International Audit of Research, Development & Innovation in the Czech Republic

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Science-Industry Links

Preliminary Findings

Annex 5 to the Second Interim Report

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

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1. Introduction

This contribution to the Second Interim Report provides first descriptive results from WP e on science-industry linkages (SIL) in the Czech Republic's innovation system. It must be mentioned that these are preliminary, mostly descriptive results, presenting patterns derived from statistical analysis and impressions from interviews. A more detailed and comprehensive analysis will be part of next steps and will be presented in the final report.

The focus on SIL is guided by the following general questions:

- "What types of generic mechanisms that either stimulate or impede the relations between research and industry are in place in the Czech Republic?"
- "What is the practice in implementing or changing these generic mechanisms, what are the key circumstances that affect success of policy interventions, and how did they evolve over time? What are particular strength of the Czech innovation system, what are bottlenecks and weaknesses?"

After a short description of the chosen approach the following chapter deals with structures of SIL.

In the previous months, activities were focused on setting up a background for future analysis. First findings are structured along two sections in this report:

- The first section contains specialisation patterns of the Czech Republic's industry and its R&D intensities – followed by indications of collaboration. Special emphasis is placed on the role of multinational firms and some econometric results are shown.
- The second section deals with assessments regarding the relationships between science and industry and the role of public programmes from conducted interviews with stakeholders.

From the appearing picture some reflections are drawn about highlighted points of interest. Nevertheless, these results do not represent the full analysis of SIL, but first impressions. A concluding outlook provides information about next steps in the analysis to arrive at a detailed an comprehensive assessment of SIL.

2. Approach

The evaluation of the SIL and the role of policy-related framework conditions are based on using a combination of methods:

- Desk-research is used to gather existing knowledge (including available studies and documents) about SIL in the Czech innovation system. Furthermore a brief overview of the linkages will be derived and framework conditions in international context are exploited for evaluating the linkages. All together this will produce a detection of problems, strength and weaknesses.
- Analysis based on available secondary data is used to derive with insights about the range of SIL, the sources of knowledge transfer and embeddings of international enterprises in this respect, presenting stylized facts about qualitative and quantitative aspects. As much as appropriate some econometric analysis sheds light on relations characterising the linkages. Furthermore, an international comparison may derive with strength and weaknesses in the Czech innovation system.

- A more detailed analysis of linkage practices will be based on the results from the online-survey carried out under WP (a) which will partly consist of questions concerning SIL. As the survey was conducted differentiating between types of actors (universities, research organisations, companies), resulting quantitative statistics can present insights in motivation background, incentive structures and implementation problems for linkages between science and industry (or even more detailed between national/international enterprises and several types of (public) research organisations).
- Based on cases of already established good cooperative links, about 20 interviews of companies and research groups provide a more detailed qualitative picture of current practice and especially absorptive capacities. Furthermore the identification of barriers and success factor is an important part of the interviews. First results from the online-survey may feed into this part of analysis as a pre-structuring element.

In previous months all listed methods have been applied to derive with first findings about the overall situation regarding SIL. First descriptive results from statistics and comparisons with selected countries, added by information from interviews and studies, build the background for this report.

Hence, only a first sketch about the situation is provided, representing a limited insight from selective methods, while further analysis will be part of a final report.

3. Pattern of Czech Science-Industry Linkages

Patterns of SIL in the Czech Republic's system must be distinguished (1) in relations regarding R&D activities and (2) in collaborative activities to foster innovation – having in mind that R&D activities form an important background for creating innovations. As innovation means implementing some new or improved products, processes, new marketing methods or organisation in business[1], innovation activities comprise much more than just R&D (e.g. entrepreneurship, promotion of products). Hence, a more complex pattern of SIL is generated when considering innovations activities.

Linkages between science and industry sector are influenced by nationwide circumstances:

- the structures of science and industry, their R&D efforts and behavioural routines for cooperation – implying the consequences of creating long-term path dependencies,
- the prevalent needs of industry regarding production factors and services based on R&D,
- environmental conditions concerning competition in both sectors, and
- the milieu (including "cultures" and applied measures) generated by public support of SIL.

Relations emerge by highly diverse characteristics. Knowledge building and knowledge transfer is channelled and structured in various occurrences, reaching from exchange of personnel to the use of coordination activities (e.g. cluster activities).

[1] In accordance with OECD classifications.

Consequently the treatment of SIL demands for following a broader approach, from dealing with industrial structures as much as with framework conditions and public support

The descriptions and analysis in this section is based on data provided by Czech Statistical Office, Eurostat and OECD.

3.1 Industry patterns and R&D intensities[2]

Looking for linkage structures between science and industry, we start with industrial structure in Czech Republic and its R&D efforts. They build the background for the potential of linkages.

Shares of gross value added by industry highlight the most important contributors to the country's income, while annual growth rates provide an indication about the relative developments – pointing to increasing or decreasing contributions and hence importance of the single industry. Overall, the relative shares of industries may point to some possible strength and weaknesses in the Czech Republic's income pattern.

Furthermore, looking for the R&D expenditures provides information about R&D intensities in these industries. The resulting patterns illustrate to which extent national income is based on industries with higher R&D expenditures. In addition, structure and development of R&D expenditures in industry throw light on potential for links between science and industry and its consequences for the country's competitiveness.

3.1.1 Industry and R&D: structure and growth

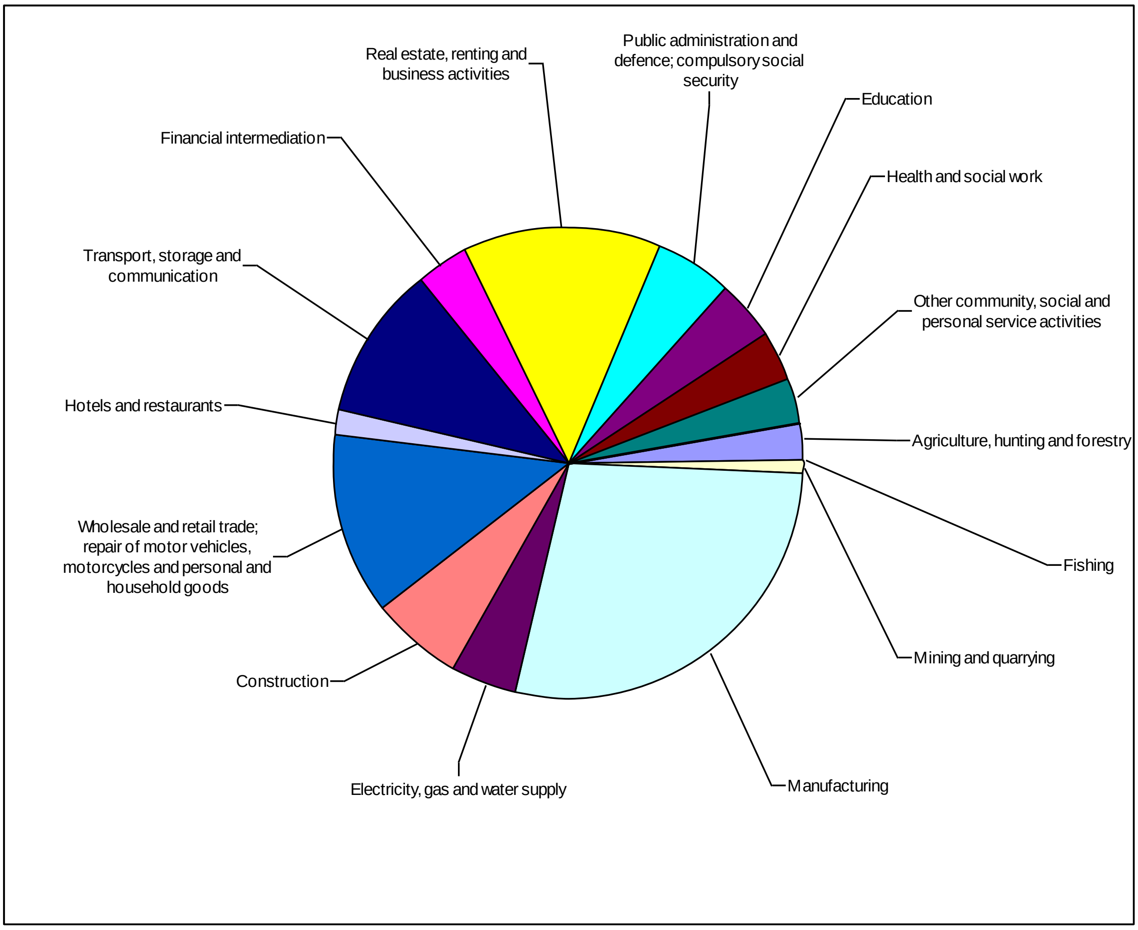
As displayed in Figure 1 largest income contributions (gross value added)[3] from the Czech Republic's industrial structure result from "Manufacturing", "Real estate, renting and business activities"[4] and "Wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods".

[2] By the term "industry" are all classes of productive activities included – not just manufacturing.

[3] One-digit level.

[4] Including „Research and development" with share of 0.32% in 2008.

Figure 1: Share of gross value added by industry (2008)



Source: Eurostat 2010, calculations JOANNEUM RESEARCH

A more disaggregated observation presents highest shares of gross value added in "Manufacturing"[5] in following industries: "Manufacture of motor vehicles, trailers and semi-trailers" (4.06%), "Manufacture of machinery and equipment n.e.c." (3.38%) and "Manufacture of fabricated metal products, except machinery and equipment" (2.70%). The former two are also leading in annual growth rates 2001-2008 amongst the industries from "Manufacturing" (see highlighted cells in Table 1).

Table 1: Gross value added (at basic prices) by industry: Share of Total (2008) and annual average growth rate (in %, nominal; 2001-2008)

		Share 2008	Average annual growth rate (2001-2008; nominal)
TOTAL	**TOTAL - ALL NACE ACTIVITIES**	**100.00**	**10.96**
A	Agriculture, hunting and forestry	2.49	5.04
B	Fishing	0.01	-1.95
C	Mining and quarrying	1.16	8.70
D	Manufacturing	27.71	11.96
DA15	Manufacture of food products and beverages	2.46	7.23
DA16	Manufacture of tobacco products	0.13	-2.56
DB17	Manufacture of textiles	0.48	1.41

[5] "Manufacturing" sector is responsibe for about 2/3 of R&D in business sector.

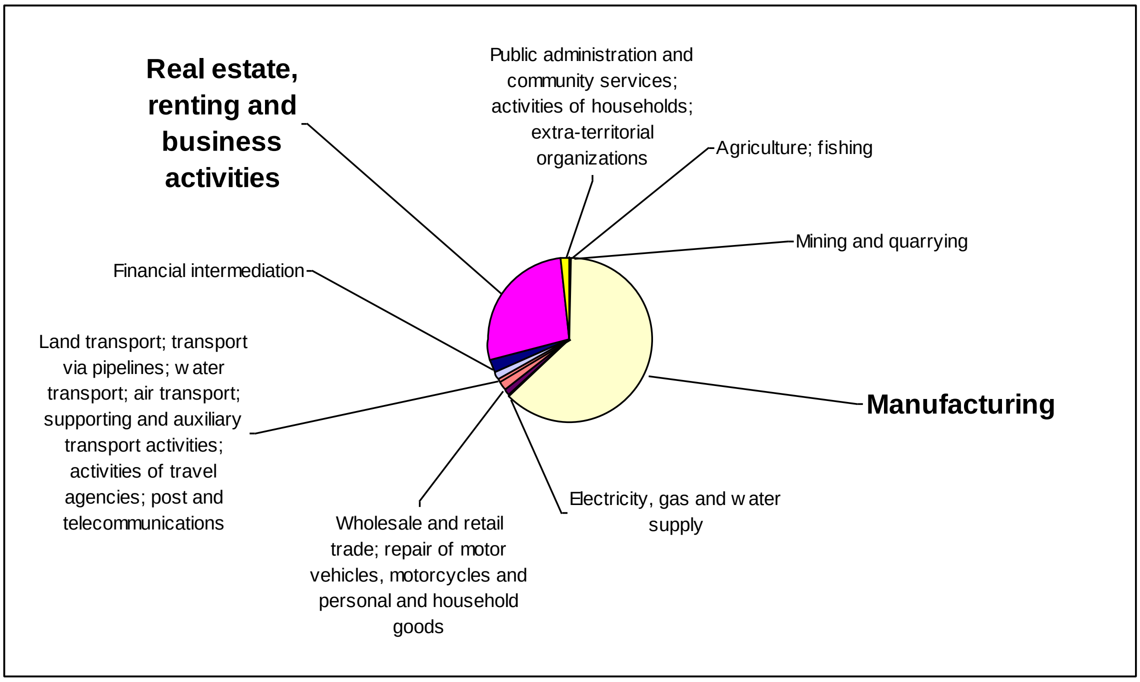
		Share 2008	Average annual growth rate (2001-2008; nominal)
DB18	Manufacture of wearing apparel; dressing; dyeing of fur	0.22	-1.09
DC19	Manufacture of leather and leather products	0.06	-5.03
DD20	Manufacture of wood and wood products	0.96	10.21
DE21	Manufacture of pulp, paper and paper products	0.51	6.87
DE22	Publishing, printing and reproduction of recorded media	0.99	16.93
DF23	Manufacture of coke, refined petroleum products and nuclear fuel	0.37	9.11
DG24	Manufacture of chemicals, chemical products and man-made fibres	1.29	8.10
DH25	Manufacture of rubber and plastic products	1.96	17.89
DI26	Manufacture of other non-metallic mineral products	1.69	8.81
DJ27	Manufacture of basic metals	1.32	9.44
DJ28	Manufacture of fabricated metal products, except machinery and equipment	2.70	12.49
DK29	Manufacture of machinery and equipment n.e.c.	3.38	16.01
DL30	Manufacture of office machinery and computers	0.30	11.68
DL31	Manufacture of electrical machinery and apparatus n.e.c.	1.94	12.00
DL32	Manufacture of radio, television and communication equipment and apparatus	0.81	16.30
DL33	Manufacture of medical, precision and optical instruments, watches and clocks	0.53	11.67
DM34	Manufacture of motor vehicles, trailers and semi-trailers	4.06	20.26
DM35	Manufacture of other transport equipment	0.40	9.63
DN36	Manufacture of furniture; manufacturing n.e.c.	1.01	10.36
DN37	Recycling	0.14	18.04
E	Electricity, gas and water supply	4.53	17.12
F	Construction	6.22	11.59
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	12.62	8.43
H	Hotels and restaurants	1.71	8.73
I60	Land transport; transport via pipelines	4.25	10.52
I61	Water transport	0.01	2.54
I62	Air transport	0.34	13.82
I63	Supporting and auxiliary transport activities; activities of travel agencies	2.95	11.97
I64	Post and telecommunications	2.82	9.21
J65	Financial intermediation, except insurance and pension funding	2.44	12.02
J66	Insurance and pension funding, except compulsory social security	0.88	19.69
J67	Activities auxiliary to financial intermediation	0.41	19.09
K70	Real estate activities	5.07	7.44
K71	Renting of machinery and equipment without operator and of personal and household goods	0.28	9.49
K72	Computer and related activities	1.95	17.92
K73	Research and development	0.32	10.85
K74	Other business activities	5.87	12.86
L	Public administration and defence; compulsory social security	5.39	10.88
M	Education	4.06	11.49
N	Health and social work	3.50	9.66
O	Other community, social and personal service activities	2.98	12.16
P	Activities of households	0.01	11.30
Q	Extra-territorial organisations and bodies	0.00	…

Source: Eurostat 2010, calculations JOANNEUM RESEARCH

While the former indicators show the importance of single industries regarding their contribution to income, a next addressed question would ask about the extension of basing this income on R&D efforts. Consequently the share of business expenditures in R&D (BERD) in industries should provide some answers.

In Figure 2 it becomes evident that the largest share of research activities is in “Manufacturing” followed by “Real estate, renting and business activities” (which include the industries “Computer and related activities” and “Research and development”, taken together accounting for about one quarter of all BERD, see Table 2).

Figure 2: Share of BERD by industry (2008)



Source: Eurostat 2010, calculations JOANNEUM RESEARCH

Regarding “Manufacturing” highest R&D efforts take place in the industries “manufacture of motor vehicles, trailers and semi-trailers” (24.39%) (this share would even be increased, if closelry related industry group DM 35 is taken into account), “manufacture of machinery and equipment n.e.c.” (7.54%) and “manufacture of chemicals and chemical products” (5.43%), with all three are only being in a middle group in annual growth rates of BERD (between 2001 and 2008), while highest annual growth rates appear in “Electricity, gas and water supply”, “Manufacture of office machinery and computers” and “Computer and related activities”, followed by “Manufacture of medical, precision, and optical instruments” (see Table 2).

Interestingly enough, Table 2 indicates that average annual growth rates of R&D in the second sector (“Manufacturing”) is lowest amongst the three sectors (Agriculture and Mining, Manufacturing and Services). Nevertheless, all data have to be treated with caution as business cycles have their influence on R&D spent in business - usually working pro-cycling.

Table 2: BERD by industry: Share of Total (2008) and annual average growth rate (in %, nominal; 2001-2008)

		Share 2008	Average annual growth rate (2001-2008; nominal)
TOTAL	TOTAL - ALL NACE ACTIVITIES	100.00	15.1
A_B	Agriculture; fishing	0.30	10.7
C	Mining and quarrying	0.25	11.7
D	**Manufacturing**	**62.34**	**13.6**
DA15-16	Manufacture of food products, beverages and tobacco	0.94	30.8
DB17	Manufacture of textiles	0.48	20.8
DB18	Manufacture of wearing apparel; dressing; dyeing of fur	0.11	-2.4
DC19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	0.04	12.2
DD20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.03	...
DE21	Manufacture of pulp, paper and paper products	0.00	-19.2
DE22	Publishing, printing and reproduction of recorded media	0.02	15.1
DF23	Manufacture of coke, refined petroleum products and nuclear fuel	0.04	6.6
DG24	Manufacture of chemicals and chemical products	5.43	13.7
DG24_X_DG 244	Manufacture of chemicals and chemical products (except pharmaceuticals, medicinal chemicals and botanical products)	2.19	8.9
DG244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	3.24	18.2
DH25	Manufacture of rubber and plastic products	1.96	25.5
DI26	Manufacture of other non-metallic mineral products	1.45	6.0
DJ27	Manufacture of basic metals	1.00	6.8
DJ27_FER	Manufacture of basic iron and steel and of ferro-alloys; of tubes and other first processing of iron and steel; casting of iron and steel	0.55	-0.5
DJ27_NFE	Manufacture of basic precious and non-ferrous metals; casting of light metals and other non-ferrous metals	0.45	33.9
DJ28	Manufacture of fabricated metal products, except machinery and equipment	1.57	8.7
DK29	Manufacture of machinery and equipment n.e.c.	7.54	15.4
DK2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.39	...
DK293-DK296	Manufacture of agricultural and forestry machinery; machine-tools; other special purpose machinery; weapons and ammunition	4.68	12.8
DK294	Manufacture of machine-tools	0.96	8.1
DK296	Manufacture of weapons and ammunition	0.24	4.0
DL30	Manufacture of office machinery and computers	0.22	45.6
DL31	Manufacture of electrical machinery and apparatus n.e.c.	3.49	21.6
DL311	Manufacture of electric motors, generators and transformers	0.51	15.4
DL312	Manufacture of electricity distribution and control apparatus	1.03	20.0
DL313	Manufacture of insulated wire and cable	0.07	16.4
DL314	Manufacture of accumulators, primary cells and primary batteries	0.00	...
DL315	Manufacture of lighting equipment and electric lamps	0.23	38.6
DL316	Manufacture of electrical equipment n.e.c.	1.66	23.8
DL32	Manufacture of radio, television and communication equipment and apparatus	3.56	18.5
DL321	Manufacture of electronic valves and tubes and other electronic components	0.74	22.1
DL322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	1.93	14.4
DL323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	0.90	29.4
DL33	Manufacture of medical, precision and optical instruments, watches and clocks	5.33	39.0
DL331	Manufacture of medical and surgical equipment and orthopaedic appliances	0.65	56.0
DL332	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	1.01	16.1
DL333	Manufacture of industrial process control equipment	3.46	57.2
DL334	Manufacture of optical instruments and photographic equipment	0.20	96.0
DL335	Manufacture of watches and clocks	0.01	...
DM34	Manufacture of motor vehicles, trailers and semi-trailers	24.39	9.4

		Share 2008	Average annual growth rate (2001-2008; nominal)
DM35	Manufacture of other transport equipment	4.42	16.1
DM351	Building and repairing of ships and boats	0.00	...
DM352	Manufacture of railway and tramway locomotives and rolling stock	2.75	27.3
DM353	Manufacture of aircraft and spacecraft	1.51	5.7
DM354_DM 355	Manufacture of motorcycles, bicycles and other transport equipment n.e.c.	0.16	32.9
DN36	Manufacture of furniture; manufacturing n.e.c.	0.30	16.5
DN361	Manufacture of furniture	0.14	29.5
DN362-DN366	Manufacture of jewellery and related articles, musical instruments, sports goods, games and toys and miscellaneous n.e.c	0.17	10.7
DN37	Recycling	0.02	30.4
E	Electricity, gas and water supply	0.20	62.7
F	Construction	1.03	12.4
G-Q	**Services**	**35.88**	**18.3**
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	2.55	28.2
H	Hotels and restaurants	0.00	...
I60-I64	Land transport; transport via pipelines; water transport; air transport; supporting and auxiliary transport activities; activities of travel agencies; post and telecommunications	1.32	22.4
I60-I64_X_I642	Land transport; transport via pipelines; water transport; air transport; supporting and auxiliary transport activities; activities of travel agencies; post and courier activities	0.01	-35.4
I642	Telecommunications	1.30	127.2
J	Financial intermediation	2.74	185.2
K	Real estate, renting and business activities	27.55	17.6
K72	Computer and related activities	10.09	40.7
K722	Software consultancy and supply	7.75	36.2
K73	Research and development	13.50	9.2
K74	Other business activities	3.90	28.6
K742_K743	Architectural and engineering activities and related technical consultancy; technical testing and analysis	3.36	32.3
L-Q	Public administration and community services; activities of households; extra-territorial organisations	1.72	2.5

Source: Eurostat 2010, calculations JOANNEUM RESEARCH

Taken together, "Manufacturing" accounts for about 62% of business expenditures in R&D (Table 2), but only for approximately 28% of gross value added (Table 1), while for "Services"[6] it is almost vice versa. Consequently enterprises from manufacturing sector have to be most important partners for SIL. On the other hand the service sector indicates the highest growth rates in R&D, e.g. "computer and related activities".[7]

Observations show that the largest share of BERD is not invested in industries with highest contributions of gross value added, but in industries with lower growth rates in R&D – which may also have an influence on the development of the potential for SIL.

3.1.2 Specialisation patterns of Czech Republic's industry

In order to detect specialisation patterns in Czech Republic's industry and hence comparative advantages the revealed comparative advantage (RCA) has been

[6] Including "Research and development" and "Computer and related activities"

[7] The high growth figures in "Financial Intermediation" need a more in-depth view.

calculated, which compares the relation between the output of sector i in country k to the total output in sector I in the benchmark (EU27) with the relation between total output (all sectors) in country k in comparison to total output in the benchmark. It is defined as

$$RCA_{ki} = 100 \tanh \ln (A_{ki} / \sum_k A_{ki}) / (\sum_i A_{ki} / \sum_{ik} A_{ki})$$ (Grupp 1997: 213[8]).

Positive values indicate a specialisation.

LN centres the data around zero and the hyperbolic tangent multiplied by 100 limits the RCA values to a range between +100 and -100. Positive values for sector i point to the fact that the sector has a higher weight in the portfolio of the country than its weight in the EU27 (all expenditures from all countries taken together). Negative values indicate specialisation in the field i below the average, respectively.

The main advantage of the RCA indicator is that it allows the assessment of the relative position of the industry in a country beyond any size effects. Neither the size of the industry nor the size of the country has an impact on the outcome of this indicator. Therefore, it is possible to directly compare countries and objectives.

We have to take into account that specialisation is a relative term. Hence, a benchmark is needed that shows in which areas a given country is specialised compared to this benchmark. The benchmark might be the world, a selection of countries (e.g. EU-15/EU-27) or a single outstanding country as regards R&D performance (best practice benchmark). The selection of the benchmark has, of course, a severe impact on the "specialisation" result, but at the same time the selection of the benchmark is heavily influenced by the availability of data.[9]

In this report two RCA calculations appear. First we look again for gross value added of industries compared to EU27 and get an indication about the industries in Czech Republic which are represented to a much higher degree than in the benchmark and hence, may also represent an competitive advantage. Secondly we try to figure out the specialisation pattern regarding R&D expenditures of industries.

Related to Table 3 RCA of gross value added is highest in "Manufacture of office machinery and computers" and "Manufacture of motor vehicles, trailers and semi-trailers", with both being not amongst the group of highest RCA in 2001. Only the two industries: "Manufacture of wood and wood products" and "Manufacture of other non-metallic mineral products" keep their position between 2001 and 2008 in the leading group. As a consequence, one may argue that in the Czech Republic's industries' restructuring took place. This may also include a change in importance of factors determining competitiveness.

8 Grupp calls this not RCA, but "relativer Welthandelsanteil (RWA)" [relative world market share]. In his work RCA is only used for the relation between imports and exports, and hence differently from Balassa's (1965) original meaning.

9 Therefore the benchmark is given in brackets.

Table 3: Czech Republic Revealed Comparative Advantage of Gross value added (at basic prices) by industry (2008 and 2001) (Benchmark EU27)

		RCA 2008	RCA 2001
TOTAL	TOTAL - ALL NACE ACTIVITIES	0	0
A	Agriculture, hunting and forestry	32	46
B	Fishing	-92	-75
C	Mining and quarrying	28	39
D	**Manufacturing**	47	29
DA15	Manufacture of food products and beverages	27	39
DA16	Manufacture of tobacco products	57	79
DB17	Manufacture of textiles	46	55
DB18	Manufacture of wearing apparel; dressing; dyeing of fur	-15	32
DC19	Manufacture of leather and leather products	-61	6
DD20	Manufacture of wood and wood products	74	69
DE21	Manufacture of pulp, paper and paper products	12	3
DE22	Publishing, printing and reproduction of recorded media	9	-47
DF23	Manufacture of coke, refined petroleum products and nuclear fuel	21	4
DG24	Manufacture of chemicals, chemical products and man-made fibres	-28	-25
DH25	Manufacture of rubber and plastic products	74	38
DI26	Manufacture of other non-metallic mineral products	67	67
DJ27	Manufacture of basic metals	49	57
DJ28	Manufacture of fabricated metal products, except machinery and equipment	46	32
DK29	Manufacture of machinery and equipment n.e.c.	49	17
DL30	Manufacture of office machinery and computers	85	51
DL31	Manufacture of electrical machinery and apparatus n.e.c.	66	55
DL32	Manufacture of radio, television and communication equipment and apparatus	49	-5
DL33	Manufacture of medical, precision and optical instruments, watches and clocks	-2	-17
DM34	Manufacture of motor vehicles, trailers and semi-trailers	80	37
DM35	Manufacture of other transport equipment	-5	-3
DN36	Manufacture of furniture; manufacturing n.e.c.	53	39
DN37	Recycling	30	20
E	Electricity, gas and water supply	62	44
F	Construction	-1	7
G	Wholesale and retail trade; repair of motor vehicles, etc.	11	22
H	Hotels and restaurants	-49	-35
I60	Land transport; transport via pipelines	45	46
I61	Water transport	-100	-99
I62	Air transport	52	13
I63	Supporting and auxiliary transport activities; activities of travel agencies	63	65
I64	Post and telecommunications	18	20
J65	Financial intermediation, except insurance and pension funding	-39	-37
J66	Insurance and pension funding, except compulsory social security	-15	-41
J67	Activities auxiliary to financial intermediation	-61	-73
K70	Real estate activities	-67	-48
K71	Renting of machinery and equipment without operator, personal, goods	-86	-83
K72	Computer and related activities	5	-33
K73	Research and development	-64	-62
K74	Other business activities	-28	-31
L	Public administration and defence; compulsory social security	-13	-14
M	Education	-20	-24
N	Health and social work	-60	-49
O	Other community, social and personal service activities	-25	-32
P	Activities of households	-100	-100

		RCA 2008	RCA 2001
Q	Extra-territorial organisations and bodies	...	...

Source: Eurostat 2010, calculations JOANNEUM RESEARCH (Highlighted are values >=66),

An indication for and specialisation on R&D in certain industries can again be expressed by expenditures above the average – compared to some benchmark. But RCA for R&D expenditure is very difficult to calculate, because of many missing values (for individual NACE classes) in official R&D statistics of different countries. Hence, we calculated the RCA only for (selected) manufacturing sectors and with a smaller benchmark for one year[10].

Table 4: Czech Republic Revealed Comparative Advantage of R&D expenditure by industry (2007) (Benchmark: Belgium, Denmark, Germany, Estonia, Spain, Hungary, Austria, Poland, Portugal, Slovenia, and United Kingdom

		RCA 2007
DA	Manufacture of food products, beverages and tobacco	-60
DB_DC	Manufacture of textiles and textile products; leather and leather products	54
DD_DE	Manufacture of wood and wood products, pulp, paper and paper products; publishing and printing	-92
DF-DH	Manufacture of coke, refined petroleum products and nuclear fuel; chemicals, chemical products and man-made fibres; rubber and plastic products	-56
DI26	Manufacture of other non-metallic mineral products	67
DJ27	Manufacture of basic metals	40
DJ28	Manufacture of fabricated metal products, except machinery and equipment	14
DK29	Manufacture of machinery and equipment n.e.c.	7
DL30	Manufacture of office machinery and computers	-98
DL31	Manufacture of electrical machinery and apparatus n.e.c.	13
DL32	Manufacture of radio, television and communication equipment and apparatus	-30
DL33	Manufacture of medical, precision and optical instruments, watches and clocks	1
DM34	Manufacture of motor vehicles, trailers and semi-trailers	41
DM35	Manufacture of other transport equipment	-25
DN36	Manufacture of furniture; manufacturing n.e.c.	-50

Source: Eurostat 2010, calculations JOANNEUM RESEARCH (Highlighted are values >=40)

Table 4 shows that "Manufacture of other non-metallic mineral products" has highest RCA, followed by "Manufacture of textiles and textile products; leather and leather products"[11] and "Manufacture of motor vehicles, trailers and semi-trailers". Having in mind the shortcomings of the benchmarks and derived RCAs one would recognise a rather interesting specialisation pattern. With the exception of "Manufacture of motor vehicles, trailers and semi-trailers" the other two are characterised by small shares in gross value added and BERD. They are also characterised by negative (textiles, leather) or moderate (non-metallic mineral products) average annual growth rates of gross value added, but substantial (textiles, leather) or low (non-metallic mineral products) average annual growth rates of BERD. Interestingly enough is the negative

[10] Due to confidentiality sometimes some sectors do not include all subsectors (e.g. in Austria DF-DH does not include information on coke and refined petroleum products).

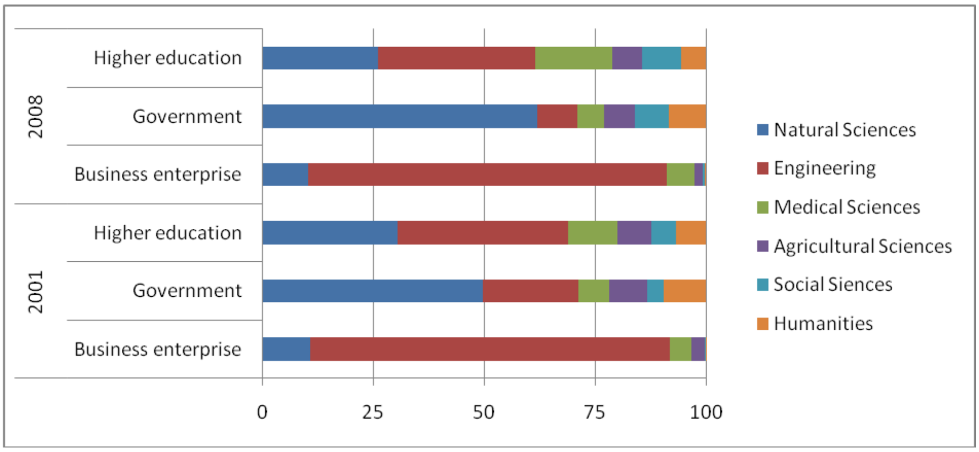
[11] This industry is in decline, represents only a small share of BERD, but relatively high annual growth rates in BERD - and needs some further investigation.

RCA for "Manufacture of office machinery and computers" [12], an industry representing only a small share but highest RCA in value added. Additionally it is indicating highest growth rates in BERD.

3.1.3 International comparison

Figure 3 shows that R&D in the business sector is very much focused on engineering whereas the government sector focuses on natural sciences.[13] Moreover, the government sector has even decreased its share in engineering between 2001 and 2008 for the benefit of natural sciences. The distribution in higher education presumably reflects the broad variety of scientific fields covered by the sector.[14]

Figure 3: Share of fields of science by sector of performance in Czech Republic (based on R&D expenditure)



Source: OECD Research and Development Statistics downloaded 12/2010

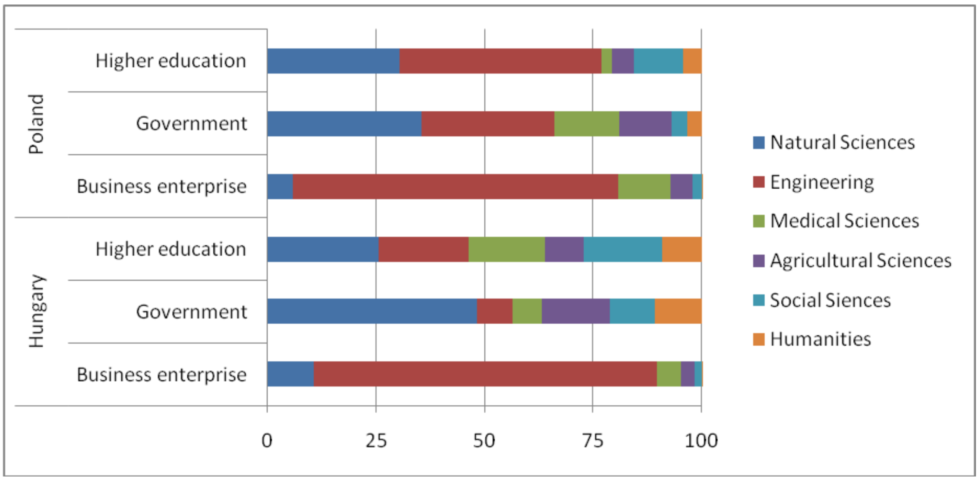
Most other countries chosen for comparison do not provide these figures for the business sector. Hence, Figure 4 shows the distribution for Poland and Hungary only. This comparison clearly indicates that the situation in the Czech Republic is not unique – the business sector in both of the other two countries is also focused on engineering. At least in Poland the higher education sector matches this concentration to a certain degree, whereas in Hungary it is even more equally split than in the Czech Republic.

[12] But this indication may be related to the benchmarking countries.

[13] Government sector includes ASCR, while universities are in Higher Education sector.

[14] One would have to mention that here are also technical universities included (with their typical engineering focus) and teaching hospitals.

Figure 4: Share of fields of science by sector of performance in selected countries 2007 (based on R&D expenditure)



Source: OECD Research and Development Statistics downloaded 12/2010

Evidence in structures of R&D activities point to quite similar patterns in neighbouring countries with clearly focused R&D activities in business sector on engineering. An interesting observation is the increasing share of natural sciences in government sector.

3.1.4 Preliminary conclusions on industry pattern

Taken all the calculations and observations from above together, "Manufacture of motor vehicles, trailers and semi-trailers" appears as the most important industry – being amongst the highest contributors to income and R&D, however, not in terms of highest growth rates.

In addition, industries like "Manufacture of machinery and equipment" and "Manufacture of chemicals and chemical products"[15] are important contributors to R&D (and income in case of machinery and equipment), with moderate growth rates in BERD (and highest growth rates in value added in case of machinery and equipment).

Another interesting industry is office machinery and computers contributing only with small share to value added and BERD but indicating highest growth rates in BERD.

Consequently, one could expect SIL in these industries with higher R&D expenditures. However, it would also be necessary to look into the industry – being aware that income growth is not only based on R&D activities.

3.2 Funding flows in R&D as indication of linkages

The former chapter dealt with the industry structure in order to look for those industries being of importance for the country and having already the potential for SIL and the ones which may be candidates for increased SIL derived from their growth rate and R&D base. In this chapter we will have a look on funding flows of R&D.

An indication for the interrelatedness of actors in national innovation systems – i.e. SIL – are the financial flows (e.g. between science and industry). These cross-sectoral

[15] Which include pharmaceuticals.

funding flows do not present collaborative research or innovative activities as such, but indicate interactions and provide hints on division of labour (e.g. expressed by contracted research patterns).

While these flows are analysed in more detail in WP a by focussing on structures, here the focus is more on relations between the sectors (i.e. science and industry).

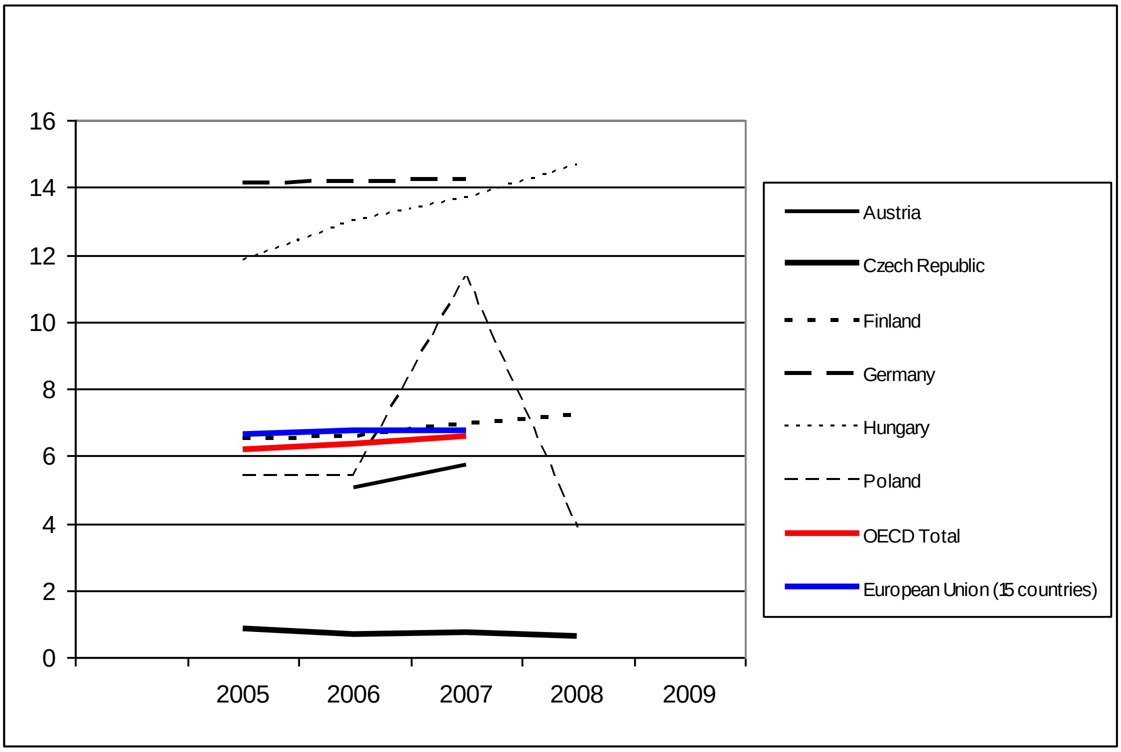
3.2.1 R&D in public sector financed by industry

First, there are payments from industry to the science sector – either being represented by organisations from higher education sector (e.g. universities) or organisations being included in the government sector (e.g. ASCR). Consequently, shares of financing the R&D activities of both sectors by industry are marking to which extend industry uses these research capacities, either by contracted research or by any kind of collaborative research with actors from these sectors.

Business enterprises' R&D funded by government on the other side show to which extend private R&D is supported. This support includes measures and activities to intensify SIL.

Figure 5 shows the (internationally) very low industry involvement in higher education research (which includes mainly universities).

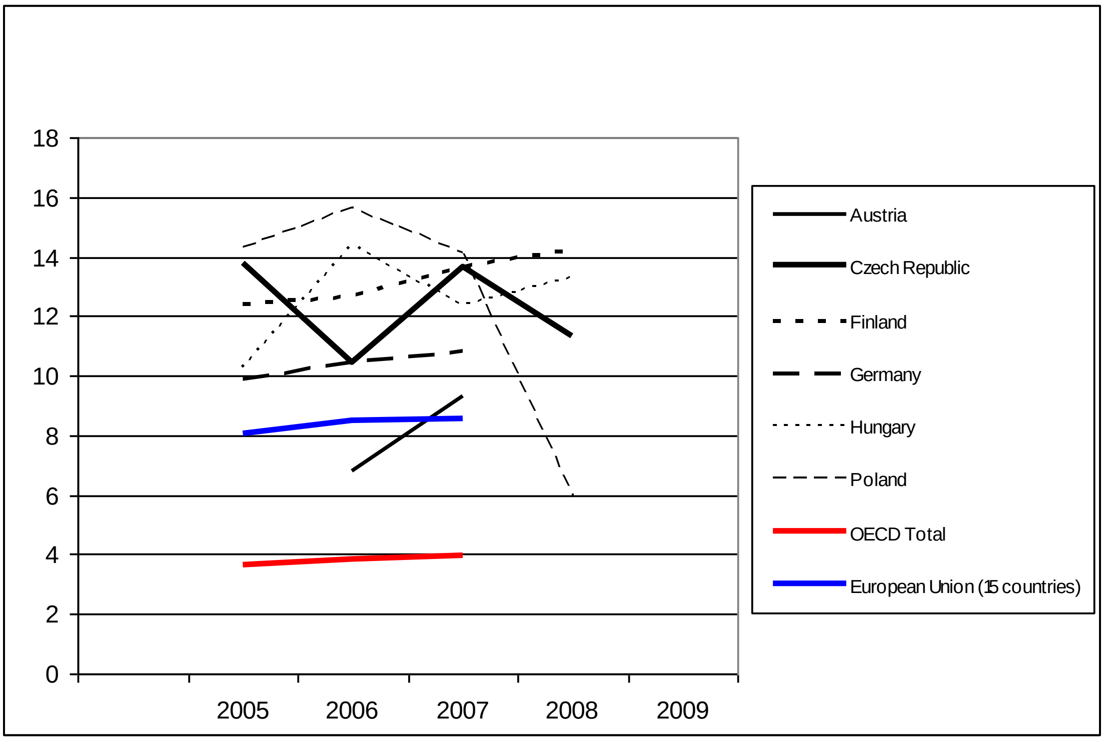
Figure 5: Share of HERD (%) financed by industry (2004-2008)



Source: OECD MSTI downloaded 12/2010

Figure 6 shows that the industry share is clearly higher in government sector (which contains also the ASCR and some other institutes) as a result of a fairly strong recent growth.

Figure 6: Share of GOVERD (%) financed by industry (2004-2008)



Source: OECD MSTI downloaded 12/2010

These observations would derive with a hypothesis of higher interactions with industry in government sector R&D institutes than with universities.

It has been shown before that industry funding of higher education R&D is very low. Table 5 now shows the share of R&D in higher education (by scientific field) that is financed by the business sector and international sources in 2001 and 2008. According to these figures the share of business funding used to be highest in agricultural sciences (which however plays a minor role in total R&D expenditure/funding) and engineering in 2001. By 2008 the share of business funded engineering R&D in higher education reduced markedly while medical and social sciences received a clearly higher relative contribution in 2008 than in 2001.

Table 5: Selected funding sources of R&D in higher education by field of science

	2001			2008		
	Total	Business sector	Abroad	Total	Business sector	Abroad
	(Mill. national currency)	(% of total funding in the field)		(Mill. national currency)	(% of total funding in the field)	
All fields of science	4,437	0.70	2.76	9,090	0.62	4.34
Natural Sciences	1,352	0.09	3.09	2,357	0.10	6.47
Engineering	1,707	1.27	2.37	3,228	0.65	5.13
Medical Sciences	487	0.00	2.22	1,573	0.97	1.89
Agricultural Sciences	343	2.28	3.62	613	1.66	0.49
Social Sciences	246	0.00	5.04	812	0.93	3.88
Humanities	303	0.10	1.55	506	0.05	2.34

Source: OECD Research and Development Statistics downloaded 12/2010

Table 5 also shows the increased shares of funding from abroad (except agriculture and social sciences). Participation rates in EU programs between 2001 and 2008 may have their influence here. Consequently, one would hypothesise higher shares of international collaborations (e.g. within EU programs).

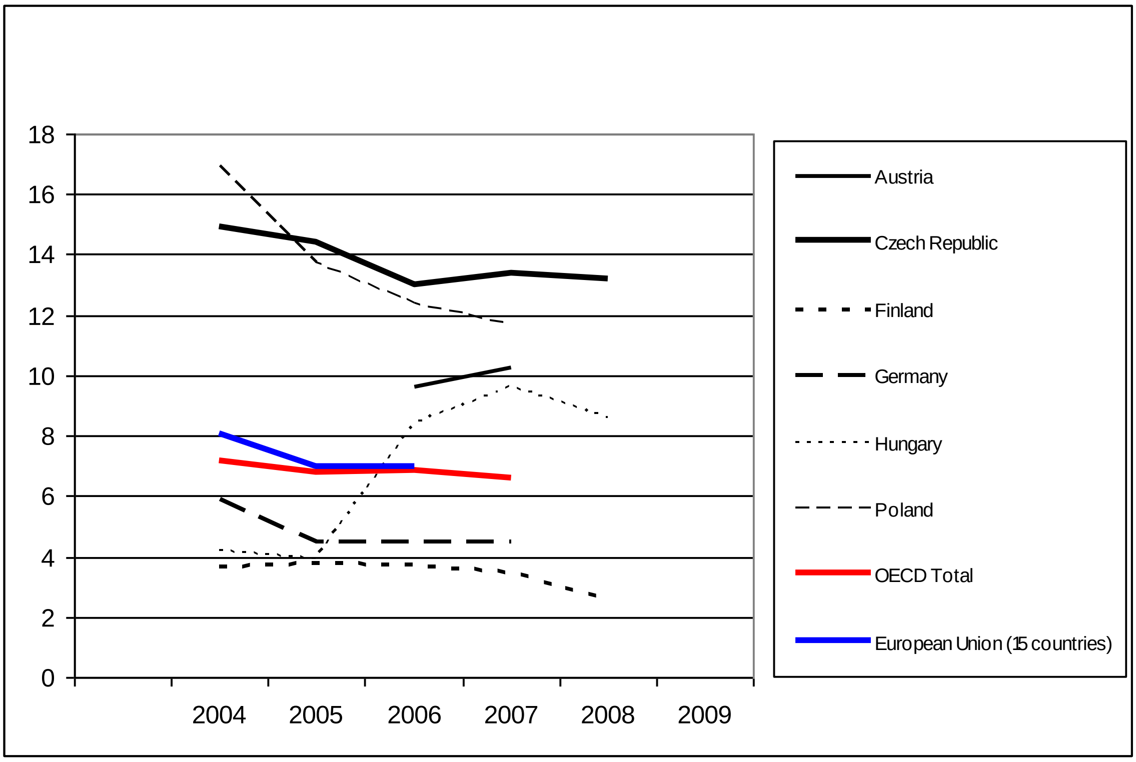
Overall, while engineering still accounts for the largest sum of funding from business in universities, it seems that business is becoming less committed in terms of funding – which may also have its consequences in SIL.

The less intensive links between universities and businesses demonstrated by low level of mutual R&D financing can be also attributed to legal difficulties (e.g. treatment of IPR) and inexperience related to the linkages between public and private partners. According to statements from interviews there are some examples in technology transfer centres of the more pro-active Czech universities to overcome this situation but as a result of these factors they are not able (partly because of fear of making a wrong step) to fully offset the existing structural problems.

3.2.2 Private R&D financed by government and programs for SIL

The financial flow from government to R&D performed in the industry displays public efforts pushing the country's innovation system towards higher R&D-intensity and founding a more international competitive industry. In these supporting measures usually several instruments to foster SIL are included.

Figure 7: Share of BERD (%) financed by government (2004-2008)



Source: OECD MSTI downloaded 12/2010

Figure 7 shows that share of government funding of BERD is high compared to other countries..

Only few measures, which are represented in these financial figures, are oriented towards science-industry cooperation. Amongst are one direct programme and one indirect programme being administerd by the Ministry of Industry and Trade (MIT):

(1) TANDEM (2003-2010) was aiming at co-operation on R&D&I activities, but this programme was finished in 2010. Core target was the transfer of research to applications in products, technologies and services by composing teams of people from science and industry.

Table 6: Projects supported by the TANDEM programme

	No of projects	Total eligible cost (ths. Kč)	Total public support (tis. Kč)	No of projects with a partner	Total no of partners	From which	
						Public R&D	Uni
2004	60	1 837 489	1 263 896	60	154	19	68
2005	45	1 179 184	646 211	45	86	9	45
2006	104	2 361 095	1 320 907	104	167	19	95
2007	43	1 119 187	629 689	43	86	11	39
2008	38	765 327	439 873	38	61	9	31
Total	290	7 262 282	4 300 576	290	554	67	278

Note: Year – starting year of the project.

Source: IS VaVaI – calculations Technology centre (ASCR)

(2) IMPULS (2003-2010) as another programme to support SIL in a more indirect way was also finished in 2010, but there will be a continuation of the programme's idea in the TIP programme. This programme was focusing on support of SME in order to increase their productivity and competitiveness by research activities. These research activities are partly conducted in a collaborative way, however, the projects of industrial research undertaken can also be carried out by business themselves.

Table 7: Projects supported by the IMPULS programme

	No of projects	Total eligible cost (ths. Kč)	Total public support (tis. Kč)	No of projects with a partner	Total no of partners	From which	
						Public R&D	Uni
2004	133	3 385 355	1 304 327	65	121	5	54
2005	106	2 693 288	704 093	39	59	4	33
2006	128	2 515 258	919 671	54	78	3	46
2007	128	2 965 320	1 163 303	47	77	1	48
2008	151	3 201 061	1 330 916	67	115	4	64
Total	646	14 760 282	5 422 310	272	450	17	245

Note: Year – starting year of the project.

Source: IS VaVaI –Technology centre calculations (ASCR)

(3) Research Centres 1M (2005-2011) was implemented by 2 calls in order to ensure effective collaboration between R&D institutions and users of their R&D results and to ensure a knowledge transfer between particular research stages and beneficiaries of R&D results.

In total 178 participants (either R&D institutes or companies) were responsible for 6 726 045 CZK of total eligible costs including 5 934 731 CZK of public support by the programme.

Amongst current programmes to foster SIL are:

(1) The current programme TIP is foreseen for the period 2009-2017. The programme aims to promote R&D projects carried out in phases prior entering of the new product (new materials and products, , new advanced technologies, new information & controlling systems) into the market. Each project has to result in at least one of the following outputs: patent, pilot, proven technology, functioning model, design, prototype, "utility model", applied certified methodology, software.

The call documents on the Ministry website do not provide specific indications on the constitution of the project teams (e.g. collaboration industry-research) nor on their size. Both industry and public or private research organisations can apply, provided they can clearly prove that co-financing of the project costs will be provided for their own private funds or other private funds. TIP has no specific focus on SIL, but delivers indirect support.

(2) Moreover, the new Technology Agency CR set up the Alfa Programme running from 2011 till 2016. This programme is explicitly aiming for support of SIL. Projects of applied research and experimental development being performed by collaborative research are significantly favoured in selection criteria. Increased interplay is seen as an important condition to provoke the effectiveness of SIL in future.

(3) Most recently (January 2011) a new programme (the programme „Centra kompetence“ (Centres of Competence)) of the Technology Agency aiming at strengthening SIL was approved by the government.

3.2.3 Preliminary conclusions on cooperation patterns of SIL

First conclusions derived from the presented funding patterns would point to some specificities of the Czech Republic’s system concerning SIL:

- almost missing R&D funding from industry for institutes in higher education sector,

  funding from industry for R&D performed in government sector are above EU average,

  with both observations maybe pointing to specific structures in Czech Republic’s innovation system – and both have to be taken cautiously as the classification of institutes in R&D statistics is different between countries (e.g. Academy of Sciences institutes would be related to higher education sector in Austria);
- engineering and natural sciences are those scientific areas attracting the largest shares of business R&D funding in public sector – however with reduced shares of funding R&D in engineering between 2001 and 2008;
- funding from government for business R&D is above EU average,
- but programmes to foster and support SIL are still rare.

Overall, from funding patterns one would expect a specific situation of SIL in Czech Republic, with institutes in government sector still being important and universities are catching up (increased volumes of funds from business sector), but showing some structural effects with medical sciences and social sciences getting some more attention.

3.3 Collaboration patterns and determinants

The descriptions provided before have shown some of Czech Republic's specificities regarding industrial structures and relations in R&D funding. Those patterns can only be taken as a rather indirect way of representation, but are an important background of SIL. More direct expressions of these linkages are given by collaboration data.

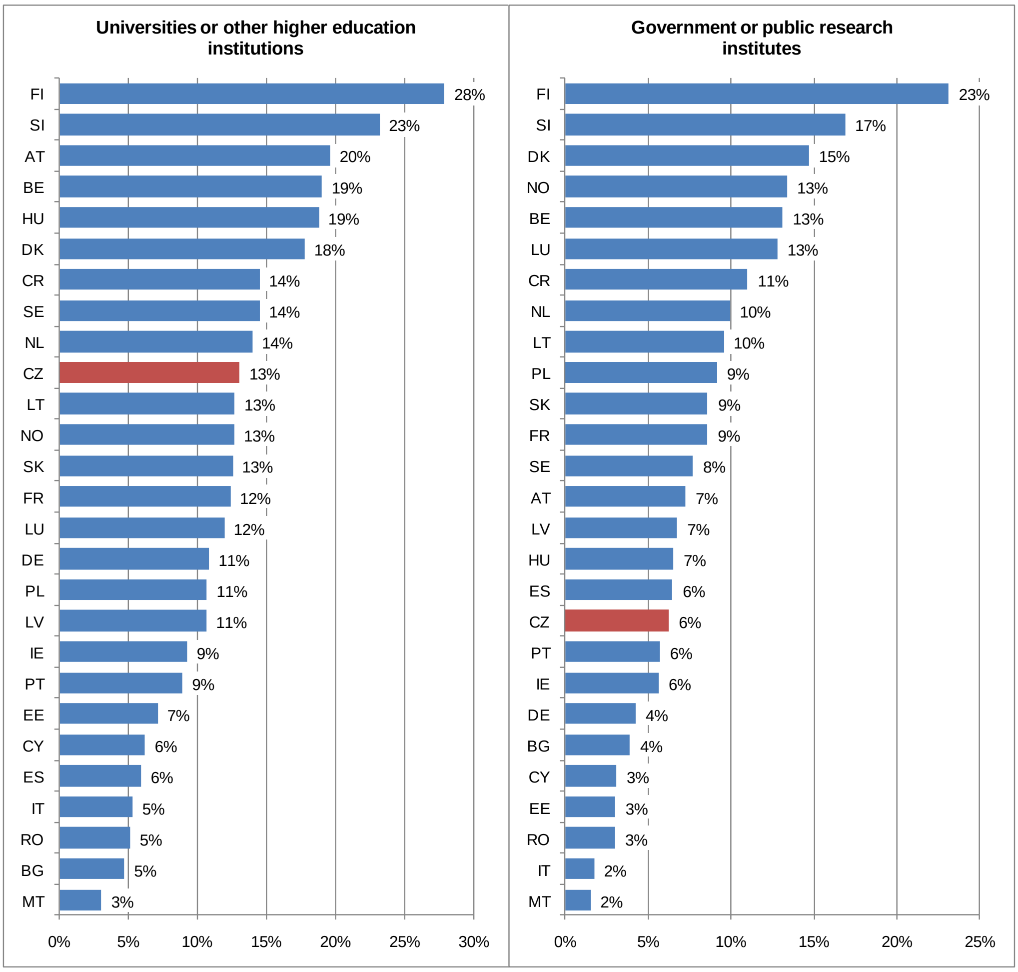
3.3.1 Cooperation patterns of SIL

In order to analyse collaboration patterns in innovation activities, data from the Community Innovation Survey (CIS) 2008 are used, covering the period of 2006-2008. This data are available in two different formats, first as aggregated statistics provided by Eurostat (for 25 Member States and two associated countries), and second as (anonymised) micro data provided by the CSU (Cesky Statisticky Urad) for the Czech Republic only. Both data sources have advantages and disadvantages for the analysis. Eurostat data are comprehensive in its geographic coverage and give detailed information for industry classes, but do not allow for a differentiation between national and international innovation cooperation. This is possible with the Czech microdata, which also allow for distinguishing domestic and foreign firms, but do not provide detailed NACE categories (one digit level B – N only).

The division of public and private R&D activities is confirmed also in other statistical sources. The conducted questionnaire survey revealed that companies carry out their research activities mostly in house or in collaboration with other private companies. While approximately 70 % of the companies carry out joint research with other private companies, only one third of them indicated knowledge co-operation with either university or research institutes.

CIS data provide a comparative European perspective for Czech Republic's industry and presents a share of innovative firms that collaborate with universities as fairly average, whereas the share of firms cooperating with public research organisations being well below the average (Figure 8). This creates an interesting picture: in international comparison exceptional low shares of HERD is financed by industry but cooperation seems to be fairly average (based on CIS data), while almost average shares of GOVERD funded by financial flows from industry are followed by less than average cooperation activities. Part of an explanation may result from the differences in statistics and its applied methods (financial data are given for all units while CIS data represent a sample), however, indicating that financial flows are not the only relevant channel, i.e. that SIL between universities and industry may largely be based on informal exchange.

Figure 8: Share of innovative firms that have innovation cooperation with (domestic or foreign) universities and research organisation (2006-2008)



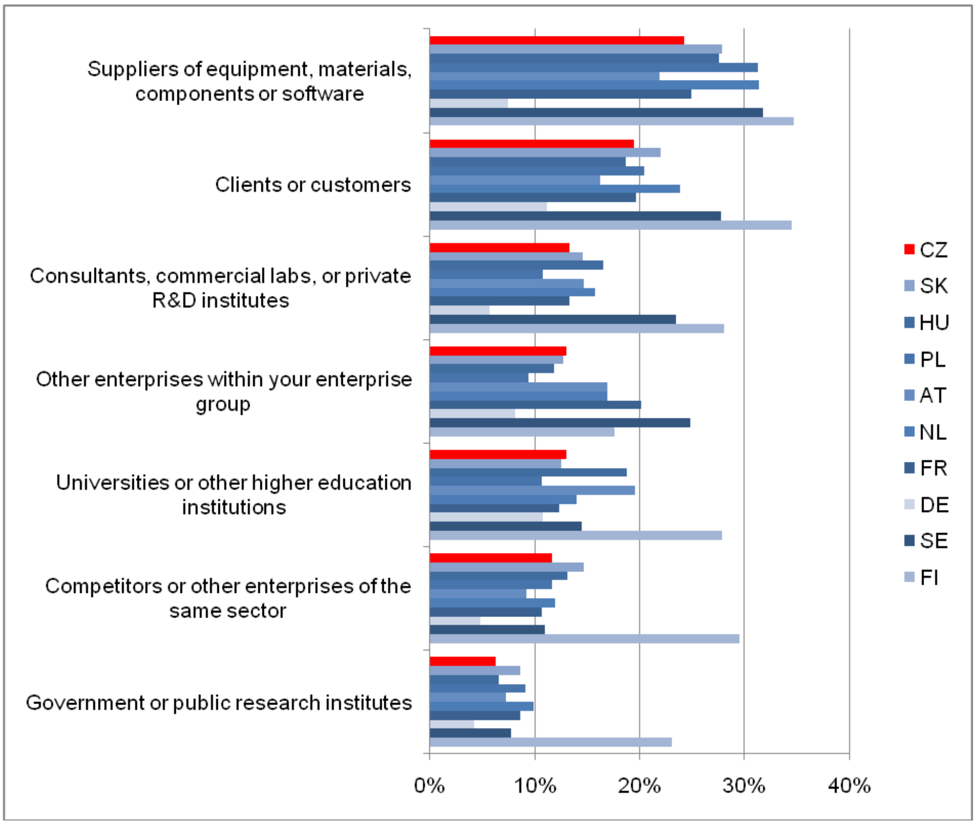
+Enterprises with technological innovation (product, process, ongoing or abandoned), regardless organisational or marketing innovation

Source: Eurostat 2010, CIS2008; calculations JOANNEUM RESEARCH

In general firms collaborate on innovation most frequently with suppliers (24%; unweighted average for all European countries available at Eurostat) followed by clients (20%), other enterprises within the group (14%) and consultants or commercial labs/ private R&D institutes (14%). Universities (12%), competitors (12%) and public research organisations (8%) are less often named. In this 'ranking' appears evidence about the differences between innovation and research activities. Innovation must not only be based on R&D activities but on a much broader concept of relations and interplays with other actors (e.g. collaborating with suppliers of equipment).

The 'ranking' can also be observed in the Czech Republic, albeit universities are as often cooperation partners as other enterprises within the group and consultants (Figure 9). In addition, one may also recognise that for both groups – universities or other higher education institutions and government or public research institutes – Czech Republic is not amongst the leaders regarding innovation cooperation between private firms and public science actors. It seems to belong to the middle or low-end group in the presented sample of countries.

Figure 9: Share of innovative firms that have innovation cooperation with (domestic or foreign) partners (2006-2008) (selected countries)



+Enterprises with technological innovation (product, process, ongoing or abandoned), regardless organisational or marketing innovation

Source: Eurostat 2010, CIS2008; calculations JOANNEUM RESEARCH

A more detailed pattern appears, once looking at innovative firms and their cooperation by industry. The sectors that encompass the highest share of firms collaborating with universities or higher education institutions are: transport equipment, electrical equipment, basic metals, architectural/ engineering/ testing and R&D, advertising and market research and computer, electronic and optical products. In case of government or public research institutes the dominant industrial cooperation actor is located in scientific research and development.[16]

The figures in Table 8 show for almost all industries (except scientific research and development) that cooperation with universities is more frequent than with government or public research institutes. This evidence also contrasts derived results when looking for funding flows. But part of an explanation may be offered looking for the different methods of gathering the data. While financial data are collected accordingly to the official classifications by Czech Republic's statistical office, CIS data contain answers from a sample of enterprises participating in the survey. Consequently some different treatment of notions may appear and classifications differ. Another point to mention are characteristics of dominant orientation in research activities (e.g. basic vs. applied) as much as the characteristics in innovation activities of certain industries. They may also form the background for this pattern.

[16] This would base a hypothesis of intensive cooperations between institutes – and will be explored in more detail later.

Interestingly, this evidence opens another perspective on industry: it does not show highest shares of innovative firms cooperating with universities and public research organisations in accordance with largest contributors to BERD (see chapters above). Therefore it gives some hints about the fact that competitiveness of these industries may be based on innovative activities which are a kind of non-R&D activities. Consequently, SIL are not most important relations – but relations with value-chain actors. However, catching-up of Czech Republic and some subsequent – already ongoing – changes in industrial structures may demand for higher R&D intensities in future.

Table 8: Share of innovative firms that have innovation cooperation with (domestic or foreign) universities and research organisations by industry (2006-2008)

		Universities or other higher education institutions	Government or public research institutes
B	Mining and quarrying	16%	:
C10-12	Manufacture of food products; beverages and tobacco products	6%	5%
C13-15	Manufacture of textiles, wearing apparel, leather and related products	9%	6%
C16-18	Manufacture of wood, paper, printing and reproduction	8%	5%
C19-22	Manufacture of petroleum, chemical, pharmaceutical, rubber and plastic products	18%	8%
C23	Manufacture of other non-metallic mineral products	16%	2%
C24	Manufacture of basic metals	25%	8%
C25	Manufacture of fabricated metal products, except machinery and equipment	12%	5%
C26	Manufacture of computer, electronic and optical products	20%	6%
C27	Manufacture of electrical equipment	26%	10%
C28	Manufacture of machinery and equipment n.e.c.	17%	5%
C29	Manufacture of motor vehicles, trailers and semi-trailers	15%	4%
C30	Manufacture of other transport equipment	38%	22%
C31-33	Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment	11%	6%
D	Electricity, gas, steam and air conditioning supply	16%	7%
E	Water supply; sewerage, waste management and remediation activities	16%	11%
F	Construction	5%	3%
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	7%	4%
H	Transportation and storage	8%	7%
J	Information and communication	15%	6%
J58	Publishing activities	11%	:
J61	Telecommunications	5%	5%
J62	Computer programming, consultancy and related activities	19%	7%
J63	Information service activities	10%	:
K	Financial and insurance activities	5%	5%
L	Real estate activities	11%	8%
M69-70	Legal and accounting activities; activities of head offices; management consultancy activities	6%	6%
M71-73	Architectural and engineering activities; technical testing and analysis; scientific research and development; advertising and market research	21%	13%
M71	Architectural and engineering activities; technical testing and analysis	20%	11%
M72	Scientific research and development	:	58%
N	Administrative and support service activities	3%	3%

+Enterprises with technological innovation (product, process, ongoing or abandoned), regardless organisational or marketing innovation

Source: Eurostat 2010, CIS2008; calculations JOANNEUM RESEARCH

Being aware that cooperation with suppliers of equipment, materials, components of software and clients and customers are amongst highest shares (see Table 9), innovation collaboration with domestic universities and research organisations show a clear size effect. Larger firms (>=250 employees) are more likely to be involved in innovation cooperation. Furthermore, this holds also for all other cooperation with partners, which in consequence means that cooperation patterns may depend on the size pattern of industries. Furthermore, it becomes evident from these figures that domestic partners are predominantly selected - an orientation which is especially high for collaborations with research organisations.

Table 9: Share of innovative firms collaborating with the following partners (by location and size)

Cooperation partner		size (employees)			
		9-49	50-249	>=250	Tota
	n	*675*	*941*	*737*	
Any external partner	domestic & foreign	31.4	42.1	59.8	44
Public research infrastructure (universities or public research institutes)	domestic & foreign	14.4	18.9	33.0	22
	domestic	14.1	18.4	32.6	21
	foreign	1.5	3.0	4.6	3
Universities or other higher education institutions	domestic	13.3	16.8	30.9	20
	foreign	1.2	2.8	4.1	2
Government or public research institutes	domestic	6.8	8.6	12.6	9
	foreign	0.3	0.5	1.4	0
Suppliers of equipment, materials, components or software	domestic	20.0	26.0	37.9	28
	foreign	9.2	14.8	30.5	18
Clients or customers	domestic	17.5	17.4	27.5	20
	foreign	9.5	13.4	26.2	16
Competitors or other enterprises of the same sector	domestic	9.8	8.8	12.8	10
	foreign	4.2	6.5	12.9	7
Consultants, commercial labs, or private R&D institutes	domestic	11.1	17.5	28.8	19
	foreign	2.2	4.9	9.5	5

[+]Enterprises with technological innovation (product, process, ongoing or abandoned), regardless organisational or marketing innovation

Source: CSU, CIS2008; calculations JOANNEUM RESEARCH

3.3.2 Multinational corporations and SIL

Tracing the history of the Czech Republic's system with high activities in FDI in recent decades, many formerly state owned enterprises are now controlled by Multinational Corporations (MNC). As a lot of these acquisitions regards largest companies in Czech

Republic, and size is an important determinant in SIL (see above), their influence is to be explored.

According to the OECD (2010)[17] subsidiaries of multinational firms[18] account for 50% of production and 46% of value added in manufacturing in 2007. In respect to R&D, MNCs are responsible for 55% of expenditure and 43% of researchers (2007). Especially, in the single most important sector of the manufacture of motor vehicles, which accounts for 38% of total R&D expenditure in manufacturing 2007 (OECD ANBERD 2009) the share of MNCs in the national total is high very high: 95% of R&D investment (2007) comes from MNC affiliates. In machinery and equipment (15% of total R&D expenditure) the share of MNC is 47%, in chemicals (9%) it is 69% etc. These findings are supported by detailed firm level R&D investment (Table 10) according to the EU Industrial R&D Investment Scoreboard (several years).

Table 10: The largest R&D spender in the Czech Republic 2005-2008

	Euro million			
Company	2008	2007	2006	2005
Skoda Auto AS **	203.4	205.3	170.8	186.4
Komercni banka	...	29.9	28.1	...
Zentiva (now part of Sanofi-Aventis)	22.8	20.5	...	...
Cez	0.8	21.8	12.2	8.0
AERO Vodochody **	2.5	5.4	5.2	...
Trinecke Zelezarny	2.2	3.4	4.6	4.1
Unipetrol **	0.8	4.6	4.4	0.4
Spolchemie (Spolek Pro Chemickou a hutni vyrobu)	0.7	0.7	1.0	0.8
Paramo As **	0.3	0.3	...	...
Ceske drahy	...	0.0	...	...
Telefonica O2 Czech Republic **	...	...	0.6	...
Deza	...	...	0.4	...
Vitkovice Steel **	...	...	0.3	...
Oskar Cesky Mobile **	...	...	...	0.3
Cesky Telecom **	...	...	...	0.2
NKT Cables **	...	...	...	0.1

Note: This table includes also foreign subsidiaries (marked with two stars "**"). All the rules for inclusion in the Scoreboard are applied (i.e. availability of accounts and disclosure of R&D). ... = no information
Source: EU Industrial R&D Investment Scoreboard 2006-2009.

The ‘embeddedness’ of MNC subsidiaries in SIL of Czech Republic is analysed by looking into their innovation collaboration pattern using firm-level CIS data. The following three models try to shed some light on these patterns. Applying a simple probit model the likelihood for innovation cooperation is estimated while controlling

[17] Globalisation database, Activity of multinationals, Inward activity of multinationals (manufacturing)

[18] Foreign affiliates refer to enterprises which have a foreign capital share of at least 50% in terms of immediate control. Indirectly foreign-controlled affiliates are not included.

for firm size and sector[19] (sometimes also innovation expenditure and location), explaining types of cooperation. Here we distinguish between following dependent variables:

- **Coop:** Any type of external innovation cooperation
- **Cointl:** Innovation cooperation with international partner (any partner)
- **Copub**: Innovation cooperation with universities or research institutes (domestic or foreign)
- **Copubdom:** Innovation cooperation with universities or research institutes (domestic)
- **Copubfo**: Innovation cooperation with universities or research institutes (foreign)
- **Counidom:** Innovation cooperation with universities or higher education (domestic)
- **Cortodom:** Innovation cooperation with government or public research institutes (domestic)

Since MNC subsidiaries tend to have a larger workforce and are restricted to certain sectors, Table 11 firstly depicts the results for them. From this calculation it appears that foreign ownership has a positive and significant effect on international cooperation (2) and negative effects on domestic cooperation with universities and research organisations (4)(6) and (7).

[19] Sector information is, however, only available at the one digit level, hence manufacturing for example is one sector.

Table 11: Impact of foreign ownership on cooperation behaviour (Model 1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	coop	cointl	copub	copubdom	copubfo	counidom	cortodom
MNC subsidiary	-0.0881	**0.150****	**-0.307*****	**-0.317*****	0.136	**-0.313*****	**-0.388*****
	(0.0644)	(0.0673)	(0.0740)	(0.0744)	(0.131)	(0.0758)	(0.0944)
Size (log number of employees)	**0.292*****	**0.259*****	**0.332*****	**0.334*****	**0.263*****	**0.334*****	**0.259*****
	(0.0225)	(0.0240)	(0.0260)	(0.0261)	(0.0494)	(0.0266)	(0.0314)
Innovation expenditure (log innovation expenditure per employee)	**0.119*****	**0.124*****	**0.164*****	**0.165*****	**0.155*****	**0.171*****	**0.130*****
	(0.0144)	(0.0158)	(0.0174)	(0.0176)	(0.0337)	(0.0180)	(0.0216)
Industry dummies	yes	yes	yes	yes	yes	yes	yes
Location dummies (NUTS)	yes	yes	yes	yes	yes	yes	yes
Constant	-2.051***	-2.672***	-3.050***	-3.049***	-8.948***	-3.285***	-3.076***
	(0.294)	(0.331)	(0.350)	(0.350)	(0.582)	(0.362)	(0.447)
Observations	2353	2353	2353	2353	2037	2353	2353
Standard errors in parentheses							
*** p<0.01, ** p<0.05, * p<0.1							

Source: CSU, CIS2008; calculations JOANNEUM RESEARCH

Looking for the influence of the MNC's origin presents other interesting insights. As outlaid in Table 12 evidence is pointing to the fact that subsidiaries being from outside Europe have a significant negative effect on external innovation collaboration (1), while foreign ownership has mostly positive effect on international cooperation (2). Other results are that negative effects on domestic cooperation with universities and research organisations are mainly explained like this:

- Belonging to a MNC from a neighbouring country has a slightly stronger negative effect on cooperation with universities than belonging to MNCs from other countries;
- Belonging to a non-European MNC has a strong negative effect on collaboration with domestic research organisations.

Table 12: Impact of foreign ownership on cooperation behaviour (Model 2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	coop	cointl	copub	copubdom	copubfo	counidom	cortodom
MNC subsidiary from **neighboring country** (AT, DE, PL, SK)	-0.0142	**0.162***	**-0.339*****	**-0.341*****	0.118	**-0.367*****	**-0.362*****
	(0.0866)	(0.0898)	(0.102)	(0.102)	(0.180)	(0.105)	(0.130)
MNC subsidiary from **other European country**	-0.104	0.100	**-0.263*****	**-0.288*****	0.123	**-0.266*****	**-0.341*****
	(0.0855)	(0.0894)	(0.0977)	(0.0985)	(0.168)	(0.100)	(0.124)
MNC subsidiary from **outside Europe**	**-0.261***	**0.264***	**-0.351****	**-0.336****	0.209	**-0.306****	**-0.622*****
	(0.135)	(0.137)	(0.151)	(0.151)	(0.243)	(0.153)	(0.219)
Size (log number of employees)	**0.295*****	**0.257*****	**0.332*****	**0.334*****	**0.263*****	**0.334*****	**0.260*****
	(0.0225)	(0.0241)	(0.0260)	(0.0261)	(0.0494)	(0.0266)	(0.0314)
Innovation expenditure (log innovation expenditure per employee)	**0.119*****	**0.124*****	**0.164*****	**0.165*****	**0.155*****	**0.171*****	**0.130*****
	(0.0145)	(0.0158)	(0.0174)	(0.0176)	(0.0337)	(0.0180)	(0.0216)
Industry dummies	yes	yes	yes	yes	yes	yes	yes
Location dummies (NUTS)	yes	yes	yes	yes	yes	yes	yes
Constant	-2.065***	-2.656***	-3.057***	-3.053***	-8.936***	-3.289***	-3.097***
	(0.295)	(0.331)	(0.350)	(0.350)	(0.552)	(0.362)	(0.449)
Observations	2353	2353	2353	2353	2037	2353	2353
Standard errors in parentheses							
*** p<0.01, ** p<0.05, * p<0.1							

Source: CSU, CIS2008; calculations JOANNEUM RESEARCH

Lastly, the influence of the level of R&D expenditures (represented by GERD) in the MNC's origin country is estimated. As seen in Table 13 a negative effect of foreign ownership is higher for MNC from countries with higher GERD (above 2% of GDP) - and presumably good domestic R&D infrastructure.

Table 13: Impact of foreign ownership on cooperation behavior (Model 3)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	coop	cointl	copub	copubdom	copubfo	counidom	cortodom
MNC subsidiary from **high GERD country** (> 2% of GDP)	-0.0990	**0.156****	**-0.346*****	**-0.359*****	0.148	**-0.354*****	**-0.549*****
	(0.0729)	(0.0760)	(0.0847)	(0.0853)	(0.146)	(0.0871)	(0.116)
MNC subsidiary from **low GERD country** (< 2% of GDP)	-0.0650	0.139	**-0.231****	**-0.233****	0.109	**-0.231****	-0.137
	(0.0967)	(0.1000)	(0.109)	(0.110)	(0.193)	(0.111)	(0.129)
Size (log number of employees)	**0.293*****	**0.259*****	**0.332*****	**0.334*****	**0.263*****	**0.335*****	**0.259*****
	(0.0225)	(0.0240)	(0.0260)	(0.0261)	(0.0494)	(0.0266)	(0.0314)
Innovation expenditure (log innovation expenditure per employee)	**0.119*****	**0.124*****	**0.164*****	**0.165*****	**0.155*****	**0.171*****	**0.130*****
	(0.0144)	(0.0158)	(0.0174)	(0.0176)	(0.0337)	(0.0180)	(0.0216)
Industry dummies	yes	yes	yes	yes	yes	yes	yes
Location dummies (NUTS)	yes	yes	yes	yes	yes	yes	yes
Constant	-2.052***	-2.670***	-3.056***	-3.056***	-8.938***	-3.292***	-3.109***
	(0.294)	(0.331)	(0.350)	(0.351)	(0.582)	(0.362)	(0.453)
Observations	2353	2353	2353	2353	2037	2353	2353
Standard errors in parentheses							
*** p<0.01, ** p<0.05, * p<0.1							

Source: CSU, CIS2008; calculations JOANNEUM RESEARCH

From these calculations the importance of MNC's subsidiaries regarding SIL becomes evident. There were clear signs for negative impacts on relationship with domestic universities or research organisations. The more, the MNC has its origin in a country with a high level of R&D expenditures. But it is also shown that these MNCs are an important source for international cooperations.

3.3.3 Preliminary conclusions on cooperation

The descriptions and analysis in the chapters above have come up with an overall pattern of science-industry linkages (SIL) consisting of following characteristics:

- in international comparison innovation cooperation is on average regarding universities, but below average in case of public research organisations according to results from CIS data – a pattern that seems somehow encountered by the shown very low share of HERD financed by industry;
- cooperation with public research organisations (both, universities and government research institutes) in innovative activities is less intensive than with other actors from value chain (e.g. suppliers of equipment) – expressing that non-R&D activities are an important part in innovation;

- SIL being not congruent with the specialisation of the Czech Republic's industry system[20];
- both, a size effect – large enterprises are more likely to collaborate – and an industry effect – some industries have higher degree of connectivity with R&D in public sector - appear;
- which clearly express a strong orientation towards domestic partners;
- foreign enterprises (MNC) constitute less collaboration with domestic universities/government institutes, depending also on their origin

4. Science-Industry Linkages from Stakeholders' Views

In this section some first results of characterisations of SIL will be presented. This information is structured along ideas of assessment and addressing SIL based on conducted interviews and on some published material provided by Technology Centre ASCR. Therefore the qualifying statements are mainly descriptive or express opinions and views from different stakeholders of Czech Republic's innovation system.

Furthermore, this is only a preliminary listing of issues and items, while a more elaborated and in-depth analysis is foreseen for the final report, bringing together all streams of empirical work – data analysis of questionnaire and statistics, interviews and reviews of conducted studies.

4.1 Methods and Data

To gain insights from the academic and industrial point of view about their obstacles and success in current practice of cooperation, 21 interviews with companies, universities, research institutes and public organisations have been conducted in November and December 2010. In cooperation with the Technology Centre selection criteria have been defined. Thereby, it was agreed to interview participants of successfully operated joint research projects and informed people from public organisations. The Technology Centre identified participants in research projects centring on different disciplines. Moreover, it suggested interviewing large well known MNE which are heavily involved in joint R&D projects. Interviewing people who are actively participating in SIL gave us the opportunity to learn about their experience. Although giving joint effort, we were not able to identify applicants of joint research projects which have been rejected finally.

Interview partners were invited by the Technology Centre. They received ex-ante a set of topics we were intended to talk about. The interviews have been conducted by two participants from the international audit team and lasted about an hour. The interviews were open-structured and covered the following topics:

(1) Structures of SIL

- type of linkages exist (e.g. research collaboration, personnel mobility, cooperation in training, commercialization, informal exchange)
- Involvement of partners (e.g. universities, ASCR, other private and public research institutes, Czech firms, multinationals)

[20] This should not be overstretched. Similar structures are observable in other countries.

- Change of SIL over time (dynamics)

(2) Processes and experiences with SIL

- Working modes of SIL
  - Motivating drivers
  - Identification of partners
  - Design of project outline/proposal
  - Course of project (schedule, day-to-day business, workshops, etc.)
  - Funding of research projects
  - Solving IPR issues
  - Sharing of outputs of cooperation (patents, publications, new developments)
  - Follow-up cooperation / other projects
- Success factors and barriers

(3) Role and assessment of public measures as support action

- Perceived barriers to reduce SIL (on the firm level, on university or academy level and on the level of national regulations and framework conditions)
- Role of (1) national funding programmes, (2) EU programmes/structural funds, (3) technology centres and (4) clusters etc.
- Most beneficial measures

Table 13 presents an overview of the structure of interview partners. Our aim was to dedicate half of the interviews to firms and the other half to research organisations, whereas universities and research institutes should be equally presented. For the interviews we focussed on interview partners from three sectors, namely (1) pharmacy/chemistry/medical care, (2) manufacture of machinery and equipment, especially automobile and (3) ICT. This gave us the opportunity to interview 4-7 people from the same sector to encounter sector-specific differences while at the same time identify Czech specific conditions.

Table 14: Structure of interviewed partners

Type of interview partner	Number of Interviews
Companies, thereof	10
Large Companies	*7*
Small and medium sized Companies	*3*
Research Organisations	9
Universities	*5*
Research Institutes (includes ASCR)	*4*
Public Organisations	2
In Total	**21**

4.2 Stakeholder's view on SIL

In the following some arguments gained from the interviews have been summarised according to selected topics. It has not been tried to analyse and evaluate the given perspectives as this will be part of the final report and needs integration and mirroring with data gathered from the survey and other sources. We are well aware of the fact that not all views are shared by all interview partners and might represent a very individual perspective. Even though, for a first insight we have summarised part of the different perspectives. They are meant to show the diverse views, but by no mean they are an assessment of the situation.

Public Support Programmes: People from science and industry were asked to assess the strengths and weaknesses of public support programmes.

- Programmes limit the freedom to design contracts with research organisation the way companies would prefer to do;
- National Programmes have a heavy administration, this becomes even more burdensome in EU programmes;
- EU programmes are perceived in general as in a clearer and coherent way organised than national programmes
- Sometimes different funding sources are mixed up on project level – which may raise the issue of partly failing applications. It was argued that if national programmes emphasise R&D activities (e.g. giving money for personal), EU programmes (e.g. EU structural fund) must be complementary applied for to ensure the funding of necessary infrastructure – and if one of the applications fails the project cannot be successfully conducted;
- National programmes have clear limits in the amount of money and running time which creates difficulties to reach a critical mass for research and innovation;
- Missing follow-up programmes in Czech Republic after successful EU projects;
- MIT funding is not directly dedicated for SIL (see also Section 3.2.2).

Barriers for SIL in the National Innovation System

- From a firm's perspective, researchers have only limited incentives to innovate and cooperate with industry;
- Moreover, people from industry perceive a resistance in the academic environment in general to involve people from industry into both the educational and research activities at research organisations (to bring new trends);
- Current organisation and management of research organisations (including terms of institutional funding) supports its isolated position and is reluctant to move to modern structures, where SIL receive greater awareness;
- Legislation and the IPR protection processes require institutional backing to handle the complex procedures;
- Although industry is well aware of the quality and expertise of existing research organisation even without official branding of excellence, they do not understand the reluctance to clearly select and label the best universities as research universities (also to their own advantage of external communication);
- Technology parks do not play the catalytic role they promised;

- Lack of capital and experience in venture capital scene, MNC select other locations to carry out research activities;
- Universities do no produce sufficient scientists and engineers to satisfy the demand of industry; this hampers a potential establishment of future linkages;
- ASCR is mainly responsible for research –teaching is limited to PhD education in cooperation with the university, knowledge transfer to young researchers is bounded;
- Exceptional well known institutes (whether from ASCR or universities) seem to work more as lighthouses with little local embeddedness and therefore limited knowledge transfer to local firms, however being well known on international level.
-

Self-conception, goals and strategies are different in the scientific and industrial world: Academia is mainly focused on scientific content of research activities; whereas the business sector has a clearly defined goal derived from the market opportunities

- "Cultural" gap between industry and science: short-term vs. long-term orientation, scheduled vs. open working processes, but this is not different to other countries;
- Invisibility of SIL because people from academia become entrepreneurs when commercialising their own research findings;
- The opportunity of researchers to commercialise their own research findings might have a negative effect on science-science relations, because competition on the real market will follow;
- Universities are mainly perceived as a source for human resources by firms and only to a limited extend as collaborator in research;
- Personnel exchange between academia and industry takes only rarely place also due to limited joint projects;
- National firms hesitate to pay appropriate prices for research at public research organisations;
- Cooperation are mainly based on personal relationships;
- Usually companies approach the researchers – almost no active role of research organisations to foster SIL – which is seen as problem.

Recommendations offered by stakeholders point to changes in the issues addressed above.

- Some of the above mentioned barriers can be addressed by fostering formulation of strategies at public research organisations for knowledge transfer and establishment of technology-oriented firms (including spin-offs), and principles for co-operation in research and for contract research (based on Code of Practice).
- Furthermore, it is important to change systems of management at public research organisations in order to increase their openness towards industry and society. Long-term strategic cooperation between industry and science is worth pursuing. This must find its way into the set-up of public programmes. Industry could be much more encouraged to support teaching activities at Universities, supervise diploma or PhD theses.

Overall the listed points are just a few expressions, but they offer some points of attack considering SIL. Amongst these are more general institutional conditions (i.e. “cultural gap” and incentive structures), almost missing public support of SIL and needs for more coordination in public programmes, given organisational structures and their main orientation and some others.

5. Conclusions and Outlook

Taking all the presented materials together to form a first sketch about the SIL situation in Czech Republic’s innovation system, one would be confronted with following observations:

(1) Industry specialisation and R&D patterns as background for potential SIL:

- ”Manufacturing” accounts for about 62% of business expenditures in R&D, but only for approximately 28% of gross value added while for “Services”[21] it is almost vice versa.
- Another observation shows that the largest share of BERD is not invested in industries with highest contributions of gross value added, but in industries with lower growth rates in R&D
- “Manufacture of motor vehicles, trailers and semi-trailers” appears as the most important industry – being amongst the highest contributors to income and R&D, however, not in terms of highest growth rates. Other important industries regarding share of BERD are “Manufacture of machinery and equipment” and “Manufacture of chemicals”. All three together accounting for one third of BERD – but not representing highest growth rates in BERD.
- Another interesting industry is “office machinery and computers” contributing only with small share to value added and BERD but indicating highest growth rates in BERD.
- Based on their contribution to R&D, these industries are amongst the main candidates and potential for SIL
- It becomes clear that R&D funding is quite low from industry for institutes in higher education sector, while funding from industry for R&D performed in government sector are above EU average - with both observations pointing to specific structures in Czech Republic’s innovation system (compared to other countries). But then the remark is to be made that the classification of institutes differs between countries (e.g. in Austria Academy of Sciences is included in higher education sector, while in Czech Republic ASCR is included in government sector).
- Furthermore, engineering and natural sciences are those scientific areas attracting the largest shares of business R&D funding in public sector – however with reduced shares of funding in engineering between 2001 and 2008.

(2) Innovation cooperation and public support

- Concerning the support of SIL it appears that funding from government for business R&D is above EU average, but programmes to foster and support SIL are still rare exceptions.

[21] Including “Research and development” and “Computer and related activities”

- Cooperation patterns between innovative firms and universities are on average in international comparisons, but below average in case of public research organisations.
- Furthermore, cooperation with public research organisations (universities and government research institutes) in innovative activities is less often than with other actors – consequently expressing innovative relations are in most cases a kind of non-R&D activities – and therefore reducing the importance of SIL
- SIL are characterised by a size effect – large enterprises are more likely to collaborate – and an industry effect – some industries have higher degree of connectivity with R&D in public sector.
- Foreign enterprises (MNU) constitute less collaboration with universities/government institutes, depending also on their origin.

Consequently there may be some potential for development towards more R&D intensive and hence innovative industry structures – which in consequence increase opportunities for future competitive advantage by intensified SIL.

While this contribution to the second interim report included just a few first impressions about SIL in Czech Republic, including the assessing and addressing views from stakeholders, all streams of empirical evidence will be put together, analysed in more detail and included in the final report.

It is foreseen to raise insights by following further steps

- Analysis of the performed questionnaires related to statistics, and
- Structured analysis of interviews and conducted studies.

Furthermore, the sectoral patterns presented in this report will be extended and complemented by addressing the regional level – including innovation centres and innovation infrastructure, technology platforms, technology centres and clusters. Consequently, it will also be dealt with EU funding and other sources supporting the relationships between science and industry.

In Brighton, 04/04/2011

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