UNIVERSITY OF ECONOMICS AND MANAGEMENT

CES

CENTRE FOR ECONOMIC STUDIES

Inputs and outputs of innovation performance

Anna Kadeřábková, Karel Müller

Working Paper N° VII/2006

Č

Abstract:

Keywords:

JEL Classification

About authors:

□ *ř*

Reviewers:

č

č

Č

Content

1. Introduction

This section presents assessment of key aspects of a national innovation system (NIS) according to its inputs (including their structural characteristics), specific infrastructure conditions and outputs (innovation performance and quality of innovation environment). Presentation of the concept of a national innovation system draws on findings of economic and social studies of science, technology and innovations, and defines an appropriate framework for analysing innovation activities. A relatively reliable set of indicators and databases in this area allows determining not only the existing structural differences between individual national systems, but also certain trends in development of the sources of research and development. Results of this analysis are applied especially in identification of structural barriers that limit integration of domestic research and development into the innovation context and its use for the growth of innovation performance of domestic actors.

2. National innovation system concept and opportunities for its use in the situation of the CR

The national innovation system concept places emphasis on applying the national context in the approach to innovation and the fact that innovation is not influenced by a single factor or source but is a result of interaction of multiple sources and factors with a systemic character. Both of these aspects are currently a subject of critical studies – the national context is weakened by globalising effects, while the systemic concept, which requires a certain level of social consensus, tends to give way to the influence of conflictual approaches. However, the NIS concept remains the most productive approach to analysing innovation sources and innovation performance. It has been accepted as a framework for international studies on innovation (*Community Innovation Survey* – CIS) and is applied in the regulatory efforts of EU authorities and national governments dedicated to creating a European Innovation Area (EIA).

Interpretation framework for a national innovation system was influenced by two significant motives. The first motive draws on development of neo-Schumpeterian economics, which study changes in relationships between science and technology in developed countries. This angle of research was strongly supported by OECD and contributed to development of indicators of science and technology, analyses of this area and conceptual ideas, but also options for their practical application (at regular meetings of ministers for science and technology). A concept definition of a national research system was also created directly as a result of extensive empirical research carried out at the end of the 80's and beginning of the 90's and including 15 OECD member states. Although a great degree of diversity in the institutional structure and regulatory practices with regard to innovation was detected between monitored countries, some identical characteristics were also detected in both areas. This finding allowed defining **generally shared** (and therefore to a certain extent inevitable) conditions for the function of national innovation systems of modern societies and these were defined as follows (see Nelson, 1992):

- Comprehensive interconnection between science and technology characterised by a certain method for technical design and practices, and a system of increasing scientific knowledge surrounding it; a national education system is an institutional basis of this scientific and technological complex and is structured according to this complex; this is why effective interaction between **universities and the companies** as a source of long-term economic growth occurs;

- Innovation activity of private enterprises or companies, which is seen as the ability to adjust to new circumstances (and therefore exceeds the technological and research capacity of the relevant companies); technological competence and **orientation of companies** is based on company's own laboratories, as well as its relations with suppliers and customers;
- **Activity of governments** directly supporting innovation activities or creating a constructive environment through monetary, fiscal and industrial policies and influence on the educational system.

The Czech Republic has all basic conditions for applying the national innovation concept as defined by the original model (see Nelson, 1992). There is long-term experience in development of academic science (university education combined with research), corporate science (research laboratories in companies) and public political support for research, including regulatory and administrative practices for its implementation.[1] The viability of this tradition was not lost even in situations of radical intervention in the institutional organisation of research (nationalisation of science in the 50's and its subsequent privatisation at the beginning of the 90's). The importance of research at universities is gradually restored and corporate research has also recovered from the shock of privatisation. This is why research could be relatively easily monitored according to standard indicators.[2] Standard forms of financing and implementing research – the so-called research sectors (business enterprise, academic, public, non-profit, and foreign) and accessible and comparable indicators of their sources and inputs have been established in addition to the above mentioned restoration of academic and industrial science.

Weaknesses of the national innovation system stem from the current transformation of the economic and social environment in general and from institutional organisation of research and development in particular: new trends are enforced under the influence of structural bonds with regard to distribution of resources and persistence of established practices in conduct and decision making. Yet another reason stems from the relatively demanding pressure on formal acceptance of the institutional framework of the EU and its qualitative requirements as defined in the Maastricht memorandum. As these requirements are applied, weaknesses of the national innovation system arising from its **insufficient interactive and systemic qualities** become clearly apparent. These weaknesses were especially obvious in the assessment of the status of innovation policy in the Czech Republic carried out in connection with the accession to the EU (see EC, 2001).

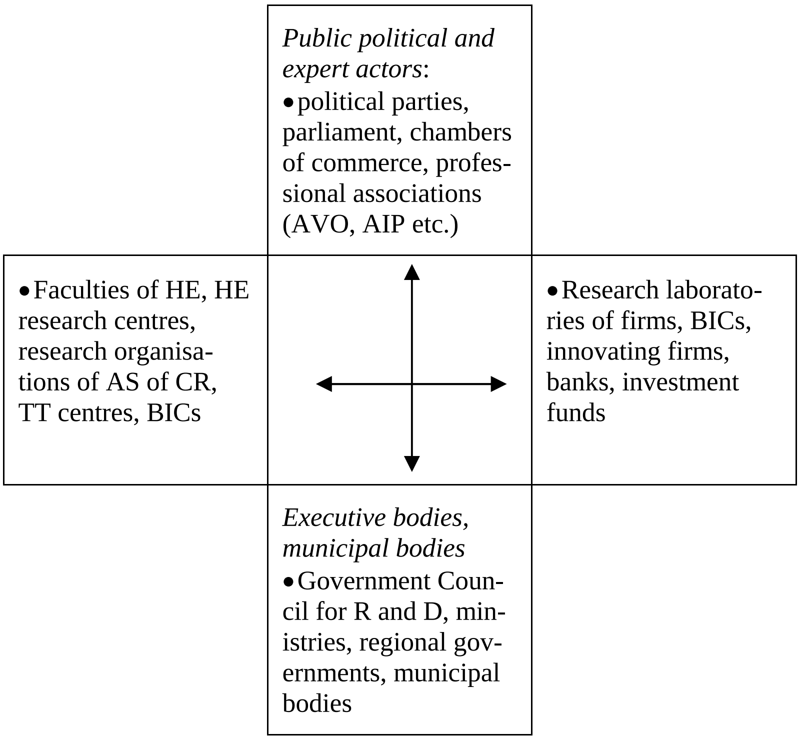
The policy of the Czech government increasingly focuses on the topic of innovation and an extensive support for these activities is available from professional association and professional public. However, effective regulatory measures and institutional changes in this area have not been enforced. The importance of large domestic companies in research and innovation is declining (especially due to changes in ownership structures), although these companies continue to account for a relatively large portion of the overall research and innovation in business enterprise sector (BES). On the other hand, the influence of large foreign companies in this area increases. Medium sized and small

[1] This arrangement relates to the so-called German model of science organisation, which was developed during the Wilhelmian period, later adopted in North America and subsequently applied in general. Naturally, it strongly influenced the situation in the Czech territory (for more details see Müller, 2002).

[2] ČSÚ has been monitoring research and development according to the Frascati manual since mid 90's and has carried out two innovation studies according to the Oslo manual.

companies were established as large companies fell apart with relatively limited finance options and often with insufficient demand and this created intolerable competitive pressure rather than systemic arrangement of creation of networks – this circumstance is important for creation of the infrastructure to support innovation in this entrepreneurial segment. The group of actors that influence the innovation process (including entities involved) structured according to research sectors is shown in Figure 1.

Figure 1: National innovation system /infrastructure in the CR



3. Inputs of research activities

Research and development is an important factor of innovation performance. However, there are some differences in the assessment of its role in relation to other innovation sources. The linear model, which currently influences actions of innovation players in the CR, sees the role of research and development as a key role. The interactive approach tends to place greater emphasis on qualitative connections between research and other actors within the NIS and sufficient development opportunities for all of its components. A different context of assessment applied at the level of innovation companies evaluates the importance of research in relation to other innovation sources. Despite these differences, the volume of resources dedicated to research and development is currently seen as equally important as their orientation on innovation performance.

3.1 Extent of financial and human resources in research and development

Table 1 characterises the position of the Czech Republic according to the indicator GERD in % of GDP (also referred to as intensity of GDP to research and development) over a longer period of time and in international comparison. Gradual restoration of the national research system after the radical decline in the extent of its resources in the first half of the 90's can be observed here. Research intensity of GDP improved slightly between 1995 and 2000 and subsequently stagnated.[3]

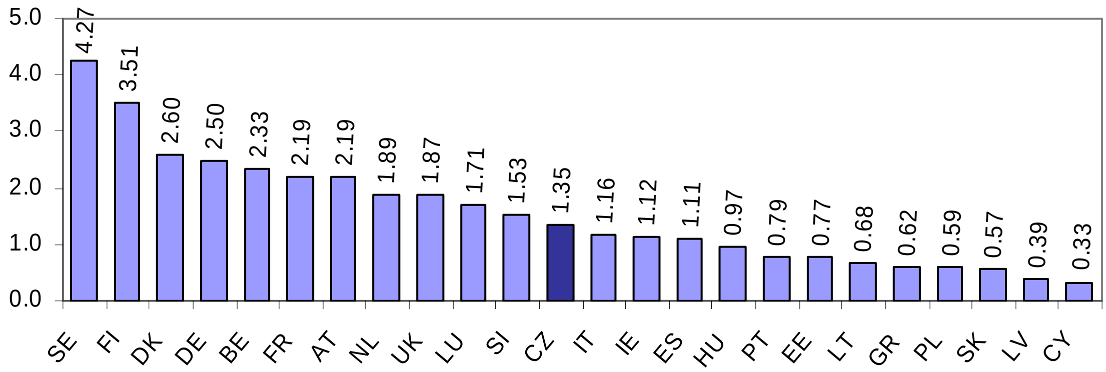
Table 1: Gross expenditures on research and development (GERD, in % GDP)

	EU-25	EU-15	CZ
1995	1.84[s]	1.88[s]	0.95[b]
1996	1.82[s]	1.87[s]	0.98
1997	1.82[s]	1.86[s]	1.09
1998	1.82[s]	1.86[s]	1.16
1999	1.86[s]	1.90[s]	1.16
2000	1.88[s]	1.93[s]	1.23
2001	1.92[s]	1.98[s]	1.22
2002	1.93[s]	1.99[s]	1.22
2003	1.95[ps]	2.00[ps]	1.35

Notes: b – break in time series, s – estimate of EUROSTAT, p – preliminary value. Sources: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

The CR is second after Slovenia in the group of new EU members (see Figure 2) according to the intensity and dynamics of this indicator. However, the extent of resources for research and development and dynamics of their growth appear as insufficient in view of the target level of 3 % of GDP. Differences between individual countries or groups in the EU-25 are considerable. Sweden and Finland hold the leading position with a significant advantage over all other countries. On the other hand, new member states record values significantly below the EU average.

Figure 2: Gross expenditures on research and development (GERD, in % GDP), 2003



Note: year 2003 or last available year. Sources: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Growth in the **number of employees in research and development** and its comparison against demographic indicators (population in their productive age, labour force, etc.) describe the intensity of research activities and its dynamics, as well as innovation performance. The extent of population carrying out research or involved in applying its results represents an important prerequisite for spreading and using innovations. However, this relationship is also intermediated by and conditional on a long-term cycle of changes in educational institutions and the impact of these changes on the society. Similarly to GERD, the number of employees in research and development as an indicator includes various functionally differentiated activities and its information value depends on distribution of resources according to functional, professional, qualification and other aspects.

[3] The positive development in 2003 was caused by different growth rates of expenditure on R&D and GDP, when GDP grew slower than the total expenditure on R&D. Compared to 1998, the share of GERD in GDP in the CR in 2003 increased by 0.2 p.p. only.

Table 2 shows development of relative number of employees in research and development and researchers in relation to the level of employment. Both of these values for the Czech Republic grow gradually but remain significantly below the EU-25 average and are also lower than in some new member states. The CR lags behind in this aspect partially due to relatively low financial rewards for these professions, and partially owing to the radical decline in the number of employees in research and development during the initial stages of transformation.[4] This indicator in international comparison reflects the GERD values – Sweden and Finland achieve the highest share in the EU, with Denmark in the third place.

Table 2: Employees in research and development and researchers (in % of total employment, HC)

	Employees					
	1997	1998	1999	2000	2001	2002
EU-25	..	..	..	..	..	1.44^s
EU-15	1.41^s	1.43^s	1.45^s	1.48^s	1.50^s	1.54^s
CZ	0.96	0.95	1.00	1.03	1.04	1.13
	Researchers					
EU-25	..	..	..	..	..	0.87^s
EU-15	0.80^s	0.81^s	0.83^s	0.86^s	0.88^s	0.92^s
CZ	0.49	0.48	0.53	0.56	0.57	0.65

Notes: s – estimate of EUROSTAT. Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Comparison in Figure 3 presents an insight into structure of human resources in research and development – staffing of research with technical and administrative workforce. Differences reflect the share of research activities with high demands on technology and equipment, but also the extent of administration. The relatively large share of companies´ research in the Czech Republic places the country in a group of states with slightly higher shares of non-research workforce; however, the value of this indicator does not deviate significantly from the average values for the EU-15 and the EU-25.

3.2 Structure of research and development resources

Distribution of research and development resources (GERD) and research and development workforce characterises their **structure** and thus creates a certain basis for analysing institutional forms of research activities. It reflects a power differential, which considerably influences the likelihood of institutional changes (for example excessive concentration of resources in a certain sector hinders institutional changes), and also allows monitoring the flow of resources between individual structural units and their intensity in turn can signal opportunities for institutional changes. An analysis of institutional changes is conditional on determining specific types of research and development arrangement (system).

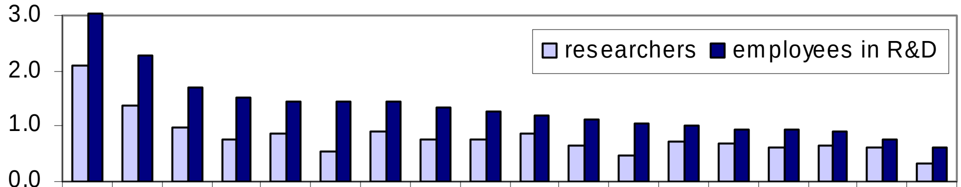
Assessment of the structure of expenditure on research and development arises from their differentiation according to the institutional[5] and functional aspect. These forms of research and development organisation were accepted in the statistical practice as **research sectors**.

An analysis of research sectors is important for monitoring the process of restructuring national research and development systems in new EU member countries. The strong position of Academies of Science under the socialistic regime, which to some extent per-

[4] Approximately 50 thousand people are currently employed in research and development in the CR; at the beginning of the 90's this indicator amounted to approximately 110 thousand.

sists to this day, leads to a situation when these countries record the largest share of basic research in GERD in the EU-25 (Czech Republic 40 %, Poland 38 %, Hungary 29 %), while this share in similar EU members ranges between 10 % and 25 %. This example demonstrates not only the diversity of the institutional context, which needs to be taken into account when assessing research and development, but also the specific position of the institutional framework (institutional gap) of new EU member states. Specific indicators capable of monitoring crucial factors of related changes must be applied when assessing development of this framework. The share of special-purpose funding for research in the overall scope of GERD can be used as an example. Decreasing importance of institutional (subsidized) funding with an increasing weight of a competitive regime, which finances projects according to successful presentation of grants or projects, positively influences qualitative changes in research organisations owing to the emphasis on their productivity. The share of special-purpose funding in GERD increased significantly in the 90's and this type of funding currently accounts for approximately 40 %.

Figure 3: Researchers and employees in research and development (in % of total employment, HC), 2002



	FI	DK	FR	NL	AT	GR	ES	SI	HU	EE	CZ	IT	SK	LV	LV	PL	PT	CY
researchers	2.1	1.4	1.0	0.8	0.9	0.5	0.9	0.8	0.8	0.9	0.7	0.5	0.7	0.7	0.6	0.7	0.6	0.3
employees in R&D	3.0	2.3	1.7	1.5	1.5	1.5	1.4	1.3	1.3	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.8	0.6

Notes: Greece – researchers in 1997, R&D employees in 1999; Austria – researchers and R&D employees in 1998; Italy – researchers in 2000, R&D employees in 1999; Netherlands – researchers in 1999 and R&D employees in 2001; Portugal – researchers and R&D employees in 2001. Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

The **structure of research sectors** forms an important segment of the national innovation system. We focus our attention especially on the internal structure of the BES and academic sectors and their existing interactions. The analysis is based on binary monitoring of expenditure on research and development according to sources of funding and performance, which allows us to monitor the flow of finance between the sectors and assess the condition of their mutual connections (their openness or closure). Examination of the situation in the EU-25 reveals significant differences between individual countries in characteristics of research sectors from a large share of the business sector in funding and implementation of research and development or alternatively a significant share of the governmental sector to widely established systems with balanced shares of the BES, governmental and higher education (HE) sectors. From the structural point of view, the Lisbon strategy at the Barcelona Summit determined the target value for the share of the BES

[5] Differentiation according to the institutional aspect is based on a long-term trend of science institutionalisation, initially in the form of the academic science (placement of science at universities with ties to education) and industrial science (placement of science in companies in the form of laboratories and with ties to company's needs), and subsequently also in the form of laboratories and research centres established for the purposes of the government and its regulatory tasks. The international character of scientific activities eventually led to a significant influence of foreign resources in financing national research and development and their institutionalisation.

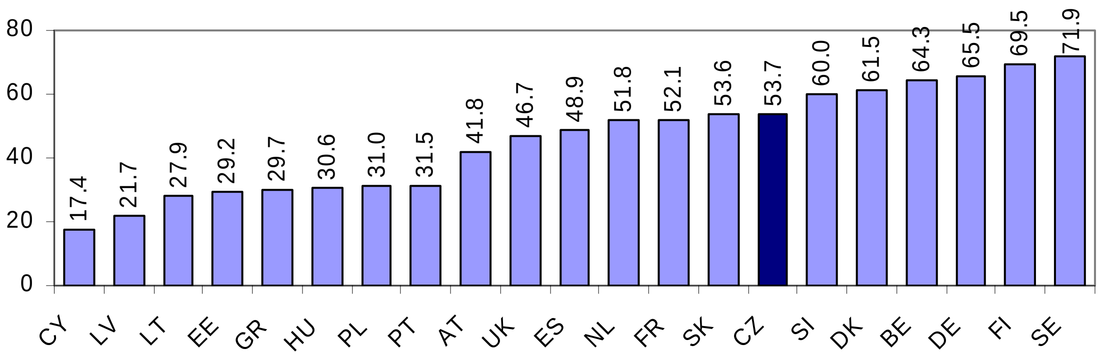
in financing research and development of at least 66 %. According to the latest available data this share in the EU-25 was as low as 55 % (67 % in the USA, 73 % in Japan) and the growth recorded compared to 1999 was very moderate. As shown in Table 3, the Czech Republic is characterised by a relatively low share of the HE sector and a high share of the governmental and BE sectors even in international comparison (see Figure 4).

Table 3: Distribution of BERD by sources of R&D funds and sector of performance (in %)

Sector of funding	Firms		Government		Foreign	
	1999	2001/2002	1999	2001/2002	1999	2001/2002
EU-25	55.2^{e}	55.4^{e}	35.4^{e}	34.7	7.2^{e}	7.6^{e}
EU-15	55.6^{e}	56.0	34.9	34.1	7.4^{e}	7.8^{e}
CZ	52.6	53.7	42.6	42.1	4.0	2.7
Sector of performance	Firms		Government		Higher education	
	1999	2002/2003	1999	2002/2003	1999	2002/2003
EU-25	64.9^{s}	64.7^{s}	14.0^{s}	12.9^{s}	20.3^{s}	21.6^{s}
EU-15	65.2^{s}	65.1^{s}	13.8^{s}	12.6^{s}	20.3^{s}	21.5^{s}
CZ	62.9	61.0	24.3	23.3	12.3	15.3

Note: s – estimate of EUROSTATu, e – estimated value. Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005, own calculations.

Figure 4: Share of BES in funding R&D (CR, 2002, in %)



Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Assessment of research sectors needs to take into account not only their relative shares in the national research and development system, but also the weight and dynamics of resources for **public and private funding**. The CR achieves values below the EU-15 and the EU-25 average in the share of government expenditure in GDP and the share of corporate expenditure (see Table 4), yet holds a very good position among the new member states (see Figure 5).

Table 4: Business enterprise expenditures on R&D and sources of funding (in %)

	BERD in % of GDP							
	1995	1996	1998	1999	2000	2001	2002	2003
EU-25	1.16	1.15	1.16	1.21	1.23	1.26	1.24	1.23
EU-15	1.18	1.17	1.19	1.25	1.26	1.30	1.28	1.27
CZ	0.62	0.59	0.75	0.73	0.74	0.74	0.75	0.77

Note: EU-25, EU-15 – estimate of EUROSTAT. Sources: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

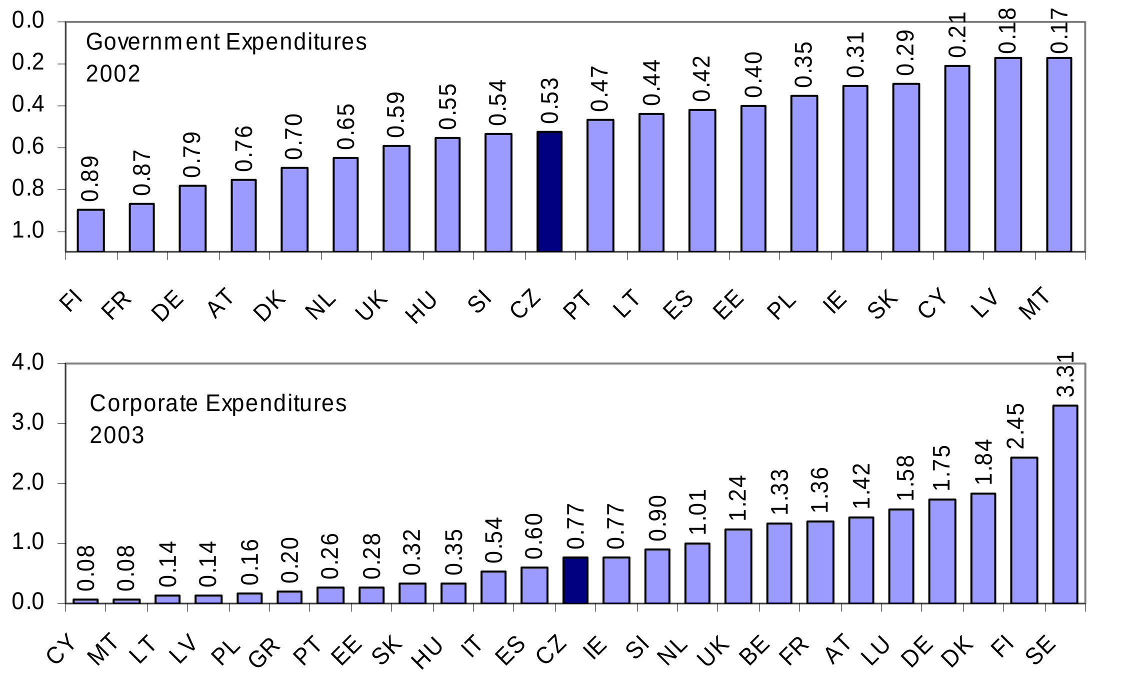
Binary monitoring of expenditure on research and development according to the source of funding and performance as shown in Table 5 allows us to detect the flow of finance between sectors and thus determine the extent of their interactions.

Table 5: R&D funding by sectors of funding and performance (in %, 2003)

	Funding		Performance	
	CZ	EU	CZ	EU
BES	51.4	54.3	61.0	63.9
Government	41.8	34.9	23.3	13.0
Higher education	1.2	0.7	15.3	21.8
PNP	1.0	1.6	0.4	..
Foreign and other	4.6	8.5	..	..

Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Figure 5: Gross R&D expenditures (in % of GDP)



Sources: EUROSTAT – New Cronos, Science and Technology, OECD – Main Science and Technology Indicators, 1. 11. 2005.

Financial flows between sectors can reveal two situations – closure of sector or its openness. The situation in the Czech Republic can be assessed according to the matrix table, which records sources of funding for research and development on one axis, while the other axis indicates capacities of research and development performance (users of these resources - see Table 6). The governmental sector is characterised by the greatest degree of openness, which arises from its function of an administrator of public finance and its role in supporting research activities. The foreign sector presents a good example of openness – sources of finance are distributed throughout sectors and suggest competitiveness of domestic research (however, in many cases the low costs in domestic research rather than its uniqueness remain the decisive factor for attracting foreign funding). Table 6 also reveals how large part of its resources for research and development the BES consumes in its own research facilities and what portion is covered by contracted research with the HE, the governmental and non-profit sectors.

Table 6: GERD by source of funding and sector of performance in the CR (2003, mil. of CZK)

	BES	Gov-ernment	HE	PNP.	Foreign	Total
BES	15928	2359	1	307	1073	19668
Govern.	583	6471	233	5	233	7525
HE	48	4571	138	2	163	4922
PNP	30	88	2	8	3	132
Total	16589	13489	374	322	1472	32247

Note: The total sums need not be exact on the last two positions due to rounding. Source: ČSÚ (2004), p. 98.

The BES in the CR obtains 16 % of total sources of R&D funding for performance of its research from other sectors (12.2 % from government resources and the remaining part from the non-profit and foreign sectors). On the other hand, the research commissioned by BES in other sectors only accounts for 3 % of its total resources (mainly in the governmental sector, the academic sector only accounts for 0.2 %). The openness of the BES therefore is not reciprocal – the volume of resources for research and development received from other sectors is far greater than the volume of resources performed externally. Yet an active approach of the BES to the academic science and its share in funding for the HE sector is one of the crucial pillars of the national innovation system. The intensity of connections between the BE and HE sectors in the CR in international comparison is significantly lower than in other Central European countries and below the level in other EU states where the relevant data is available. The BES can receive academic research services from Academies of Science (especially in Poland and Hungary) or governmental laboratories (in other EU countries). However, cooperation with universities has a special role for two reasons: it facilitates transfer of experience from companies to universities and graduates in Ph.D. studies can provide transfer of knowledge from the academic science to companies.

3.3 Industrial structure of research and development

The analysis of research and development by the structure of the manufacturing industry and services holds special importance for the situation in the Czech Republic, where significant changes in the structure and research and development facilities of the manufacturing industry occurred during the 90’s. The significance of these changes was influenced by the relatively extensive size of industrial research and development in the socialistic economic regime and excessively radical intervention of the economic reforms in this field. This resulted in a significant reduction of corporate research (for more details see Kubík, Müller, Neumajer, Obst, 1997).

Engineering, chemical and electrical industries accounted for three quarters of corporate research at the beginning of the 90’s and represented significant concentration of resources. The number of employees in this area was reduced dramatically (from 64 to 8 thousand) during the 90’s but inter-industrial proportions changed very little: mechanical engineering maintained its leading position and chemical and electrical industries retained less significant shares of research and development.

Distribution of research and development employment by manufacturing industries shows that the process of restructuring continues to this day. However, some structural trends can now be identified. While the 90’s were characterised by a significant decrease in research activities in high-tech industries, less pronounced decline in industries with medium technological demands and an increase in low-tech industries, the latest period by contrast saw an increasing importance of more research intensive industries. This applies especially to production of pharmaceuticals, electrical machines (mainly components and optical devices), other non-metal mineral pro ducts and motor vehicles. In the case of services, the importance of research and development in business services declined.

Table 7: R&D employees by branches of manufacturing industries and services in the CR (FTE, 1998–2003)

	In number				Share in total (%)	
	1998	2000	2002	2003	1998	2003
15–22 Food products, textile, wood	239	312	326	336	3.1	2.8
23–24 Coke, fuel, nuclear fuel, chemicals	1262	1099	1156	1203	16.2	9.8
24 Chemicals, chemical products, pharmaceuticals	965	915	911	929	12.4	7.6
24–244 Manufacture of chemicals	708	685	585	569	9.1	4.6
244 Manufacture of pharmaceuticals	257	230	326	360	3.3	2.9
25 Manufacture of rubber and plastic products	290	174	238	269	3.7	2.2
26 Manufacture of other nonmetallic products	197	130	278	310	2.5	2.5
27 Manufacture of basic metals	337	216	147	155	4.3	1.3
28–35 Manufacture of metal products, machinery and transport equipment	5355	5014	5466	5614	68.9	45.8
29 Manufacture of machinery equipment	1774	1425	1427	1358	22.8	11.1
30 Manufacture of office equipment, computers	11	15	14	38	0.1	0.3
31 Manufacture of electric machinery.	489	419	507	523	6.3	4.3
32 Manufacture of radio, television, communication equipment	330	370	482	548	4.2	4.5
321 Manufacture of electronic components	55	77	83	106	0.7	0.9
322 Manufacture of TV, radio sets	275	293	399	443	3.5	3.6
33 Manufacture of medical, optical eq., watches	238	322	320	422	3.1	3.4
34 Manufacture of motor vehicles	1685	1889	1840	1828	21.7	14.9
36 Manufacture of furniture	67	173	109	120	0.9	1.0
Manufacturing industry	7776	7284	11969	12258	100	100
50–52 Wholesale, retail, repair	43	157	295	273	1.3	4.9
55 Accommodation, restaurants	1	0	0	13	0.0	0.2
60–64 Transport, storage, communication	118	93	140	140	3.6	2.5
65–67 Financial services, banking	0	0	19	27	0.0	0.5
70–74 Real estate, R&D, industrial services	3065	3566	4097	4805	94.5	85.5
72 Computer and related services	193	402	771	1345	6.0	23.9
73 R&D	2682	2891	2954	2856	82.7	50.8
75–99 Community, defense, social services	16	211	334	365	0.5	6.5
Services	3243	4027	4886	5622	100	100

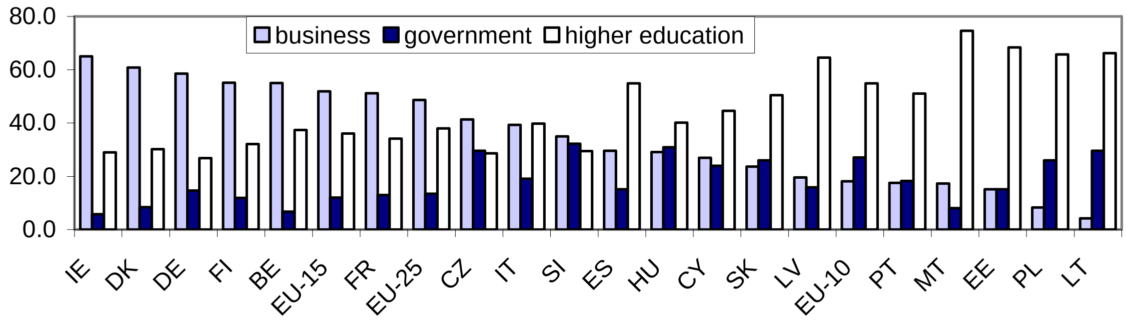
Source: ČSÚ (2005), p. 76–77, own calculations.

3.4 Other structural aspects of research and development

Specialisation, qualification and functional aspects are applied in an analysis of the structure of research and development in addition to the structure by manufacturing branches. The structure according to **research sectors** is shown in Table 8. Sectors with considerable influence of globalisation effects are characterised by a more significant role of the specialisation profile (especially in the BES). The extent of resources plays a major role in the remaining sectors as research is required to cover a whole spectrum of specialisations (this is especially obvious in university education and research). The extent of resources in the HE sector in particular is considerably lower in the Czech Republic than in most EU countries (see Figure 6).

The analysis of the structure of R&D employment by **scientific disciplines** is also associated with the indicator of the share of female employment (see Table 9). This indicator closely characterises the focus of national university institutions on covering all scientific disciplines and consequently also educational traditions and structures of economies.

Figure 6: Researchers by sectors of research and development (2002, FTE, in %)



Sources: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Table 8: Researchers by sectors (2002, FTE, in %)

	Business	Government	Higher education (HE)
EU-25	48.6	13.5	37.9
EU-15	51.9	12.0	36.1
CZ	41.3	29.6	28.6

Sources: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005, own calculation.

Table 9: Researchers by scientific disciplines (CR, 2002, FTE, in %)

	Total	%	Females	%
Natural sciences	4267	28	1160	30
Engineering	6743	45	971	25
Medical sciences	1095	7	546	14
Agricultural sc.	972	6	446	11
Social sciences	1059	7	458	12
Humaniities	838	6	336	9
Total	14974	100	3917	100

Source: ČSÚ (2002), p. 98.

However, comparison of the share of female employment in research human resources has a higher information value, despite being introduced in the European statistical practice relatively recently. The focus on increasing the **share of female employment** in research plays an important role in strategies for development of research and development in EU countries. The reasons are generally associated with emancipation. However, they are also a reaction to a limited inflow of new human resources in this area. Female population with university education is expected to provide a crucial resource for the growth of new human resources for research and development.

The situation of the Czech Republic with regards to the above-mentioned emancipation strategy is very poor in relation to other new EU members – the share of women in the overall numbers of employees in research is the lowest (see Table 10). The opportunity for increasing the share of women in research and development is clearly guaranteed by the balanced numbers of men and women in university studies, which have been generally asserted in all countries. However, participation of women in research will be influenced by embedded cultural traditions that shape the perception of gender differences. This issue is also undoubtedly influenced by the standard of the infrastructure of services, which would allow women to combine their motherhood with their professional roles.

Table 10: Share of females in total number of employees in R&D and researchers (FTE, in %)

	Year	Employees	Researchers
Hungary	2002	45.6	33.7
Slovakia	2002	45.2	40.8
Slovenia	2002	37.8	34.6
Denmark	2002	36.7	26.7
Spain	2002	36.0	35.7
CZ	2002	32.6	26.1
Belgium	2001	27.8	25.6
Germany	1997	23.6	18.1
Austria	1998	22.2	14.0

Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005, own calculations.

Illustrating the level of **regionalisation of research and development** in international comparison is very difficult.[7] However, data for the CR recorded in Table 11 is available. This data shows that the positions of individual regions change irregularly. Nonetheless, the position of the Central Bohemian agglomeration is gradually weakening and many other regions demonstrate increasing dynamics.

Table 11: Employees in R&D by regions – NUTS 3 (FTE, in %)

	2000	2001	2002	2003
Praha	45.1	41.4	42.0	42.3
Středočeský	12.3	10.9	12.2	13.0
Jihočeský	3.8	3.9	3.9	3.9
Plzeňský	3.5	3.4	3.4	2.5
Karlovarský	0.2	0.4	0.3	0.4
Ústecký	1.4	2.0	1.5	1.3
Liberecký	2.7	2.5	2.7	2.4
Královéhradecký	1.9	2.6	2.8	2.9
Pardubický	3.9	4.4	4.4	3.9
Vysočina	1.4	1.2	1.6	1.6
Jihomoravský	10.9	14.4	12.5	13.1
Olomoucký	4.0	3.5	3.6	3.6
Zlínský	2.6	3.0	3.4	3.0
Moravskoslezský	6.3	6.3	5.7	6.0

Source: ČSÚ (2001, 2003).

[7] Analytical documentation prepared by the European Commission integrates the regional aspect in the R&D analyses. Indicators for research sectors with the least influence of concentration in capital cities of countries, such as the corporate or academic sector, appear to be ideal for this type of analysis. These indicators allow us to determine the positions of individual regions according to the intensity of regional research (for more details see EC, 2003, p. 111).

4. Specific conditions for innovation performance

The following analysis uses findings on the importance of individual segments or institutions of the infrastructure for supporting innovation. The emphasis is on characteristics for which analytical and internationally comparable data is available: the importance of qualification for research and development, the influence of the academic and corporate research, the financial sector and regulatory measures and self-regulatory organisations in establishing the infrastructure for supporting innovation.

4.1 Qualification for research and development

The supply of R&D human resources is influenced by the number of **graduates in Ph.D. programs** in natural and technical sciences. The data on Ph.D. graduates in natural and technical disciplines is recorded in Table 12. Comparison with the USA shows that the value of this indicator for population aged 25–34 years in 2002 is significantly lower in EU countries (0.5 ‰ compared to 1.2 ‰). Sweden and Finland are the only two countries with values higher than the USA. However, these countries also record a lower share of Ph.D. graduates in natural and technical sciences in the total number of graduates (for example in Finland this share is 40 % and in the USA 36 %). Comparison of both of these indicators suggests that countries with a higher share of Ph.D. graduates in the population tend to have a lower share of natural and technical sciences – besides Finland, this is for example also the case in Austria and Germany (see Figure 7).

Table 12: Graduates of PhD studies in natural sciences and engineering

	Share in total of PhD graduates (in %)				
	1998	1999	2000	2001	2002
EU-25	44.3	43.9	44.1[s]	43.1[s]	43.1[s]
EU-15	44.8	44.6[s]	44.1[s]	43.9[s]	43.9[s]
CZ	56.0	57.2	57.0	52.2	50.6
	Share in population 25–34 years of age (in %)				
EU-25	..	0.5	0.5	0.5	0.5
EU-15	0.5	0.5[s]	0.6[s]	0.6	0.6
CZ	0.3	0.3	0.3	0.4	0.4

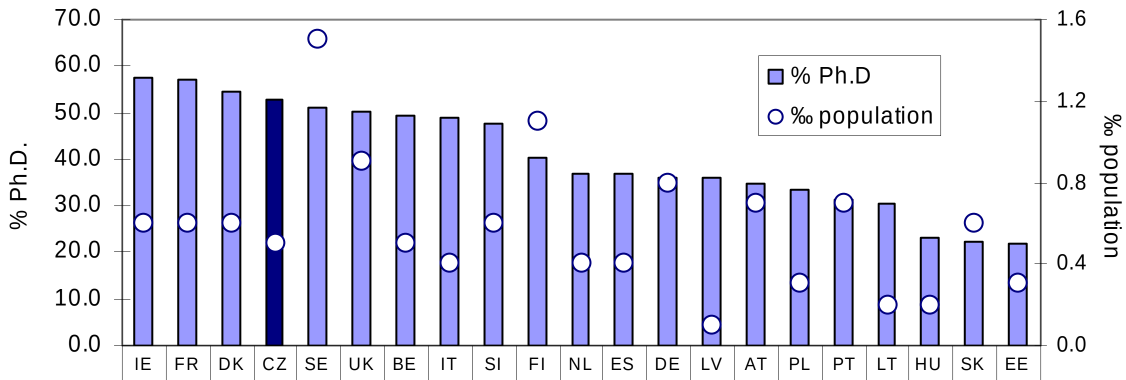
Note: s – estimate of EUROSTAT, Source: EUROSTAT – New Cronos, Education and Training, 1. 11. 2005.

The share of Ph.D. graduates in natural and technical sciences in the population aged 25–34 years in the CR is comparable to the EU-25 level in the total amount, as well as in both genders (0.7 ‰ for men and 0.3 ‰ for women). This share has been increasing slightly since 1998. The share of graduates in natural and technical sciences in the total number of graduates remains above the 50 % mark but gradually decreases. Nonetheless, in 2003 the CR still recorded a value well above the EU-25 average.

4.2 Companies and academic science

Indicators reflecting the intensity of mutual connections between companies and the HE science follow **WEF** and **IMD studies**. **Corporate innovation studies** (CIS), which monitor answers to questions relating to types of cooperating entities in innovation activities, can also be used for this purpose. Considering the specific position of the governmental sector in new EU members, which includes research institutions of academies of science, the inter-sectoral analysis can be extended to relations between the BES on one side and the HE and governmental sectors on the other side. The situation in the CR in this area has been discussed above (see Table 6 and the relating text). According to available international studies companies in the EU participate in implementation of research and development in the governmental sector the most in Poland and this share also exceeds 10% in Latvia, Lithuania, Finland, Slovakia, Slovenia and Great Britain. Besides the leading Latvia, Hungary and Germany also record the highest share of companies in research and development carried out at universities. Transfer of BES sources of funding from the governmental sector to the academic sector can be observed in Hungary, while the share of BES source of funding in the governmental sector in Germany is traditionally very low. This comparison places the Czech Republic among countries with a relatively low share of companies in implementation of research and development in the governmental sector but also a negligible share of companies in implementation of research at universities.

Figure 7: Graduates of PhD studies in natural sciences and engineering (2003)



	IE	FR	DK	CZ	SE	UK	BE	IT	SI	FI	NL	ES	DE	LV	AT	PL	PT	LT	HU	SK	EE
% Ph.D	57.7	57.3	54.4	52.7	51.3	50.2	49.6	49.0	47.7	40.3	37.1	36.8	36.0	35.9	34.7	33.6	31.3	30.6	23.0	22.2	21.7
‰ population	0.6	0.6	0.6	0.5	1.5	0.9	0.5	0.4	0.6	1.1	0.4	0.4	0.8	0.1	0.7	0.3	0.7	0.2	0.2	0.6	0.3

Source: EUROSTAT – New Cronos, Education and Training, 1. 11. 2005.

The data by WEF is used for wider comparison (based on an expert survey) of **cooperation** between companies and universities in implementation of research and development (see Table 13, Figure 8). Finland, Sweden, Netherlands, Belgium and Germany show the best long-term positions on average according to this comparison (Austria and Great Britain also hold strong positions). The Czech Republic shows gradual improvement: it held the 11th place in the EU-25 in 2004 and the best position among new member states. This assessment is in strong contrast with the above-mentioned negative evaluation of the share of the BES in funding research and development in the HE sector. The situation in Slovenia did not change compared to 2001, while Hungary recorded the greatest deterioration.

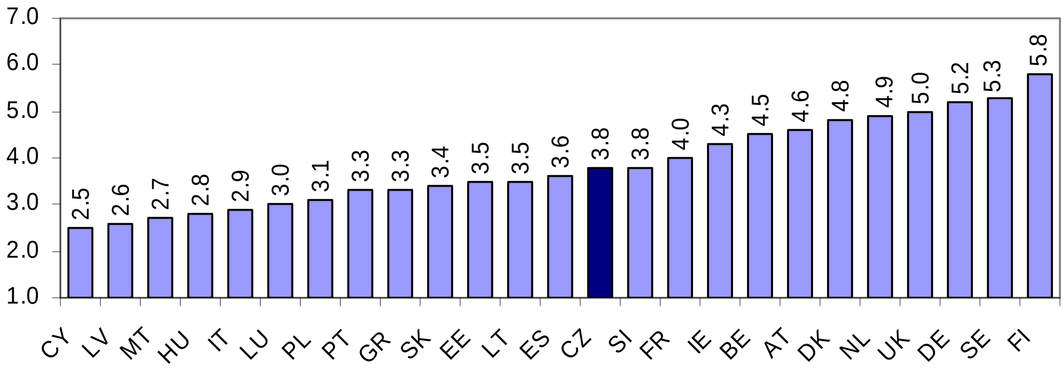
Table 13: Co-operation between firms and local institutions of higher education

	EU-25	EU-15	CZ
1998	4.28	4.46	3.55
1999	4.36	4.51	3.69
2000	4.26	4.38	3.30
2001	4.59	4.91	4.10
2002	4.21	4.56	4.10
2003	3.99	4.34	3.70
2004	3.85	4.30	3.80

Note: 7 – best evaluation, 1 – worst evaluation. EU-25 and EU-15 – non-weighted averages. Sources: WEF – Global Competitiveness Report 1998–2004, own corrections.

The data listed above shows that traditional Central European countries (Germany, Austria) and Scandinavian countries have the best situation in relationships between companies and the HE sector (see Figure 8). Most of the new member states also report a good quality of these relationships, especially when the governmental sector is included in the assessment. The detected situation is influenced by traditionally established forms of institutionalisation of research and development.[8] The socialist past state's intervention in the institutional framework of academic science in the Czech Republic significantly strengthened centralist tendencies and weakened especially the position of research and development at universities (unlike Poland and Hungary, where universities maintained their role in research).

Figure 8: Co-operation between firms and local institutions of higher education (2004)



Note: 7 – best evaluation, 1 – worst evaluation. EU-25 and EU-15 – non-weighted averages. Sources: WEF – Global Competitiveness Report 1998–2004, own corrections.

4.3 Government support for research and development

International comparison shows (see Table 14 and Figure 9) that the EU-25 is experiencing a slight growth in the share of **GBAORD in GDP**. However, the recorded value still lags behind the USA figure (1.14 %). The structure of expenditure in the EU differs significantly to the benefit of civil research and development (however, it is necessary to point out that the civil expenditure in the USA is strongly underestimated due to a different methodology of recording GBAORD). Great Britain, Spain, France and Sweden record the highest share of defence research in GBAORD in the EU. General research at universities and undirected research represent the most significant items in the EU with regard to **socioeconomic objectives**, although individual countries differ greatly in their shares of both items. The data on GBAORD in a longer time series for the Czech Republic is not available. In the basic structure, 96.7 % of expenditure accounts for civil research and the remaining part for defence research. General research at universities (28 %) and undirected research (26 %) represented the largest items with regard to socioeconomic objectives, while 10 % of expenditure accounted for production and technologies.

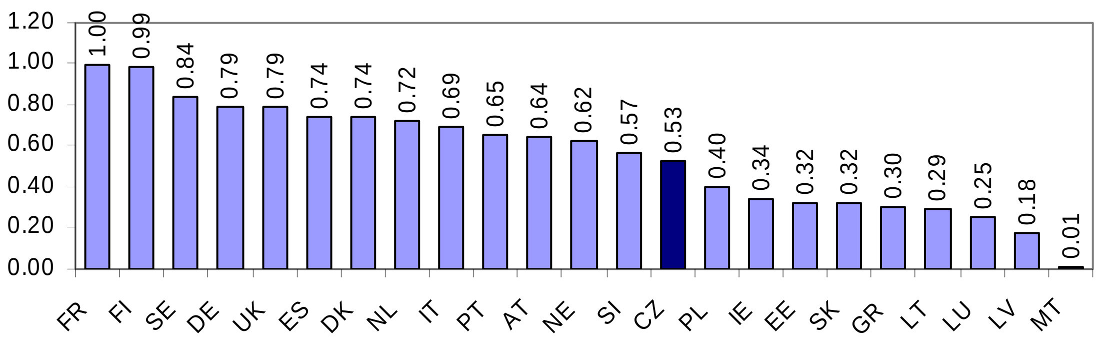
[8] This image reflects the traditional decentralised model of science organisation, which expanded from Central Europe (the so-called German model) to the Anglo-Saxon area and later found widespread application. Combination of research and teaching and openness to the needs of corporate science was one of the main features of this model (for more details see Müller, 2002). The adoption of this approach in Scandinavian countries is supported by the focus on the emancipating role of education and the importance of universities in these societies.

Table 14: Outlays of government budget to R&D (in %)

	Total (% of GDP)			
	2000	2001	2002	2003
EU-25	0.73^{s}	0.74^{s}	0.77^{s}	0.77^{s}
EU-15	0.75^{s}	0.76^{s}	0.79^{s}	0.79^{s}
CZ	..	..	0.51	0.53
	Civil R&D (% GDP)			
EU-25	0.62^{s}	0.64^{s}	0.65^{s}	0.67^{s}
EU-15	0.64^{s}	0.65^{s}	0.65^{s}	0.66^{s}
CZ	..	..	0.49	..
	% Government expenditures			
EU-25	..	..	..	..
EU-15	1.62^{s}	1.62^{s}	1.64^{s}	..
CZ	..	..	1.10	1.00

Note: s – estimate of EUROSTAT. Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

Figure 9: Outlays of government budget to R&D (2003, in % of GDP)



Source: EUROSTAT – New Cronos, Science and Technology, 1. 11. 2005.

4.4 Venture capital

EUROSTAT presents the data on venture capital as a part of structural indicators expressing its relative share (in % of GDP) and structuration by **investment stages** (see Table 15 and Figure 10). The concept of venture capital according to the definition by EUROSTAT excludes purchase by internal or external management or purchase of quoted shares. EVCA (*European Private Equity and Venture Capital Association*) provide data on venture and equity capital for European countries which are gathered by European Private Equity surveys.

When the international context of creation and application of venture capital is taken into account, we can conclude that the importance of expenditure on **venture capital** remains on average very low in the EU compared to the USA (half of the USA level in 2003). On average just under one fifth of the total venture capital in the EU is intended for the initial stages of company development. This share is higher than 40% in Denmark, Sweden and Portugal only. Finland, Ireland, Switzerland and Austria are the most attractive countries for foreign venture capital as they received higher volumes of venture capital from abroad than from domestic resources. Banking institutions in Sweden, Great Britain and Netherlands were able to create larger sources of venture capital than the volume of these resources obtained by domestic companies from abroad (see OECD, 2005f, p. 42).

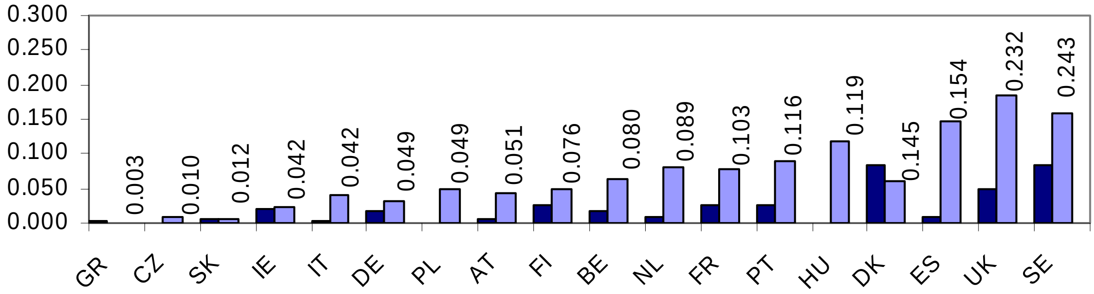
The Czech Republic holds one of the lowest positions in the EU-25 with regard to the importance of investment in venture capital. The share of venture capital in the initial stage of company development is approximately one third. In terms of technological orientation, the largest share of capital in high-tech industries is intended for communication technologies and the importance of other industrial groups is low. Adverse data on the use of venture capital is supported by evaluation of this indicator in surveys by WEF and IMD, according to which the CR was on the 20th place in the EU-25 or on the 18th place in the EU-21 in 2004.

Table 15: Expenditures on venture capital by stages of business development (in % GDP)

	Early and starting stage					
	1999	2000	2001	2002	2003	2004
EU-15	0.038	0.075	0.045	0.029	0.021	0.023
CZ	0.001	0.026	0.010	0.001	0.001	0.000
	Expansion stage and transfer of ownership					
EU-15	0.103	0.154	0.099	0.081	0.088	0.085
CZ	0.047	0.175	0.029	0.037	0.002	0.010

Source: EUROSTAT – Structural Indicators, Research and Innovation, 1. 11. 2005.

Figure 10: Expenditures on venture capital by stages of business development (2004, in % of GDP)



Source: EUROSTAT – Structural Indicators, Research and Innovation, 1. 11. 2005.

4.5 Scientific and technical publications, patent statistics

The hub of scientific production was transferred from Europe to the USA after the World War II. The EU surpassed the USA in mid 90's as the largest **producer of scientific literature** in absolute and relative representation (in the share in the scientific output worldwide). The situation has been changing since the beginning of the new century and the position of the EU has been deteriorating in relation to the USA. Scandinavian countries and the Netherlands hold the best position in the number of scientific and technical publications per capita on a long-term basis (see Figure 11). The range of specialisations in the EU is very diverse and typically focuses on a limited number of fields, reflecting partially the size of the relevant country and partially the country's technological profile. The Czech Republic is among the countries with below-average scientific and technical publication and quotation productivity in the EU-25 (see Table 16). Moderate but long-term improvement in this productivity can be seen as positive. With regard to scientific disciplines, the situation in the Czech Republic is the best in mathematics, engineering and clinical medicine. Scientific output in the CR specializes in technical sciences, in particular chemistry.

The **patent statistics** study the second aspect of scientific and technical performance. Table 17 describes the position of the EU-25 according to the **number of patent applications** at EPO per capita. However, there are considerable differences between countries or their groups (see Figure 11). Sweden holds the leading position on a long-term basis, other leaders include Finland, Germany and the Netherlands, where the patent performance has grown significantly compared to 1998. All new member states and Spain, Portugal and Greece significantly lag behind the average, with Slovenia holding the best position in 2002. Finland, the Netherlands and Sweden are the leaders in advanced technologies and the patent performance of less developed countries is negligible.

The Czech Republic is one of the EU-25 countries with low patent performance. The number of patent applications per million of residents was 11 in 2002, which means a decline compared to 2000 and a result lower than one third of the level of Slovenia in 2002. High-tech patent applications did not even reach one during the entire period.

Table 16: Number of scientific and engineering publications per 1000 population

	EU-25	EU-15	CZ
1995	0.567	0.637	0.305
1996	0.652	0.734	0.363
1997	0.666	0.748	0.365
1998	0.724	0.812	0.387
1999	0.734	0.822	0.392
2000	0.735	0.820	0.408
2001	0.758	0.843	0.440
2002	0.745	0.825	0.457
2003	0.822	0.909	0.512
2004	0.789	0.869	0.505

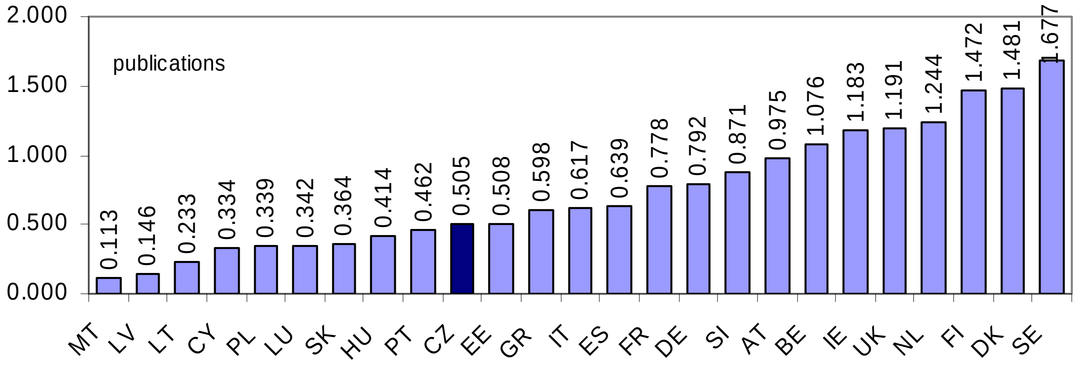
Source: ISI Web of Science (publications), 1. 11. 2005; World Bank – World Development Indicators (population), own calculations.

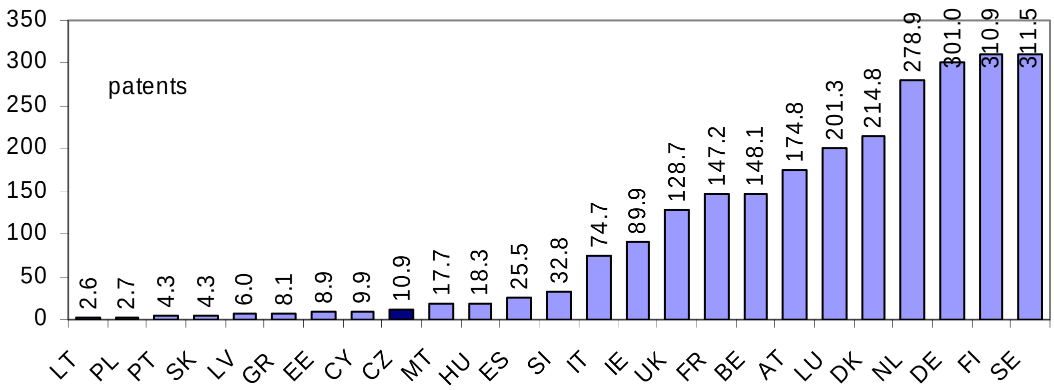
Table 17: Patent applications in European Patent Office (per million of population)

	Patent in total				
	1998	1999	2000	2001	2002
EU-25	109.2	118.3	133.6	142.0[s]	133.6[ps]
EU-15	130.0	141.0	158.7	168.3[s]	158.5[ps]
CZ	9.7	9.8	13.5	11.4	10.9[ep]
	High-tech patents				
EU-25	16.3	19.5	24.6	28.4[s]	26.0[ps]
EU-15	19.5	23.2	29.4	33.7[s]	30.9[ps]
CZ	0.7	0.6	0.8	0.8	0.5[ep]

Note: s – estimate of EUROSTAT, p – preliminary value, e – estimated value. Source: EUROSTAT – New Cronos/European and US Patenting System.

Figure 11: Number of scientific and engineering publications per 1000 population (2004) and a number of patent applications in EPO per million of population (2002)





Source: ISI Web of Science (publications), 1. 11. 2005, EUROSTAT – New Cronos/European and US Patenting System, 1. 11. 2005.

5. Innovation performance of companies and quality of environment

Results of innovation surveys (*Community Innovation Survey* – CIS) are the main source of data on innovating domestic companies. Czech Statistical office participated in the last two rounds of CIS (1999–2001, 2002–2003), which means that this data can be used to analyse the innovation potential of the BES in the CR. The data describes the level and structure of innovation sources and factors influencing this level and structure. Findings from two individual surveys of innovation sources and performance carried out in the Czech Republic are also mentioned.

5.1 Innovating companies and innovation in the CR

The following analysis is based on CIS data for the period 1999–2001, while the data from the latest survey (2002–2003) is used in addition for closer interpretation. The share of **innovating companies** represents the first approximative indicator of innovation activity in the relevant country. Table 18 describes this indicator and states types of innovation (including possible combinations) and the data is structured by branches of the manufacturing industries and services. The data shows that innovating companies account for less than 29 % of all companies. This indicator is slightly higher in the manufacturing industry and lower in services. The data from CIS 2002–2003 for the CR is slightly lower but with similar proportions between branches (manufacturing industry 28.4 % and services 22.8 %).

Table 18: Innovating firms by type of innovation (share in total number of firms, in %, 1998–2000, 2001–2002)

	Total			
	Product or process	Product	Process	Product and process
EU-25	36.2	12.3	8.4	14.3
EU-15	39.0	13.5	9.4	15.8
CZ	28.5	11.9	5.2	11.5
	Manufacturing			
EU-25	39.1	12.6	9.5	16.7
EU-15	42.1	13.4	10.5	17.8
CZ	30.2	11.7	5.1	13.4
	Services			
EU-25	32.6	12.5	7.0	11.9
EU-15	35.0	13.8	7.8	13.3
CZ	26.2	12.6	4.9	8.7

Source: EUROSTAT – New Cronos, Community Innovation Survey – CIS3, 1. 5. 2005, own calculations.

CIS data allows us to detect the relationship between the **size of companies** and their innovation activity. Table 19 shows that larger innovating companies are more frequent (around 60 % of all companies with 250 or more employees). The following group of medium-sized enterprises includes almost 40 % of companies with innovation oriented production or services, while the remaining group of small companies focuses on innovation to a limited extent (around 20 %). The data on **types of innovation activities** provide additional characteristics of innovation companies. The expended costs suggest the relative weights of individual operations in innovation activity of a company. The extent of expenditure on innovation in innovating companies remains limited – amounts to 2 % of their total revenues. As shown in Table 20, expenditure for purchasing machines and technical equipment is dominant in all sizes of companies. Smaller companies are characterised by lower expenditure on research and development (including external research) and higher expenditure on obtaining the required knowledge and launching innovations on the market.

Table 22: Most important market for innovating firms by their size (CR, 1999–2001, share of firms in %)

	Regional	National	Foreign
Small	14.0	44.5	41.5
Medium	4.2	30.2	65.6
Large	5.1	17.7	77.2

Source: ČSÚ (2003a).

Table 19: Share of innovating firms in total number of firms in the given size group (by number of employees, in %)

	Small (0–49)	
	1999–2001	2002–2003
Total	23.4	22.0
Manufacturing	23.0	23.5
Services	24.3	22.0
	Medium (50–249)	
Total	38.4	36.0
Manufacturing	35.6	38.8
Services	39.5	31.0
	Large (250 +)	
Total	64.2	57.0
Manufacturing	65.7	63.3
Services	49.6	40.0

Source: ČSÚ (2003, 2005).

Table 20: Expenditures on innovation by type of expenditures and size of firm (CR, 1999–2001, in %)

	Small	Medium	Large	Total
Intramural R&D	14.4	33.5	20.1	22.0
Acquisition of R&D	3.5	8.6	9.1	8.1
Acquisition of machinery and equipment	41.2	38.4	47.8	44.8
Acquisition of other external knowledge	12.5	5.0	9.9	9.3
Training	3.9	1.1	2.8	2.6
Market introduction	22.0	11	7.7	10.7
Design	2.5	2.3	2.6	2.5

Source: ČSÚ (2003).

Table 21: Expenditures on innovation by type (CR, CIS, in %)

	1999–2001	2002–2003
Intramural R&D	22	24
Acquisition of R&D	8	9
Acquisition of machinery and equipment	45	33
Acquisition of other external knowledge	9	10
Training	3	2
Market introduction	11	18
Design	2	4

Source: ČSÚ (2003a, 2005b).

5.2 Business environment of innovating companies

CIS detects characteristics of the business environment of innovating companies from quantitative data (for example according to the share of markets of various sizes in receipts from innovated products) and from evaluation made by innovation actors (for example on the importance of obstacles in innovation activities). From the perspective of conditions for the **application of innovation outputs,** Table 22 shows that entry at global markets is an important factor influencing innovation performance of companies. Although this effect is clearly dominant in large companies, it also influences small and medium-sized enterprises.

Companies also evaluate the significance of individual motivating factors for introducing **new products or services**. The largest portion of respondents (around 30 %) states that the range of products or services and the quality of production play an important role, the following factor include expansion of markets and production (15–20 %), opportunities for savings in production (10–15 %), regulatory measures especially with regard to the environment (10 %) and material saving (less than 10 %). The importance of market-oriented motivation therefore prevails in the focus of innovation activities. International comparison in this regard has a limited information value because the monitored factors represent symptoms of nationally specific cultural background. The only conclusion that can be drawn from this data is the fact that the fulfilment of regulatory measures and standards plays a more important role in motivation of innovating companies in the EU-15 than in new member states.

Evaluation by respondents focused on the availability of (internal and external) **innovation resources** and the impact of various factors of the business environment provides a broader outlook. The survey results suggest that unavailability of financial capital connected with high costs of innovation is the most important limiting factor (approximately 30 % of companies consider this factor significant and 60 % of companies consider it moderately significant). The following factors include excessive venture (significant for 20 % and moderately significant for 50 %) and a lack of qualified labour force and low demand for innovation (significant for 10–15 % and moderately significant for 30–40 %). The impact of other factors associated with availability of information of flexibility of organisation is evaluated as less significant or insignificant (70–85 % respondents).

Table 23 lists data on selected indicators describing the position of domestic innovating companies in **international comparison**. The innovation intensity is described in the indicator of expenditure on innovation (in % of revenues), which includes expenditure on related activities. The level of participation of innovating companies in cooperative networks is reflected in the indicator of the share of companies that concluded agreements on cooperation in innovation activities with other companies or institutions during the monitored period. Cooperation in this context means active participation in research, development and other innovation oriented projects with other organisations.

Expenditure on innovating activities in the EU-25 range from 2.7 % in Belgium to 0.5 % of revenues in Denmark. The average relative expenditure on innovating activities in the manufacturing industry is more than three times as high as in services. Smaller new member states (Hungary, Cyprus, Latvia, Lithuania) and Finland have the largest shares of cooperating innovators (more than 40 % of innovating companies). Companies operating in services cooperate less frequently than companies in the processing industry. From the perspective of **economic effects** expressed as a share of revenues from innovated products in total revenues, Germany records the highest values in products that are new for the company and Finland has the highest values in products that are new for the market (see Figure 12). The economic effects of innovations in the manufacturing industry are on average higher than in services.

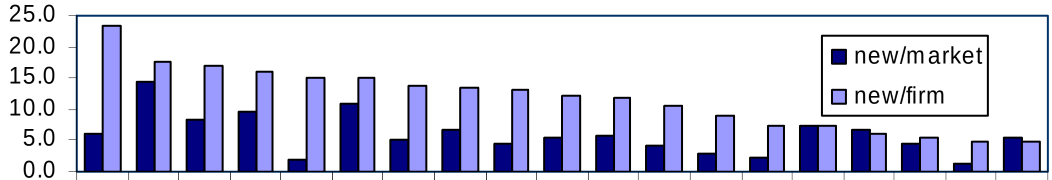
Table 23: Overview of activities in the innovating firms (CR, in %, 1998–2001)

	Total			
	expenditures	cooperation	new/ market	new/ firm
EU-25	2.1	..	5.9	16.8
EU-15	2.2	..	5.9	17.1
CZ	1.1	24.0	7.2	7.3
	Manufacturing			
EU-25	3.5	..	7.8	20.9
EU-15	3.5	..	7.8	21.2
CZ	1.5	24.8	10.8	10.7
	Services			
EU-25	1.1	..	4.4	14.5
EU-15	1.1	..	4.3	14.8
CZ	0.7	22.3	4.6	4.7

Note: expenditures – expenditures on innovation activities in % of sales, cooperation – % of firms cooperating in innovation activities, new/market, new/firm – share of sales of products, which are new for market/ firm in total sales. Source: EUROSTAT – New Cronos, Community Innovation Survey – CIS3, 1. 5. 2005, European Commission – European Innovation Scoreboard Database 2004.

Compared to the EU-25, Czech companies expend the second lowest share of their revenues on innovation activities, cooperate less with other organisations in implementation of innovation activities and record lower effects of products that are new for the company with regard to their share in total revenues, while the effects from products that are new for the market are slightly higher than the average figure in the EU-25 (higher in the manufacturing industry). In inter-sectoral comparison the Czech Republic lags behind the EU-25 less in services than in the manufacturing industry. In terms of other than technological changes, the highest number of companies with innovation activity introduced significant aesthetic changes (49 %), which are followed by changes in strategies (39 %) and changes in organisational structures (38 %). The share of companies with other than technological changes places the Czech Republic on average on the 12th place in the EU. The share of companies that protect their innovations through formal or informal means is low in the CR. The majority opts for protection through trademarks (23 %), while patents account for the smallest portion (8 %).

Figure 12: Sales from product innovations (in % of total sales, 1998–2000)



	DE	FI	ES	IT	UK	PT	BE	DK	AT	NL	FR	LT	GR	LU	CZ	SK	EE	HU	SI
new/market	6.2	14.5	8.3	9.5	1.9	10.8	5.1	6.6	4.6	5.6	5.7	4.3	2.9	2.1	7.2	6.6	4.5	1.4	5.3
new/firm	23.4	17.5	17.0	16.1	15.1	15.1	13.9	13.5	13.2	12.1	11.7	10.6	8.9	7.3	7.3	6.2	5.4	4.9	4.9

Source: EUROSTAT – New Cronos, Community Innovation Survey – CIS3, 1. 11. 2005; European Commission – European Innovation Scoreboard Database

6. Conclusion

The capacity of local **research and development** is a significant source of innovation performance. The CR holds one of the leading positions among the new EU member states according to the indicators of the extent of financial and human resources in research and development. Better results are achieved in Slovenia only and in some indicators also in Hungary. However, the extent of these resources remains below the average level for the EU. Despite the current growth trend, there is very little evidence of any significant move towards to the standard situation in the EU. This assessment is supported among others by a relatively weaker position of the CR in the extent of human resources compared to the extent of financial resources and a slower growth in public funding for research and development. Limiting factors of the growth of research resources to the benefit of innovation performance stem from distribution of resources according to research sectors and branches of manufacturing industries and services, low intensity of flow among these segments and persisting institutional barriers. It is mainly an issue of interconnections between academic research and the government sector (funding and performance) and the underrated position of the university research and development sector (although the position of this sector is improving significantly, this development is accompanied by a range of internal problems). Openness between research sectors and the subsequent opportunities for using mutual interactions for their restructuring has not been promoted so far. The low level of flow between resources of business enterprise sector and the university research sector is one of the main strategic weaknesses. The evaluation included herein is confirmed by individual innovation indexes on the subject of innovation stimuli and creation of knowledge, which assess the innovation performance of research and development according to the dynamics of their key factors: with the exception of the level of employment in industries with higher technological demands, employment in services with high technological demands, education of the young generation and ICT expenditure, the entire education and research segment is characterised by low dynamics and very slow approach to the institutional framework of the EU.

The **innovation activity of corporations** is a crucial factor in the growth of the national innovation system's performance. Available internationally comparable and local studies suggest that although the relative share of innovating companies is far below the EU-25 level, their profile according to innovation types is becoming increasingly similar to the proportions common in the EU. Similarly positive approach towards the EU standard can be observed in the share of small, medium and large companies in innovations and the level of activity of innovating companies in services can also be seen as positive. Innovating companies focus mainly on internal (research, qualification and financial) resources and acquisition of tangible assets (machinery and equipment) from external resources. External intangible resources (contracted research, consultancy, training, etc.) and especially commercial funding of innovation projects currently play a small role in the set of factors influencing innovation activities of companies.

The situation in the extent of adjustment of market factors to mobilisation of innovation activities in companies is relatively positive. However, this phenomenon focuses mainly on incremental product innovations (improving the quality, service) in relation to the market segment. Other external environment factors (public financial support, pressure of regulating standards) do not currently play any significant role in this regard. The prevailing impact of incremental innovations is also reflected in the profile of industrial property protection: greater attention is paid to protecting trademarks than to patent protection of products. Studies carried out at a regional level, which allow better specification of innovation activity even in the context of small companies, show that the micro-company segment (up to 10 employees) is characterised by high concentration of highly qualified labour, which creates favourable conditions for combining professional creativity and entrepreneurship.

The impact of **structural** factors, including their *institutional* aspects, was analysed from the perspective of innovation performance of research and development as well as findings concerning the entrepreneurial environment of innovating companies. As the impact of the knowledge base on the growth of innovation generally lessens, some positive structural conditions occur in the relatively high level of education in the young generation and the above-average position of the CR in the number of PhD graduates in natural and technical sciences. The CR is above the EU-25 average and even belongs to the four leading countries in this aspect. Analyses of CIS and EXIS data present a more comprehensive preview of structural characteristics. According to these analyses the innovation system of the CR displays the following growth factors: employment in industries with higher technological demands and services with high technological demands; education of the young generation; ICT expenditure accompanied by a relatively positive extent of organisational flexibility in companies; activity of small and medium-sized companies accompanied by a growth of their internal innovation resources; dynamics of the growth of corporate research in industries with higher technological demands and the impact of demand factors.

On the other hand, hindering factors are defined as follows: predominantly imitative character of innovations limiting opportunities for export; low dynamics of the growth of cooperation between small and medium-sized enterprises; significantly lagging rate of growth of the risk capital; poor level of indicators of new knowledge creation caused by the low level of funding of university research provided by the entrepreneurial sector; low quality of public administration. According to the available data, the profile of the infrastructure for supporting innovation is described as adaptive. This means that those infrastructure elements that allowed the country to make use of openness to EU markets have been strengthened while those that allow modifying and based on the circumstances making use of or even asserting new types of innovations fall behind. The weak modification dimension typical for smaller and technically advanced countries is especially critical.

References

Balzat, M., Hanusch, H.: Recent Trends in the Research on National Innovation Systems. Augsburg, Institut für Volkswirtschaftslehre 2003.

Carlsson, B., Jacobsson, S., Holmen, M., Rickne, A.: Innovation Systems: Analytical and Methodological Issues. *Research Policy*, 2002, No. 2, pp. 233-245.

Conway, P., Janod, V., Nicoletti, G.: Product Market Regulation in OECD Countries: 1998-2003. Paris, OECD 2005.

ČSÚ: Ukazatele vědy a techniky v ČR za období 1995-2002. Praha, Český statistický úřad 2004.

ČSÚ: Statistická ročenka vědy a technologie. Praha, Český statistický úřad 2005.

Doloreux, D., Parto, S.: Regional Innovation Systems: A Critical Review. Maastricht, MERIT 2004.

Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (eds.): *Technical Change and Ecoomic Theory*. London, Pinter 1988.

Dunning, J. H.: *Multinational Enterprises and the Global Economy*. Workingham, Addison-Wesley Publishing 1993.

EC: New Products and Services: Analysis of Regulations Shaping New Markets. Brussels, European Commission, Enterprise DG 2004.

EC: Competitiveness and Innovation Framework Programme. Brussels, European Commission 2005.

Edquist, C. (ed.): *Systems of Innovation: Technologies, Institutions and Organizations*. London, Pinter 1997.

EIS: European Innovation Scoreboard. Brussels, European Commission 2003-2005.

Europe Economics: The Developmennt of Analytical Tools for Assessing Market Dynamics in the Knowledge Based Economy. London, Europe Economics 2003.

EUROSTAT: R&D and Internationalisation. *Statistics in Focus*, 2005, No. 7.

EXIS: An Exploratory Approach to Innovation Scoreboards. Brussels, European Commission 2005.

Fabry, N.: The Role of of Inward-FDI in Transition Countries of Europe: An Analytical Framework. Noisy-le-Grand, Université de Mame-la-Vallée 2000.

Fagerberg, J., Guerrieri, G., Verspagen, B.: *The Economic Challenge for Europe: Adapting to Innovation Based Growth*. Cheltenham, Edward Elgar 1999.

Freeman, C.: *Technology and Economic Performance: Lessons from Japan*. London, Pinter 1988.

Jaumotte, F., Pain, N.: An Overview of Public Policies to Support Innovation. Paris, OECD 2005.

Kadeřábková, A.: Hospodářský růst a strukturální změny. Praha, Oeconomica 2003.

Kadeřábková, A.: *Výzvy pro podnikání – inovace a vzdělávání*. Praha, Linde 2004.

Kadeřábková, A. a kol.: *Ročenka konkurenceschopnosti České republiky 2005*. Praha, Linde 2005.

Kadeřábková, A., Müller, K.: Národní inovační systémy: výzkumné a vývojové zdroje, infrastrukturní předpoklady. Praha, CES VŠEM 2005.

Lundvall, B.-A. (ed.): *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London, Pinter 1992.

Malerba, F.: Sectoral Systems of Innovation and Production. *Research Policy,* 2002, No. 2, pp. 247-264.

Nelson, R. (ed.): *National Innovation Systems: A Comparative Analysis*. Oxford, Oxford University Press 1993.

OECD: Science, Technology and Industry Scoreboard. Paris, OECD 2005.

OECD: Economic Policy Reforms: Going for Growth 2005. Paris, OECD 2006.

Pavitt, K.: Patterns of Technical Change: Towards a Taxonomy and a Theory. *Research Policy*, 1984, No. 6, pp. 343-373.

Porter, M.: Clusters and the New Economics of Competition. *Harvard Business Review*, 1998, November-December, pp. 77-90.

Porter, M.: Building the Microeconomic Foundations of Prosperity: Findings from the Business Competitiveness Index. In: *Global Competitiveness Report 2003-2004*. Oxford, Oxford University Press 2003, pp. 29-56.

Sala-i-Martin, X., Artadi, E.: The Global Competitiveness Index. In: *Global Competitiveness Report 2004-2005*. New York, Palgrave Macmillan 2004, pp. 51-70.
Srholec, M.: *Přímé zahraniční investice v ČR: Teorie a praxe mezinárodního srovnání*. Praha, Linde 2004.
Srholec, M.: Teoreticko-metodologická východiska hodnocení inovační výkonnosti na alternativních analytických úrovních. Praha, CES VŠEM 2005.
UNCTAD: World Investment Report 2002-2005. Geneva, UNCTAD 2002-2005.
WB: *Doing Business in 2006: Creating Jobs*. Washington, World Bank 2005.
WEF: *Global Competitiveness Report 2004-2005*. New York, Palgrave Macmillan 2004.
WEF: *Global Information Technology Report 2004-2005*. New York, Palgrave Macmillan 2005.

CES
CENTRE FOR ECONOMIC STUDIES
I.P.Pavlova 3
120 00 Praha 2
Czech Republic
tel +420 841 133 166
bulletin@vsem.cz
www.cesvsem.cz