trnava	Trnava	7,414
	Slovak University of Technology in Bratislava	Bratislava (1 faculty Trnava)	17,697
	University in Sládkovičove	Sládkovičovo	3,014
	University of Economics	Bratislava	12,697
	School of Economics and Management in Public administration in Bratislava	Bratislava	4,287
	Police Academy in Bratislava	Bratislava	1,478
	Centraeuropean University	Skalica	1,109
	Academy of Performing Arts	Bratislava	977
	Academy of Fine Arts and Design	Bratislava	616
Czech CENTROPE	Mendel University Brno	Brno	10,617
	Masaryk University Brno	Brno	38,216
	STING Academy Brno	Brno	941
	Karl Englis College Brno	Brno	575
	Rašín college, Brno	Brno	464
	NEWTON College, Brno	Brno	279
	B.I.B.S – Brno International Business School	Brno	478
	Private College of Economic Studies Znojmo	Znojmo	789
	College of Business and Hotel management, Brno	Brno	359
	Real Estate College – Institut of Frank Dyson, Brno	Brno	20
	Brno University of Technology	Brno	21,695
	University of Veterinary and Pharmaceutical Sciences	Brno	2,899
	University of Defence	Brno	1,912
	Janacek Academy of Music and perormig Arts	Brno	695
Hungarian CENTROPE	Széchenyi István University, Győr	Győr	10,786
	University of West Hungary,	Sopron	14,261
	Theological College, Győr	Győr	153
	Berzsenyi Daniel Tanarkepzo Foiskola Szombathely	Szombathely	245
Austrian CENTROPE	University of Vienna	Wien	85,708
	Medical University of Vienna	Wien	7,381
	Technical University Vienna	Wien	23,438
	University of Natural Resources and Life Sciences,	Wien	9,127
	University of Veterinary Medicine	Wien	2,320
	University of Economics and Business Administration	Wien	26,825
	Danube University (Universität für Weiterbildung)	Krems	5,054
	Academy of fine Arts Vienna	Wien	1,211
	University of Applied Arts Vienna	Wien	1,586
	University of Music and Performing Arts Vienna	Wien	3,091
	Danube Private University	Krems	44
	Modul University Vienna	Wien	231
	PEF, Privat University for Management Vienna	Wien	79
	New design University St. Pölten	St.Pölten	218
	Konservatorium Wien University	Wien	908
	Sigmund Freud University Vienna	Wien	716
	Webster University Wien	Wien	537
	University of Applied for defence and Sports	Wien	314
	University of Applied Sciences Campus Wien	Wien	3,215
	University of Applied Sciences bfi Vienna	Wien	1,502
	University of Applied Sciences St. Pölten	St.Pölten	1,698
	University of Applied Sciences Technikum Wien	Wien	2,939
	University of Applied Sciences Wiener Neustadt	Wr. Neustadt	2,763
	University of Applied Sciences Burgenland	Eisenstadt / Pinkafeld	1,453
	Fachhochschul-Studiengänge der Wiener Wirtschaft	Wien	2,362
	University of Applied Sciences Vienna	Wien	305
	IMC University of Applied Sciences Krems	Krems	1,750
	Lauder Business School	Wien	296

Notes: Data for Austria, the Czech Republic and Hungary refer to the year 2009/10, Data of Slovakia to the year 2010/11.

Annex 3: Clusters in CENTROPE

Austria

- Life science cluster of the Vienna region (LISAVR) – http://www.lisavr.at/siteLayout.php
- Mobility Cluster Vienna – http://www.clusterwien.at/
- Food cluster Lower Austria – http://www.ecoplus.at/en/ecoplus/cluster/food
- Green building cluster Lower Austria – http://www.ecoplus.at/en/ecoplus/cluster/green-building
- Plastics-cluster of Lower Austria – http://www.kunststoff-cluster.at/
- Logistics cluster of Lower Austria – http://www.ecoplus.at/en/ecoplus/cluster/cluster-logistics-lower-austria
- Mechatronics cluster in Lower Austria – http://www.mechatronik-cluster.at/
- Well-being cluster Lower Austria – http://rdir.at/ecoplus/cluster/wbc_en/34800.htm
- Umweltcluster Wien – http://www.wirtschaftsagentur.at/service/technologienetzwerke/fokus_umwelt/
- IT-cluster of Vienna – http://it.clusterwien.at/page.aspx
- ICT Cluster Burgenland – http://www.ict-burgenland.at/
- Plastics-Cluster Burgenland – http://www.kunststoff-burgenland.at/pages/en/plastics-cluster.php
- Austrian Traffic Telematics Cluster (ATTC) – http://www.attc.at/
- Rail Technology Cluster Austria (RTCA) – http://www.rtca.at/
- Austrian Aeronautics industries group – http://www.aaig.at/
- Austrian Automotive Association – www.aaa.or.at/
- Network Metal – http://www.netzwerk-metall.at/

Czech Republic

- Water Treatment Alliance – http://www.wateralliance.cz/
- Czech Furniture Cluster – http://www.furniturecluster.cz/?lang=en
- CEITEC Bioinformatics cluster – http://www.ceitec-cluster.com/
- CREA Hydro&Energy – http://www.creacz.com/
- ENERGOKLASTR – http://www.energoklastr.cz/cz/
- NetSecurity Cluster – http://www.nsmcluster.com/en/
- Innovation in transport – http://www.nca.cz/cs/katalog-eskch-klastr

Hungary

- Arrabona West-Transdanubian Regional Cluster for Environment Protection – no homepage found
- Biogas and Fermentation Cluster – no homepage found
- Hungarian Furniture Industry Cluster – http://www.mabuk.hu/index.html
- West-Transdanubian Winery and Wine Tourism Cluster – http://www.soproniborvidek.hu/hu/nyertesprojekt.php?link=klaszter
- West-Pannon Eco-cluster – http://www.okoklaszter.hu/
- Pannon Automotiv Cluster – http://www.autocluster.hu/content_2-en.html
- Pannon Wood and Furniture Industry Cluster – http://www.panfa.hu/
- Pannon Local Product Cluster – http://www.zalaifalvak.hu/index.php?cid=394

- Pannon Information Technology Cluster – http://www.it-klaszter.hu/
- Pannon Logistics Cluster – http://www.panlogklaszter.hu/
- Pannon Mechatronics Cluster – http://www.pfa.org.hu/panel /
- Pannon Renewable Energy Cluster – http://www.panenerg.hu/projektek/a-pannon-megujulo-energia-klaszter-szolgaltatasainak-fejlesztese#
- Pannon Thermal Cluster – http://spahungary.info/index.php
- Pannon Textile Cluster – no homepage found
- Professio Metal Works Vocational Education Cluster – http://professio-gyor.hu/
- Regional Pellet Cluster – http://www.pannonpellet.hu
- Sopron Region Informatics Cluster – http://www.itklasztersopron.hu/
- Sopron Region Logistics Cluster – http://www.gysevcargo.hu/en/our_services/logistics/sopron_region_logistics_cluster/
- T-Arrabona Second-Tier Supplier Cluster – no homepage found
- Content and Knowledge-industry Cluster – http://ttklaszter.pannonprojekt.hu/
- West-Pannon Audiovisual Cluster – no homepage found
- Hungarian Vehicle Engineering Cluster – http://www.engineering-cluster.com/

Slovakia

- Autocluster – West Slovakia (AKS) – http://autoklaster.sk/
- Electronics Cluster West Slovakia (EKS) – http://www.elektroklaster.sk/
- The Energy Cluster CENTROPE – http://www.centrope.com/de/newsletter-3-2011/energie-cluster-centrope
- Energy Cluster West Slovakia – http://www.enks.sk/
- Tourism Cluster - West Slovakia – http://www.trnava-vuc.sk/

Source: Own research.