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

Final Report - 5

Science-Industry Linkages

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Abbreviations

ASCR	Academy of Sciences Czech Republic
AVO	Association of Research Organisations
BERD	Business Expenditure on R&D
CIS	Community Innovation Survey
CR	Czech Republic
EU	European Union
FDI	Foreign Direct Investments
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GOVERD	Governmental Expenditure on R&D
HERD	Higher Education Expenditure on R&D
ICT	Information Communication Technology
LE	Large Enterprise
MEYS	Ministry of Education, Youth and Sports of the Czech Republic
MIT	Ministry of Industry and Trade of the Czech Republic
MNE	Multinational Enterprise
OECD	Organisation for Economic Co-operation and Development
OPEI	Operational Programme Enterprise and Innovation
OPRDI	Operational Programme Research and Development for Innovation
R&D	Research and Development
RCA	Revealed Comparative Advantage
R&D&I	Research Development Innovation
SF	Structural Funds
SIL	Science-Industry-Linkages
SME	Small and Medium-sized Enterprise
SWOT	Strengths, weaknesses, opportunities, threats
TC	Technology Centre of the Academy of Sciences
TTO	Technology Transfer Office
TU	Technical University
VC	Venture Capital
WP	Workpackage

Executive Summary

This WP describes, analyses and assesses the development and status of industry-science linkages in the Czech Republic (CR) as part of the International Audit of Research, Development & Innovation in the CR. Cooperation between the (public) science sector and the private business sector is of increasing importance for utilising technological opportunities and ensuring distribution of new knowledge and technologies for any innovation system, but especially for those seeking to change their trajectory of development towards more R&D and knowledge-intensive activities and branches, such as the CR. Therefore, this report addresses the following questions:

- What are the strengths and weaknesses of the Czech innovation system regarding science-industry linkages?
- Which institutions either stimulate or impede the cooperation between science and industry in the CR?
- Which policy instruments in the CR support science-industry linkages, how effective are they and how can they be improved?

The report starts with an international perspective comparing science-industry linkages in the CR with both advanced and transition economies, followed by an in-depth analysis of the Czech knowledge production system and the respective framework conditions for science-industry linkages. Subsequently, the collaboration patterns (motives, interaction modes, barriers) of research organisations and enterprises in particular are analysed from a micro perspective. Based on these findings, a SWOT analysis highlights the issues determining, supporting and restraining the development and strengthening of science-industry linkages in the CR. Finally, recommendations are provided for stimulating and improving science-industry linkages.

The findings of this report are based on multiple data sources and a variety of methods. Desk research was used to gather the available studies and documents about science-industry linkages in the Czech innovation system. Descriptive analysis of secondary data from the Czech Statistical Office, Eurostat and the OECD provided insights about supply, demand and specialisation of the knowledge producers and users in an international comparison. A survey was conducted to reveal behaviour and attitudes of research organisations and enterprises regarding SIL. Interviews and workshops were used to derive more intimate knowledge on the barriers and success factor, especially regarding public programmes.

International comparison

An international comparison portrays the CR as being in a position of catching-up in terms of the innovation system, heading towards EU-15 levels. Comparing the supply and demand conditions for science-industry linkages with countries such as Austria, Hungary and Poland, the CR is in quite a good position. However, given the respective performance levels of the business and science sectors, comparable international data reveal a relatively low level of interaction between science and industry in the CR. Furthermore, compared to other countries, the CR carries out very few policy programmes that might remedy weak science-industry linkages.

Supply and demand indicators of R&D reveal that the CR occupies a roughly central position in an international comparison, somewhat above Poland and Hungary, but lower than in more advanced economies (such as Austria, Germany, Finland and Denmark). Compared to leading countries such as Denmark, Finland and Germany, the CR science branch shows significantly lower investments in the higher education sector, a lower number of R&D personnel in higher education, lower expenditure per student and consequently fewer scientific articles per resident. This indicates the new research role of universities in the CR (still undergoing development), but also points to limited human resources for science-industry linkages. On the industry side, the CR is characterised by a lower absorptive capacity due to limited R&D investments and personnel. Although the CR displays a large share of high-tech manufacturing employment, the corresponding activities are often not high-tech (e.g. assembly). Additionally, the low share of knowledge-intensive services indicates that industrial competitiveness is, to a lesser extent, based on indigenous R&D&I efforts.

A regional analysis shows a strong centralisation of research activities in Prague and - to a lesser extent – in Brno, whereas the enterprise sector is more uniformly distributed within the country. In countries such as Austria, Denmark, Hungary and Poland, centralisation is at a lower level. However, centralisation is not a negative phenomenon as such, and could indeed be perceived and treated as an asset. As a result of this highly uneven spatial distribution of R&D activities, extra-regional SILs are necessary for most industries to cooperate with research organisations in the CR. Even though Prague is characterised by excellent public research infrastructure, collaboration between science and industry is below average. This can be explained by the high share of foreign enterprises in Prague (mostly in the service sector) and the low number of manufacturing enterprises.

Knowledge production system

Manufacturing is dominant in terms of value added as well as in terms of business R&D expenditure. Within industry, ICT revealed the highest dynamic, while in terms of levels, automotive and related industries (e.g. rubber and plastic, electronics, transport) account for the highest contribution to GDP, but also indicate a revealed comparative advantage in gross value added and exports measured against the EU average. Moreover, manufacturing - with the largest share of foreign-owned companies - represents the internationally most competitive segment. However, MNEs do not contribute significantly to the establishment of science-industry linkages and hardly display any regional embeddedness. Regarding R&D&I activities, it becomes evident that in many cases, enterprises are conducting activities at the lower end of the R&D&I value chain – and hence have less demand for SIL.

On the 'supply side', the research system in the CR includes public and private universities that made a transition from purely educational institutes to research-oriented organisations after the communist era. They now employ about 19,000 researchers. The Academy of Sciences is the largest government sector research institute, employing about 7,000 researchers. Furthermore, there are currently 19 research institutes related to ministries and about 60 private research organisations (with a high variety of purpose, activities and outputs). Both underwent substantial changes after the fall of the iron curtain (privatisation and changing activities – often substituting previous applied R&D activities with production activities). *While performance in terms of international publications generated increasing international visibility and in some cases led to international science-industry linkages, domestic science-industry relations in the CR have remained low because of widening gaps between universities that strive to develop (excellent) research capacities on the one hand, and industrial needs on the other.* Additionally, only very few institutes of the Academy of Sciences implemented substantial science-industry linkages. Another important feature of the knowledge production system is a high average age among scientists in engineering and natural sciences, which – together with low levels of investment in young scientists - may cause a supply gap in the future.

A first sketch of science-industry interactions derived from the Community Innovation Survey revealed that enterprises collaborate predominantly with suppliers, clients, consultants or other enterprises. The "new" private research organisations are often named as partners for industry, while universities or public research institutes are less important. The highest share of collaboration can be seen in the automotive, electrical equipment, engineering and ICT sectors, which were also outstanding in terms of R&D expenditure. Besides sectorial effects on SIL, there is also a size effect: larger enterprises cooperate more frequently than smaller enterprises. Furthermore, the Community Innovation Survey shows a domestic effect (foreign ownership seems to reduce science-industry linkages): our analysis indicated that MNEs are responsible for 55% of R&D expenditure in the CR and employ 43% of researchers. However, they are only engaged to a small extent in domestic science-industry linkages, while they are more active in cross-border science-industry linkages.

Framework conditions and support programmes to foster SIL

To foster and stimulate SIL, appropriate framework conditions and public support programmes on the national level are needed and have to be evaluated. The National R&D&I policy 2009-2015 stressed the importance of science-industry linkages in one of the nine main objectives: "Utilize the R&D results in innovation processes and enhance the co-operation of the public and private sector in R&D&I." The most crucial elements of supporting science-industry linkages from the perspective of the national government are the development of human capital and appropriate funding schemes.

Human capital is necessary, as only qualified and trained researchers are able to engage effectively in technology transfer activities. Unfortunately, researcher careers in the CR are characterised by high levels of uncertainty, low salaries and limited social prestige. This results in fewer people opting for a scientific career and triggers high rates of brain drain. A coherent policy mix supporting human resource development related to science-industry linkages is missing.

Public funding to support and steer science-industry linkages is also limited. Although government-funded R&D expenditure in enterprises is relatively high, it is not sufficiently geared towards science-industry linkages. Furthermore, the public research sector is supported by high institutional funding, but incentives or evaluation criteria concerning science-industry linkages are missing. Venture capital enterprises are not yet well established on the Czech market and fiscal incentives for venture capitalists are not present. Programmes supporting joint projects between industry and science have just been rearranged. The new strategy established the TIP programmes (2009-2017), administered by the Ministry of Industry and Trade, as the most important support measure for science-industry linkages. Unfortunately, the programme supports SIL only indirectly (it does not require joint teams). The newly introduced ALFA programme (2011-2016) of the Technology Agency is of a similar nature and funds almost identical types of projects. The only promising policy approach is the competence centre programme (introduced in January 2011) managed by the Technology Agency. Selection criteria for support include mandatory SIL, a joint research agenda and the potential to implement research results. Infrastructure for joint activities is mainly funded through the Operational Programmes from European Structural Funds (SF), but there are doubts as to whether the infrastructure is being fully utilised.

What do stakeholders think about the state of SIL?

So far, science-industry linkages in the CR have not been systematically monitored and evaluated. A survey was conducted to gather information from enterprises, researchers and directors of research organisations. This survey enabled us to draw a picture of motives, cooperation patterns, interaction modes and perceived barriers of SIL from the perspective of industry and science. Moreover, interviews with enterprises, universities, public research institutes and public bodies provided more in-depth information on the structure and performance of SIL.

The firm survey focused on innovative enterprises, as they have the highest potential for science-industry linkages. 160 enterprises from various sectors responded (manufacturing, R&D services, ICT, construction). *The manufacturing sector displayed a below-average share of highly qualified staff, which corresponds with statistical data. This may indicate a low absorptive capacity for scientific knowledge of the most important industrial sector in the CR.* Most enterprises were of Czech origin and count as small or medium-sized enterprises (SMEs) with less than 250 employees. The 689 respondents in the researcher survey are mainly associated with public universities, technical universities and the Academy of Sciences. The survey covered all disciplines ranging from natural sciences, engineering and medicine to humanities. Of particular note are the small size of research teams and the high average age of scientific staff. The survey among 74 directors of university research institutes and institutes at the Academy of Science focused on the behaviour of large units in terms of science-industry linkages in comparison to individual behaviour of researchers.

The most important motive for researchers to engage in R&D cooperation with industry is funding-oriented, especially at the Academy of Sciences. For researchers at technical universities and universities, gaining industrial knowledge and experience is a second motivation. *On the other hand, enterprises are motivated to work with research organisations because of access to scientific knowledge and highly qualified people.* The survey also showed that research organisations do not compete with R&D units from the business sector. *Enterprises engage in R&D cooperation with other enterprises because of reduced costs, time and risks.* Apart from individual motives or policy programmes, research organisations can set incentives and support measures for science-industry linkages on their own. Unfortunately, the survey reported that measures to support science-industry linkages are hardly important for research organisations. If so, research and service contracts seem to be most desired by research organisations, whereas spin-offs and licensing agreements do not receive much attention from researchers. A distinction according to types of research organisations showed that technical universities and universities provide more incentives than the Academy of Sciences.

According to the survey results, 48% of researchers indicated having industry cooperation, whereas technical universities perform best. Generally, substantial differences exist between scientific fields and organisations. The analyses demonstrated that the larger a research group (critical mass), the more frequently science-industry linkages are performed. Furthermore, time for managing industry relations also significantly increases science-industry linkages. If science-industry linkages exist, SMEs are the most frequent cooperation partner - only a few research groups work with MNEs. Whereas technical universities and universities strongly focus on domestic science-industry linkages, the Academy of Sciences performs better in cross-border science-industry linkages due to its high degree of specialisation. 44% of all surveyed enterprises reported engaging in SIL. This share is high due to a biased selection towards innovative enterprises. A logit model shows significant influence of two variables: firm size (the larger the firm, the more science-industry linkages) and share of highly qualified employees (the more highly qualified the employees, the more science-industry linkages occur). Human resources seem to be of utmost importance for the performance of science-industry linkages. Technical universities are the most preferred cooperation partners in SIL for enterprises, even though this means frequent cross-regional cooperation.

Personal contacts, conferences and joint projects are the most frequently used channels of knowledge transfer between enterprises and researchers in the CR. Whereas personal contacts and conferences provide a good platform for establishing and maintaining a network, joint projects require the activation of networks and the actual exchange of ideas. Networks are good to have and need to be available and “ready to use” if there is an opportunity to set up SIL. Tangible projects push the transfer of knowledge according to interview results. Technical universities most actively use the different knowledge transfer channels, whereas researchers at the Academy of Sciences rely more often on personal relations.

A comparison between regions shows that the Moravian-Silesian region and the region around Brno perform particularly well in using different channels for technology transfer. Regions can learn from each other’s experiences in how to set up and use specific channels more effectively.

The assessment of science-industry linkages by researchers and business people in the CR is by no means purely negative, but rather shows a broad range of opinions. National enterprises assess science-industry linkages as being a larger problem than international enterprises. *Although our empirical findings show that there are activities under the umbrella of science-industry linkages, the judgement of the quality of policy support measures is very negative.* The greatest satisfaction with science-industry linkages in the CR from both perspectives – researchers and enterprises - is reached in the South Moravian region.

The major barriers for industry and science are (1) difficulties finding appropriate partners, (2) mismatch of knowledge and research needed, (3) difficulties defining expectations and managing projects and (4) conflicts of interests between academic and industrial researchers. In general, people from science and industry indicated the same problems. Scientists and enterprises without science-industry linkages assess barriers as being higher than experienced people in science-industry linkages. Accordingly, researchers and enterprises may need support to reduce matching problems, formulate expectations and manage practices.

Additional evidence for the problems and solutions for creating science-industry linkages was gained from 27 interviews with enterprises, researchers and research agencies/ministries. Against a background of framework conditions that hamper science-industry linkages, for example the mismatch of research fields in enterprises and research organisations, research networks lacking critical masses, etc., we identified two main findings providing hints for potential solutions:

Many large enterprises and some research organisations employ a systematic pattern of how to contact potential partners, prepare projects, respond to calls, conduct and follow up relations. They learn from experiences and adjust their pattern and find solutions. Many examples, which may be considered as good-practice examples, already exist, which should be taken as a basis for organisational learning.

Science-industry linkages follow an evolutionary process. Cooperation starts with small projects or teaching courses. According to experience and development of relations, cooperation continues on medium-scale (larger joint project on a national or EU level, supervision of PhD theses) or large-scale projects (long-term research cooperation, joint organisation in PhD programmes, enterprise representation in scientific councils of universities).

Overall assessment and SWOT analysis

The CR experienced a catching-up process following the communist era. This development was mainly driven by cost advantages, a qualified labour force and foreign direct investments with a rather limited role for R&D, SIL and structural changes in the public research and business sectors.

The public research sector has undergone an extensive reorganisation, establishing research as an additional mission for universities and privatising many former branch research institutes, with many of them liquidated or terminating research in favour of production. *Consequently, the traditional "linear model" – with the Czech Academy of Sciences as almost the only basic research organisation and branch research institutes responsible for applied science and knowledge transfer to industry – does not exist any more. Public sector research institutions are still attempting to find their appropriate role in the innovation system.*

Industry has seen huge foreign direct investments, often in industries with long-standing traditions, higher R&D intensity and important contributions to gross value added, such as the automotive, machinery or chemical sectors. *As a consequence, business R&D&I activities have become significantly determined from abroad. R&D activities performed in the CR's industries are, in many cases, at the last stages of internal R&D value chains of MNEs, which reduces opportunities for science-industry collaboration with academic institutes striving for scientific excellence simultaneously.* Despite the considerable increases in R&D expenditure and fairly high public funding of R&D in the business sector, direct support of science-industry linkages through programmes has been fairly limited. Consequently, low interaction of science and industry has been caused by the reorganisation of the public research sector, structural and ownership changes in the business sector and virtually absent direct public support.

- *Strengths* arise from the high attractiveness for foreign direct investments, excellent research institutes and emerging high-tech industries. Partly reshaped and upgraded industries with long-standing traditions are now internationally highly competitive representatives of "high-tech" and "medium high-tech" industries (e.g. automotive, rubber and plastics) – fully integrated into global value chains. Growing ICT-related industries (e.g. computing machinery and services, electrical and optical instruments) are supporting the structural change towards a more knowledge-intensive industry.
- *Weaknesses* comprise weak SIL, an underdeveloped knowledge-intensive service sector, insufficient public support of SIL, obstructive incentive structures in public research institutes through existing evaluation methods for institutional funding and regional mismatch in public funding.
- *Threats* result from the still low absorptive capacity of the business sector. Furthermore, unfavourable demographic patterns and low investments in young scientific human capital may reduce the attractiveness of the CR as an R&D&I location.
- *Opportunities* are present in the form of newly created infrastructure, such as research centres, and internationally well-known excellent research institutes provide strong opportunities for more intensified SIL. Furthermore, the existing concentration of R&D&I activities in the Prague and Brno regions may constitute a favourable background for increasing SIL through tailor-made interventions to sharpen regional profiles.

Policy Recommendations

1. *Invest in human capital to improve the performance of SIL*
   - Explore the variety of interaction modes of SIL. So far, policy initiatives and programmes hardly consider the variety of science-industry linkages. We recommend utilising the potential of SIL via inter-sectoral mobility and training in a more effective way.
   - Increase priority and awareness measures of science-industry linkages on the individual level. The quality of awareness measures targeting individual researchers must be improved.
   - Allow and encourage industry to participate in education programmes. This includes: (1) incentivising PhD funding from industry, (2) establishing industry-oriented PhD programmes as a complement to research-oriented PhD programmes and (3) incentivising chairs funded by industry.
   - Counteract lock-in effects of small informal networks. Internationalising peer review processes, permitting international enterprises to participate in SIL-oriented programmes and intensifying awareness measures about the possibility of harmful lock-in effects are possible appropriate policy measures. They help to foster the choice of cooperation partners and the setting up of SIL-based criteria of excellence.
2. *Improve the matching of supply and demand in SIL*
   - On a strategic level, research priorities in the CR should be defined. There are different opportunities and methods for setting priorities. We recommend including science-industry linkages in the national priorities of the CR to ensure not only output, but also economic impact of research activities. This

also includes a strategy and a roadmap on action to be taken at the national level, for example:

  - Defining the specific role of the Academy of Sciences and universities in the national innovation system
  - Reconsidering the role of science-industry linkages in the evaluation methodology according to disciplines and mission of research organisations
  - Easing regulations on the sponsoring and supervision of PhDs by enterprises and the Academy of Sciences,
  - Introducing tax incentives for enterprises in the case of R&D cooperation with research organisations (discussion has already started)

- Foster awareness and coordination of science-industry linkages at the ministry level. Define a clear division of labour between the ministries and especially between the MIT and MEYS.
- At the level of research organisations, science-industry linkages should be part of the mission and strategy of research organisations.
- Introduce direct and adequate public support programmes for science-industry linkages.
- Attract and integrate MNEs more intensively into the networks of regional and national innovation systems.

3. *Support science-industry interaction at the regional level*
   - Rely on existing R&D infrastructure in the region and its continuous development.
   - Provide supporting infrastructure for science-industry linkages tailored for different regional circumstances and trajectories
   - Learn from the regional experiences with SIL policies in other regions due to best-practice exercises

1. Introduction

1.1 Scope of the work package

This report provides the findings on the structure of science-industry linkages (SIL) in the Czech republic (CR). The analyses on this topic were conducted in Work Package e (WPe) of the International Audit of Research, Development and Innovation in the CR.

Interactions between the (public) science sector and the private business sector are a core element of innovation systems. Their presence and characteristics greatly impact on opportunities to ensure the distribution and adoption of new ideas, concepts and technologies, and hence economic growth. Consequently, the use of scientific knowledge by business enterprises in their innovative efforts is increasingly seen as a crucial dimension for the performance of a 'national system of innovation' (Mowery and Sampat 2005). On the other hand, several stakeholders fear negative impacts on the scientific system due to the increased and politically supported adoption of business norms and practices in the scientific community (Larsen 2011, Bergman 2010). Despite these contested issues, science and technology policy has devoted growing attention to fostering industry-science relations via specific policy initiatives. As a result, policies targeting SIL are now common in most countries (Mustar et al. 2010, Yusuf 2008).

For economies such as the CR, seeking to change their trajectory of development towards more R&D and knowledge-intensive activities and branches, effective SIL are of utmost importance. However, many studies report concerns related to science-industry relations in the CR:

- The ERAWATCH policy mix report 2009 states that a major barrier to R&D investment and innovation is weak linkages between academic research and the business sector: *"There is a broad consensus that the low degree of collaboration between public and private R&D sectors and the low practical relevance of public research results both represent important challenges for Czech R&D. The situation is hindered by a lack of appropriate support structures for commercialisation of R&D results, and a lack of awareness of IPR issues*." (ERAWATCH[1])
- This view is also supported by the White Paper on R&D&I in the CR (Klusáček et al 2008), emphasising missing and inadequate infrastructure and averse attitudes towards cooperation: *"The infrastructure for the transfer of knowledge from the public research to the application sphere, which represents another significant factor of the competitiveness growth based on the use of knowledge, is lacking in the CR or works ineffectively as a result of an unfavourable environment. The consequence is a poor co-operation of HEIs and other ROs with the application sphere, reflected in an insufficient utilization of new R&D knowledge in practice."* (p.32f) and *"The co-operation between the research and application spheres and other participants in the national innovation system is still insufficient in the CR. This is reflected in the detachment of the process of knowledge creation and its transformation into practical applications. Reasons can be seen, among other things, in different approaches and motivations of the public and private sectors to this issue and in the environment that does not stimulate researchers to cooperate with the application sphere."* (p.33)
- A recent White Paper on Tertiary Education (Matějů et al 2009) again found problems in SIL, specifically mentioning the necessity of relevant management skills and legislative framework conditions: *"The implementation of the 'third*

[1] http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=6&parentID=4&countryCode=CZ

role' will require … changes in managerial approaches at all levels of strategic management … systematic implementation of a set of principal legislative amendments …" (p. 31f).

- Furthermore, it is mentioned that a low absorption capacity of the business sector and insufficient interest of small and medium sized-enterprises (SMEs) for R&D results are major risks in the system. Another closely related issue is the problem of low commercialisation of R&D output.
- Other analyses (Blažek and Uhlíř 2007) point to historical reasons and institutional changes responsible for inadequate SIL (p. 874f)

Taken together, a variety of factors have been discussed in the literature as explanatory variables for the rather weak performance of SIL in the CR. These results serve as a natural starting point for our investigation. This WP addresses the following main questions:

- What are the strengths and weaknesses of the Czech innovation system regarding science-industry linkages?
- Which institutions either stimulate or impede the cooperation between science and industry in the CR?
- Which policy instruments in the CR support science-industry linkages, how effective are they and how can they be improved?

Based on a conceptual model of the factors determining structure and performance of SIL, multiple data sources and methods were applied to answer the above stated questions and to derive policy-relevant recommendations. The report begins with an international perspective comparing SIL in the CR with both advanced and transition economies, followed by an in-depth analysis of the Czech knowledge production system and the respective framework conditions for science-industry linkages. Subsequently, the collaboration patterns (motives, interaction modes, barriers) of research organisations and enterprises in particular are analysed from a micro perspective. Based on these findings, a SWOT analysis highlights the issues determining, supporting and restraining the development and strengthening of science-industry linkages in the CR. Finally, recommendations are provided for stimulating and improving science-industry linkages.

1.2 A conceptual model for the analysis of SIL

The applied conceptual model (Figure 1) enables us to address SIL from the innovation system perspective, including framework conditions and processes of knowledge generation and distribution.

The conceptual model provides a device to describe, analyse and systematically compare the structures and processes that lie behind the SIL. Several factors work as facilitators, enabling or disabling forces in this respect. Furthermore, science and industry interact through different channels, ranging from personnel mobility to joint research projects. Their presence, structures and dynamics are governed by the framework conditions.

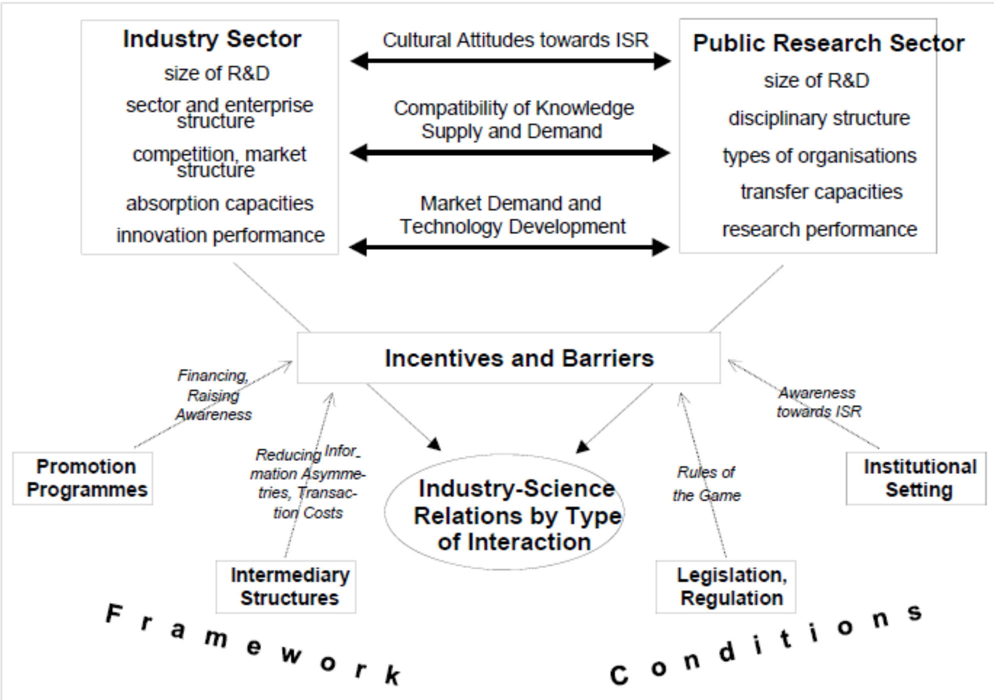
Special attention must be paid to:

- Legislation and regulatory framework with respect to the different channels of SIL, as they define the rules of the game;
- Institutional settings in public science, including incentive systems and institution-specific barriers, as they support or hamper interactions;
- Public promotion programmes and other policy initiatives aimed at stimulating SIL;
- Intermediary structures implemented to foster interaction between industry and science, as they represent necessary infrastructure.

In addition to these framework conditions, the other crucial factors in the conceptual model comprise structural determinants of the business and science sector respectively. Finally, SIL will be realised if supportive cultural attitudes and compatibility of knowledge supply and demand are present. Given the multitude and interaction of factors influencing SIL, it is no wonder that empirical research on this topic produces a "... picture of great heterogeneity, that is characterized by great differences among academic disciplines, types of universities, types of channels or linkage mechanisms, research teams of different characteristics, preferences, and values of individuals. This heterogeneity is one of the most important reasons for caution in making sweeping generalisations about the 'university-industry interface', and should be taken as a basis for caution as well in policy recommendations ..." (Gulbrandsen et al. 2011, p. 4).

Acknowledging these up-to-date research results, we identify the following channels for SIL: collaboration in R&D (joint R&D activities, contract research, R&D consulting, co-operation in innovation, informal and personal networks), personnel mobility (temporary or permanent movement of researchers from industry to science and vice versa), co-operation in training and education (further professional education, curricula planning, graduate education, PhD programmes), and commercialisation of R&D results in science through spin-offs (disclosures of inventions, licensing patents, start-ups of new enterprises).

Figure 1: Conceptualisation of the approach



Source: Adapted from Polt et al [2001]

For analytical reasons we distinguish between processes of knowledge production and policy-related framework conditions:

- The 'knowledge production structure' – depicted at the top of Figure 1- covers general features of the Czech innovation system, such as size, industry structure, R&D orientation, sector specialisation, market characteristics, and cultural and social attitudes.
- 'Policy-related framework conditions' – depicted at the bottom of Figure 1 - refer to those factors which are strongly shaped by policy decisions, such as legislation, public promotion programmes and initiatives, the institutional setting of public science and the publicly established or supported infrastructure of intermediaries

in the field of industry-science linkages. All influence the incentives and barriers for SIL.

The following analysis, based on the conceptual model presented above, applies diverse methods and data sources to produce a SWOT analysis and policy recommendations.

1.3 Data sources and applied methods

1.3.1 Data sources

Results for this report have been derived from several data sources, with substantial support provided by the Technology Centre of the Academy of Sciences. SIL are assessed and the role of policy-related framework conditions is analysed based on a combination of the following data sources and methods:

- Desk research was used to gather existing knowledge (including available studies and documents) about SIL in the Czech innovation system. Furthermore, a brief overview of the linkages was derived and framework conditions in the international context were used for evaluating the linkages. Altogether, this produced first impressions of problems, strengths and weaknesses. Subsequent steps were performed which considered these issues.
- Another source of data is secondary data from the Czech Statistical Office, Eurostat and the OECD. They were used to obtain insights about the 'knowledge production structure'. Combining data from different statistical sources, industry patterns and R&D intensities as well as cooperation patterns in R&D&I were analysed. The range of SIL, the sources of knowledge transfer and embeddings of international enterprises in this respect have been considered. As much as was considered appropriate, some econometric analysis shed light on relations characterising the linkages. Furthermore, international comparisons indicate specialisation patterns, and hence strengths and weaknesses in the Czech innovation system.
- An important source is the results from an online questionnaire carried out under WPa. A more detailed analysis of linkage practices is based on these results. From this questionnaire, which included a range of questions concerning SIL, an impression of the stakeholders' perceptions is derived. As the survey was conducted differentiating between types of players (universities, research organisations, companies), resulting quantitative statistics can present insights into 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). It should be mentioned that the list of enterprises addressed in this survey consists of companies which had already participated at least once in a SIL project cooperation.
- Based on cases of good cooperative links already established, more than 20 interviews with companies and research groups in universities and research institutes, but also with programme managers, provide a more detailed qualitative picture of current practice and especially of absorptive capacities in SIL. Furthermore, the identification of barriers and success factors was an important part of the interviews – and in this respect, public programmes are reviewed.
- Another source of information and feedback on recommendations was provided by a workshop which took place in Prague on 3 May 2011. Participants provided comments and discussed elements of results and recommendations.

More details about the data sources used will be provided – where necessary – in the respective chapters.

1.3.2 Applied methods

The analysis was performed following the conceptual model presented in Chapter 1.2. In order to achieve reasonable results, descriptive and explicative methods were applied. These included:

- Comparative analysis – before applying econometric analysis, data from either statistical sources or the survey were analysed using descriptive statistics. In the case of qualitative information, these comparisons resulted in qualitative statements. A large part of the study is based on this method. This method allowed for the generating of an overview of patterns established in the CR related to SIL. In addition, it allowed for the recognising of specificities compared to other countries and delivered hints as to interesting aspects.
- Econometric analysis – depending on the quality of the data, some econometric analysis took place in order to achieve more robust explanations concerning structures. These analyses were based either on data from official sources or on the survey conducted. Nevertheless, the results were proofed by relating them to other sources of explanations, for example results from other studies, etc.
- Interviews – to some extent, SILs are characterised by 'hidden' influences, meaning that statistical sources cannot provide a detailed answer, for example about incentives or hindering forces. Furthermore, experiences are not accessible without interviewing the related people. Consequently, semi-structured interviews were applied to gather more in-depth, mostly not yet codified (tacit) knowledge about the SILs in R&D&I.
- Focus group/Workshop – this method was implemented as the most feasible for obtaining feedback on results and recommendations. Confronting participants, mostly people from interviews, with important parts of results and suggested preliminary recommendations proved to be a kind of "reality check" for them. Feedback helped to increase applicability, practicability and fit of recommendations in the CR's innovation system.

All listed methods have been applied to derive findings about the situation regarding SIL. More details about applied methods are provided in the following chapters when deemed useful and necessary.

2. International comparisons

This section is dedicated to the international comparison of Czech SIL. The aim of this exercise is at least twofold: firstly, by contrasting the Czech structure and performance of SIL with the situation of other countries, it is possible to come up with a more robust appraisal of the Czech stage of development regarding SIL and come into contact with interesting features. Secondly, a policy analysis of policy actions undertaken in countries of comparison reveals several pathways in policy making that might serve as guidance in the design of prospective SIL-related policy actions in the CR. In this sense, this chapter serves to compare the comprehensiveness of dealing with SIL.

The chapter is organised as follows: firstly, it presents the selection of countries to be used for comparison. The arguments behind this selection are discussed and should be kept in mind when it comes to drawing conclusions. Secondly, some empirical indicators are considered to illustrate differences and similarities in the structure and intensity of SIL. Thirdly, based on this contextualisation, concrete policy portfolios and selected policy instruments are delineated and evaluated following available evaluation studies.

2.1 Selection of countries – elements of interest

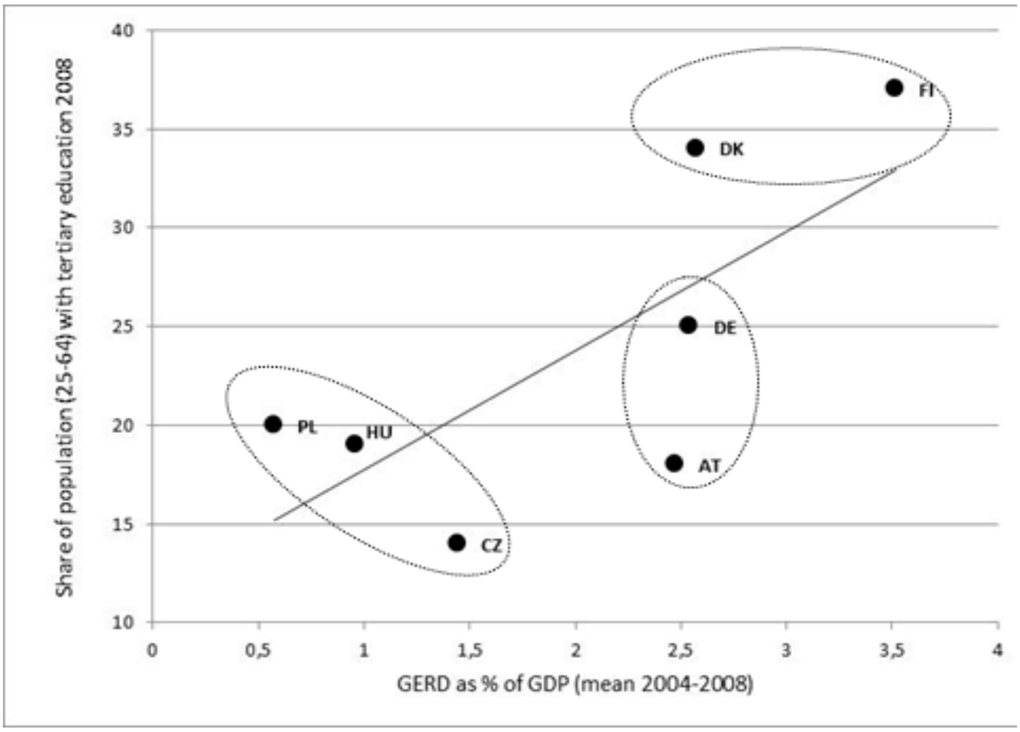
In order to compare the structure and performance of SIL as well as the respective policy instruments in the CR with those in other countries, the following countries were selected: Austria, Denmark, Finland, Germany, Hungary and Poland. We generally exclude the average of the EU-27 from the analysis, because it makes much more sense to compare countries that represent different models of economic development and innovation systems than to compare the CR with an aggregated and hence necessarily highly abstract average value. The learning effects would be rather small, so we concentrate on well-chosen countries for the international comparison.

The selection of these countries can be justified based on various factors: most important is the fact that they belong to systematically different groups of countries, regarding their socio-economic and innovative structure and performance. As a result, the comparison enables us to control these differences and to infer results that are differentiated according to groups for comparison. Given the importance of policy learning based on the orientation towards ideal types or models of economic development and innovation systems, this strategy of comparison provides a significant value added when it comes to the deduction of policy recommendations. However, there are also some more specific factors that make this selection of countries a useful selection for comparison.

The selected countries can be grouped into three clusters that represent **different socio-economic models and levels of economic and social development**. Firstly, Denmark and Finland belong to the so-called "Scandinavian Model". The countries from this group display a superior economic performance and the highest level of future-oriented investments, such as in R&D, ICT or education. Interestingly, they all combine in a unique way a superior economic competitiveness with a high level of social protection and public expenditure quota. Secondly, Austria and Germany are representatives of the "Continental Model", with high levels of economic welfare and remarkably lower investments in the future compared to the Scandinavian model. Hungary and Poland are, like the CR, part of the "catching-up model" (Aiginger 2006). Compared to the other models, their level of economic welfare and innovation capabilities is inferior. However, a catching-up process can be observed, differing from country to country and interrupted – in some cases quite severely – by the "great recession" that set in after the insolvency of Lehman Brothers in September 2008. As a result, several scholars suggest that the post-crisis growth model will differ remarkably from the model that has prevailed hitherto. For example, Landesmann (2010) expects reduced inflows of FDIs in the future, the main agent of industrial upgrading before the crisis. He suggests that this decrease can be at least partially compensated for by deploying policies to foster a more endogenous growth model due to a strategic and consistent employment of human capital policy, technology policy as well as industrial and regional policy.

A very rough characterisation of the countries, capturing some important elements of future investments as one crucial factor for assigning countries to the different socio-economic models described above, is given by the scatterplot in Figure 2. It shows the position of countries measured according to their performance in R&D expenditures and their respective human capital stocks, measured according to the share of the tertiary-educated population of working age. The Scandinavian model countries are the top performers with a combination of high R&D expenditures and a very well educated population. Austria and Germany are clearly less successful, especially in the performance of human capital. Poland and Hungary display a higher share of tertiary education among the population than Austria. The catching-up countries combine lower R&D expenditures with lower shares of tertiary-educated population. Considering the trend line, the CR features a much lower share of well-educated human capital than expected. In this sense, the situation is very similar to the case of Austria. A recently conducted evaluation of the Austrian innovation system identified human capital as the main bottleneck for a further increase in innovation intensity (Aiginger et al. 2009).

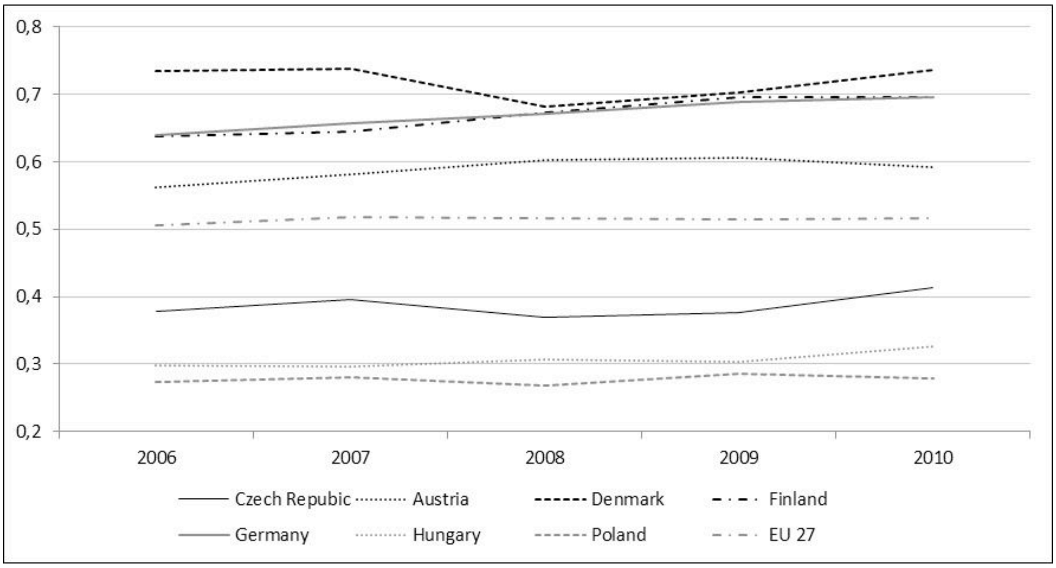
Figure 2: GERD (2004-2008) as % of GDP and share of population with tertiary education (2008)



Source: Eurostat, OECD 2010

Evidence from the European Innovation Scoreboard is presented in Figure 3. The development of the CR is characterised by a quite stable development between 2006 and 2010 and a position in the middle between the other transition countries Hungary and Poland on the one hand, and the economies that are already positioned at the technology frontier, such as Denmark, Finland or Germany, on the other hand. However, the innovation performance of the CR is significantly below the average level of the EU 27, with no strong trend towards convergence. Following the cluster analysis of the Innovation Union Scoreboard, the countries can be divided into three groups. Firstly, Denmark, Finland and Germany belong to the innovation leaders, i.e. the top performers in Europe. Austria is the only country that represents the group of innovation followers. The CR, Hungary and Poland are part of the third group, the so-called “moderate innovators”. Taking this into account, Austria represents a model that might be a very useful case for comparison because it is not too far away from the stage of development of the CR.

Figure 3: Innovation performance according to the summary innovation index (SII) 2006-2010



Source: Innovation Union Scoreboard 2010

More specific factors that render the selected countries suitable for comparison include the sectoral composition and scientific landscape of these countries. For example, the CR reveals a similarity in the advanced middle technology sector to Austria, Denmark and Germany. Specific attention may be paid to the ICT sector in the CR (see Chapter 3), but this remains far removed from a high-tech situation such as in Finland (NOKIA).

First impressions of these selected countries show the catch-up progress of the CR's innovation system towards EU standards (far ahead of other more recent EU members). It seems also to point to a significant weakness regarding human capital (and the education system).

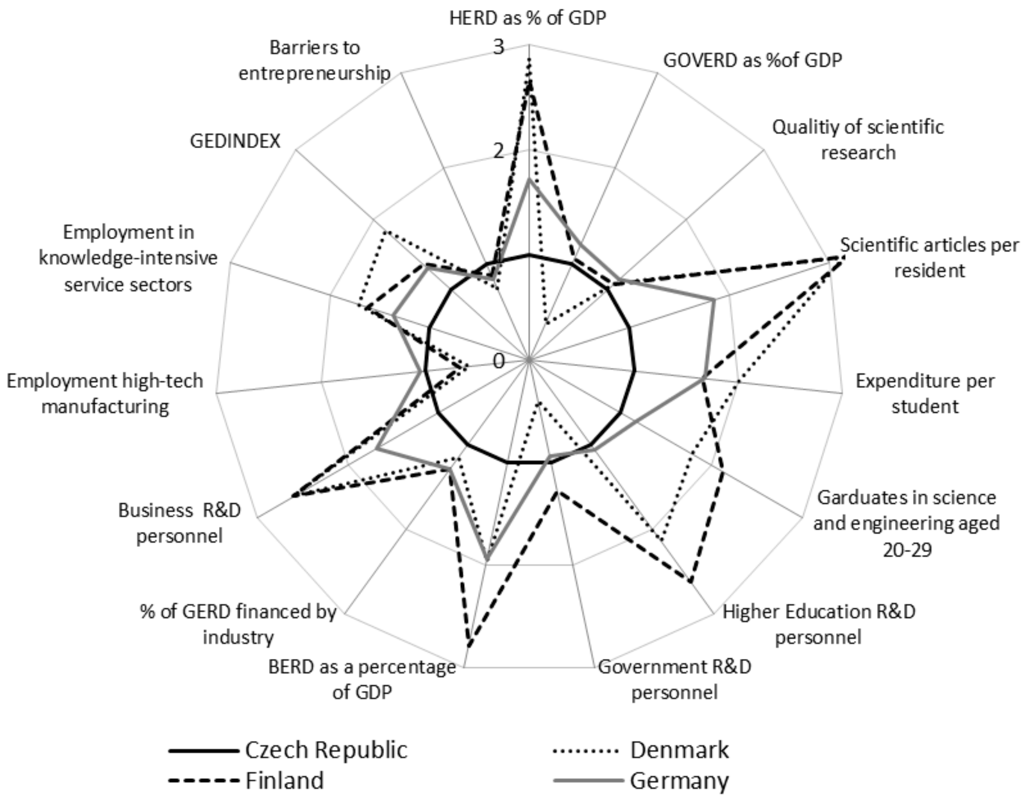
2.2 Comparison of the science-industry linkage situation

Comparison of the selected countries regarding the SIL may include indications from the supply and demand sides (i.e. "science" – the public research sector – and "industry" – the enterprise sector). In order to obtain an overview of the situation, several indicators have been collected. The next 2 figures illustrate patterns with supply (science) and demand (industry) indicators. The supply side is characterised by funding figures (HERD as % of GDP, GOVERD as % of GDP), measures of the quality and productivity of science (quality of scientific research, scientific articles per resident), education figures (expenditures per student, graduates in science and engineering aged 20-29) and measures for human resources (higher education R&D personnel and government R&D personnel). The demand side is captured again by funding figures (BERD as % of GDP, % of GERD financed by industry), measures of human resources (business R&D personnel, employment in high-tech manufacturing, employment in knowledge-intensive service sectors) and indicators for entrepreneurship (GEDINDEX[2], barriers to entrepreneurship).[3]

[2] The GEDINEX (Global Entrepreneurship and Development Index) measures entrepreneurial performance by adjusting sheer quantitative indicators, e.g. firm foundations, with indicators that also capture qualitative elements of the entrepreneurial process. Examples include the skills of the entrepreneurs or the technology intensity of the enterprises founded. The higher the index scores, the better the performance.

The following figures show to what extent the single indicators are higher (>1) or lower (<1) than in the CR. On the left of the spider diagram, one can observe the "industry side". Based on an innovation system perspective, these indicators represent the elements of absorptive capacities and express potentials for interaction with the public research sector. The right side of the spider diagram demonstrates main observations related to the "science side". They express the capabilities of science, its sources and contributions for interacting with industry. Figure 4 shows the comparison with more advanced countries and Figure 5 with the follower group.

Figure 4: Supply and demand conditions for SIL (I)



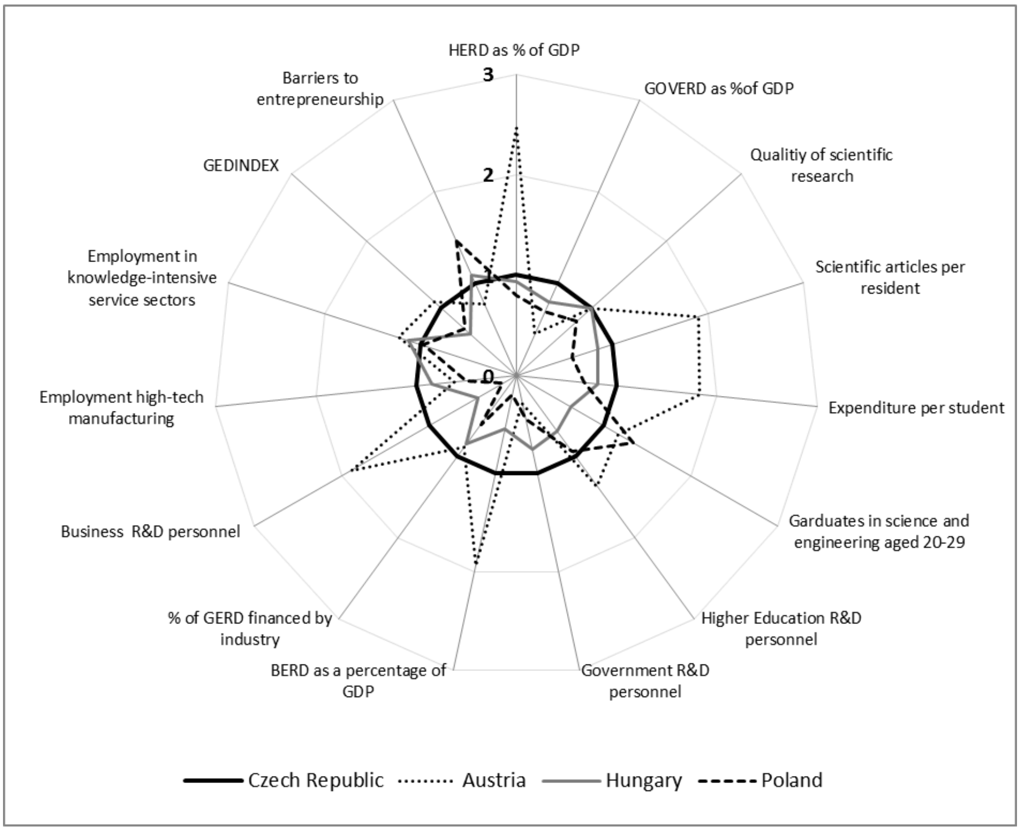
Source: Eurostat, OECD MSTI Database, OECD 2010, SCImago Journal & Country Rank [4/2011], National Center for Science and Engineering Statistics [4/2011], Global Competitiveness Reports 2009-2010 and 2010-2011, Acs/ Szerb 2010.

The patterns of indicators highlight the differences. On the "science side", the historical track of a catching-up process to integrate the research agenda into universities is observable, indicated by significantly lower HERD as a % of GDP and also by a lower number of highly education R&D personnel – and, as a consequence, a lower number of scientific articles per resident. The low figures in expenditures per student and in graduates in science and engineering aged 20-29 appear even more important, pointing to an upcoming problem of reasonable supply with human capital in science and industry. On the "industry side", lower BERD as a % of GDP, fewer business R&D personnel and a lower employment level in knowledge-intensive service sectors may represent lower absorption capacities. Although there is a relatively high

3 The opposite holds true for the OECD indicators in "barriers to entrepreneurship". This index provides information on the barriers to entrepreneurship on a scale of 0-6. The lower the index score is, the lower the barriers for entrepreneurs.

level of employment in high-tech manufacturing, it can be assumed that actual R&D activities are carried out to a lesser extent. The comparison also reveals almost equal barriers to entrepreneurship, but a poorer performance due to a lower GEDINDEX.

Figure 5: Supply and demand conditions for SIL (II)



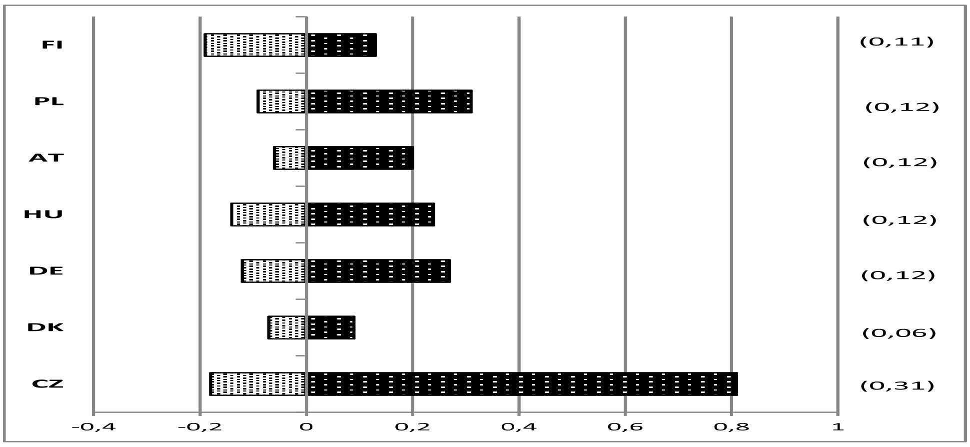
Source: Eurostat, OECD MSTI Database, OECD 2010, SCImago Journal & Country Rank [4/2011], National Center for Science and Engineering Statistics [4/2011], Global Competitiveness Reports 2009-2010 and 2010-2011, Acs/ Szerb 2010.

Comparing all the indicators with Austria, Hungary and Poland, a first impression arises showing quite a good position for the CR. The CR shows higher values in almost all indicators than Hungary (except employment in knowledge-intensive service sectors) and Poland (except graduates in science and engineering aged 20-29 and barriers to entrepreneurship). So for both sectors – the "science side" and the "industry side" – the CR has more preferable indications, and hence represents a better position. Only two shortcomings are apparent: knowledge-intensive services and graduates in science and engineering – but both are important determinants if the CR wants to evolve towards a more knowledge-intensive system.

Overall, human resources (graduates in science and engineering) is a high priority amongst the pressing problems. Furthermore, the absorptive capacities, build on human resources (more business R&D personnel as well as higher education R&D personnel) and a complementary increase in R&D funding are to be developed.

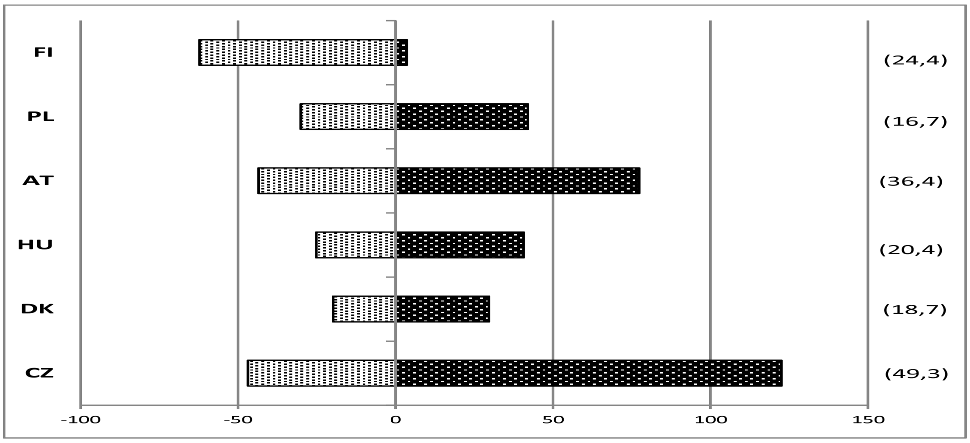
SILs are not only shaped by the quality of supply and demand, but also by their **spatial structure**. Despite significant heterogeneity regarding the types of universities and business sectors, it is generally accepted in the literature that the positive externalities of public research organisations display a spatially localised pattern. For example, Jaffe (1989) finds that university research triggers additional business R&D within the same region, and D'Este and Iammarino (2010) show that spatial proximity has a positive impact on the occurrence of university-industry partnerships, while a higher quality of university research leads to the attraction of more distant business partners. The following 3 figures delineate the spatial configuration of supply and demand of SIL in an international comparison.

Figure 6: Researchers in the government sector in % of total employment, deviation of minimum and maximum value at NUTS2 level from national value (=0) and standard deviation in brackets



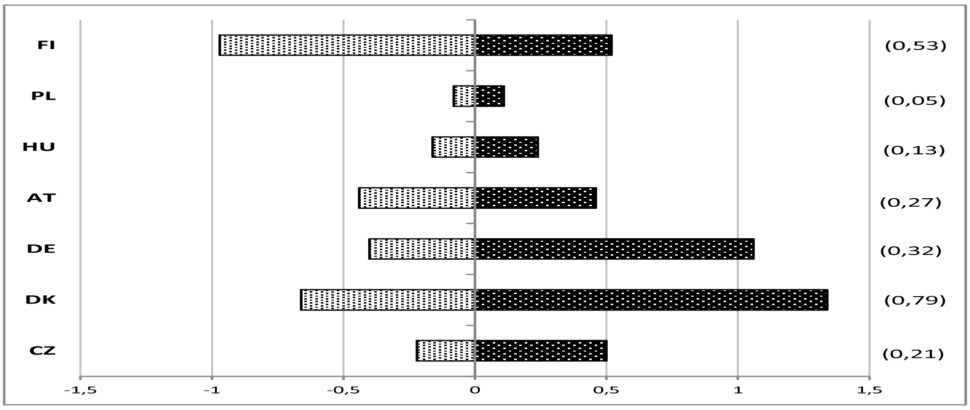
Data: Eurostat, calculations Joanneum Research

Figure 7: Students in tertiary education (ISCED 5-6) - as % of the population aged 20-24 years at the regional level, deviation of minimum and maximum value at NUTS2 level from national value (=0) and standard deviation in brackets



Data: Eurostat, calculations Joanneum Research

Figure 8: Researchers business sector in % of total employment, deviation of minimum and maximum value at NUTS2 level from national value (=0) and standard deviation in brackets



Data: Eurostat, calculations Joanneum Research

The results are as follows: on the one hand, Prague is the leading scientific region in terms of the number of students and researchers in research organisations. The central function of Prague goes along with high regional disparities. The dispersion measured by standard deviation is also the largest for the CR (see Figure 6 and Figure 7). The high agglomeration of researchers should be interpreted as an important asset. On the other hand, researchers in firms are more uniformly distributed than is the case for richer countries. Figure 8 shows that all transformation countries follow a pattern of low disparities compared to the more advanced economies. Hence, if spatial proximity plays some role in encouraging SIL, which might be the case especially for SMEs, there is a clear need to establish effective transfer channels between Prague as the centre of supply in SILs and the other regions, where large parts of the enterprise sector are located. The CR needs a research centre such as Prague to have a critical mass of researchers in spatial proximity, but the CR also needs to ensure that research findings are transferred to and specifically generated in the regions where firms are located. The structural funds make the establishment of appropriate infrastructure possible (i.e. regional R&D centres, centres of excellence, technology platforms). In an ideal way, these centres have potential to support knowledge transfer into regions, increase the economic performance of a majority of regions in the CR and reduce regional disparities. But this also requires the attraction of researchers, as top scientists are sometimes needed. The “soft” location-related factors also need to be strengthened to make the “infrastructure” workable. Prague benefits only to a minimal extent from SF. However, Prague must be supported in order to maintain the scientific centre. The CR must guarantee that Prague receives the necessary scientific infrastructure.

Internationally comparable data on **patterns and intensity of cooperation in SIL** are provided by the Community Innovation Survey (CIS). Table 1 shows selected results of the CIS 2006 and CIS 2008 on SIL.[4] The numbers in parentheses display the rank of the countries regarding the performance in SIL. While SILs are clearly most intensive in Finland, followed by Denmark, the mediocre results for Germany are somewhat surprising. However, previous studies mention interpretation problems with the term “cooperation” in the German language, which might lead to an underestimation of cooperation intensity in SIL.

For the CR, the results reveal a relatively low level of interaction in the CR between the science base and the business sector. First of all, the share of innovative enterprises

4 A word of caution on the interpretation of CIS data is warranted because a comparison between CIS data from different surveys display a high volatility and leads to changes regarding the relative position of countries in the performance of SIL.

that cooperate in innovation is, at 36%, the smallest of all countries. However, even that relatively small share of innovative and cooperative enterprises displays relatively low levels of cooperation with universities and public research institutes respectively. In both categories, the CR displays the second lowest value of cooperation intensity. Compared to the share of enterprises cooperating with government research institutes, the share of enterprises cooperating with commercial R&D institutes is much higher (41% compared to 19%). This value is higher than those for Germany, Austria, Poland and Hungary. The low level of SIL is also reflected in the following variable that measures the importance of several sources of information in innovation activities. The values for universities and government research institutes are the lowest or second lowest for the compared countries. For example, only 1.9% of innovative enterprises indicated government research institutes as an important source for information on innovation.

While other R&D indicators show a middle position of the CR between the other transition economies and the more advanced economies, this is not the case for cooperation intensities in R&D. Here, the CR shows a lower or equal level to that of the other transition economies.

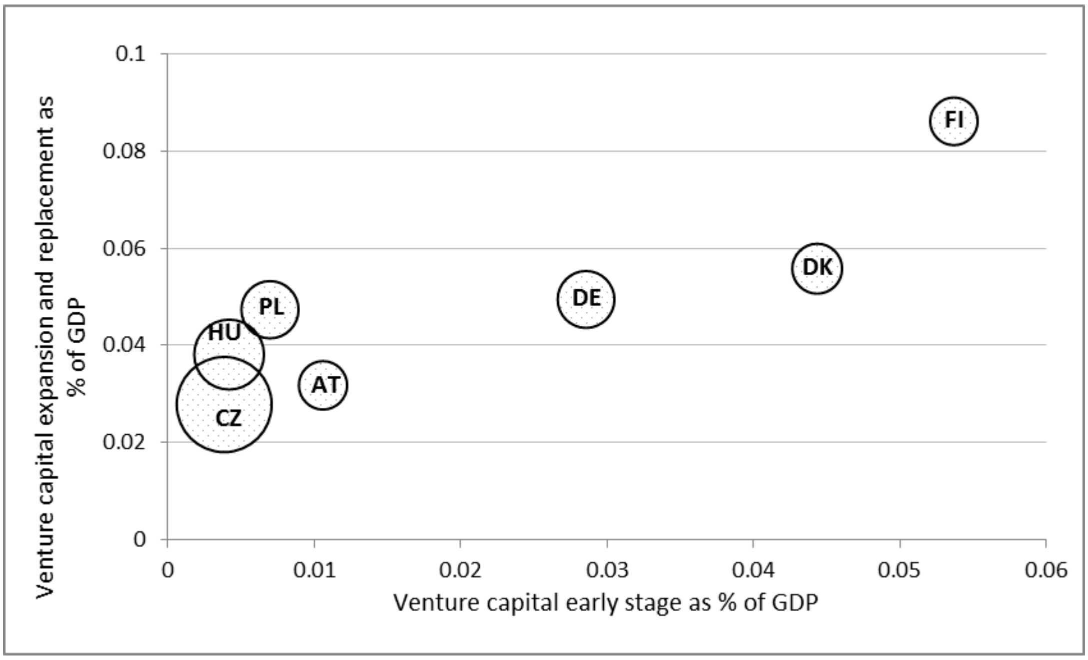
Table 1: Patterns of cooperation of innovative enterprises: Comparison across time and partners of cooperation, rank in parentheses

Indicator	**Share of...**	**CIS Survey**	**CZ**	**AT**	**DK**	**FI**	**DE**	**HU**	**PL**
Enterprises with cooperation in innovation	all enterprises with technological innovation	CIS 2006, 2008	36 **(6)**	39 (4)	46 (2)	47 (1)	19 (7)	40 (3)	38 (5)
Enterprises cooperating with universities or other higher education institutions	all cooperative enterprises with technological innovation	2008	40 **(5)**	52 (2)	31 (6)	76 (1)	52 (3)	45 (4)	27 (7)
Enterprises cooperating with government or public research institutes	all cooperative enterprises with technological innovation	2008	19 **(5)**	19 (6)	26 (2)	63 (1)	21 (4)	16 (7)	23 (3)
Enterprises cooperating with consultants, commercial laboratories, or private R&D institutes	all cooperative enterprises with technological innovation	2008	41 **(3)**	38	46 (2)	76 (1)	28 (5)	40 (4)	27 (6)
Enterprises citing universities or other higher education institutes as highly important sources of information	all enterprises with technological innovation	2008	3.4 **(5)**	n.a.	n.a.	4.6 (2)	5.0 (3)	10.2 (1)	5.3 (4)
Enterprises citing government or public research institutes as highly important sources of information	all enterprises with technological innovation	2008	1.9 **(4)**	n.a.	n.a.	2.1 (3)	1.7 (5)	4.2 (2)	7.2 (1)

Source: Eurostat, Community Innovation Survey 2006 and 2008, calculations Joanneum Research

In order to transfer results from science to industry, **academic spin-offs and high-tech start-ups** play a prominent role. However, literature has shown that young and innovative enterprises are credit-constrained as a consequence of market failures on the capital markets because of information asymmetries, a lack of collaterals, etc. Hence, equity financing via venture capital is very important to circumvent barriers for risk-taking entrepreneurs. However, comparisons between the selected countries illustrate that the CR ranges lowest according to the level and funding of early stages (Figure 9). From these observations, one may also conclude a need for policy action to implement opportunities for set-ups and spin-offs by supporting the VC situation. There are virtually no systematic analyses of spin-off activities in the CR. Therefore, we collected primary data in questionnaires and interviews, providing at least some kind of overview (see Section 5.2.2 and Section 5.6.4).

Figure 9: Level and volatility of venture capital investments at the early and expansion stage of investment



Source: Eurostat

Note: The level of VC is measured as the mean of 1998-2009 and volatility is captured by the coefficient of variation for the same period of VC investment. The size of the circuit displays the degree of volatility. The latter is measured by the coefficient of variation to account for different levels in VC investment. Given the same degree of volatility for both high and low levels of VC investment, a downward swing of VC might reduce the availability of VC in the low level case to almost zero, while making no significant difference in the opposite case.

The overall patterns resulting from comparisons with selected countries indicate that the absorptive capacity of industry appears to be above that of countries such as Hungary and Poland, but somewhat below the leading group in Europe. The public science sector also ranks above Hungary and Poland, with the important exception of graduates in science and engineering (compared to Poland). Overall, the indications would suggest relatively favourable conditions for SIL. However, this potential does not translate into actual linkages, as demonstrated by empirical evidence from the EU-CIS (community innovation survey).

2.3 Comparison of public initiatives

Comparing the situation between the selected countries in a policy perspective shall provide first impressions about public support for SIL.[5] These comparisons are drawn from a study by the European Commission (ProInno Policy Trendchart).[6]

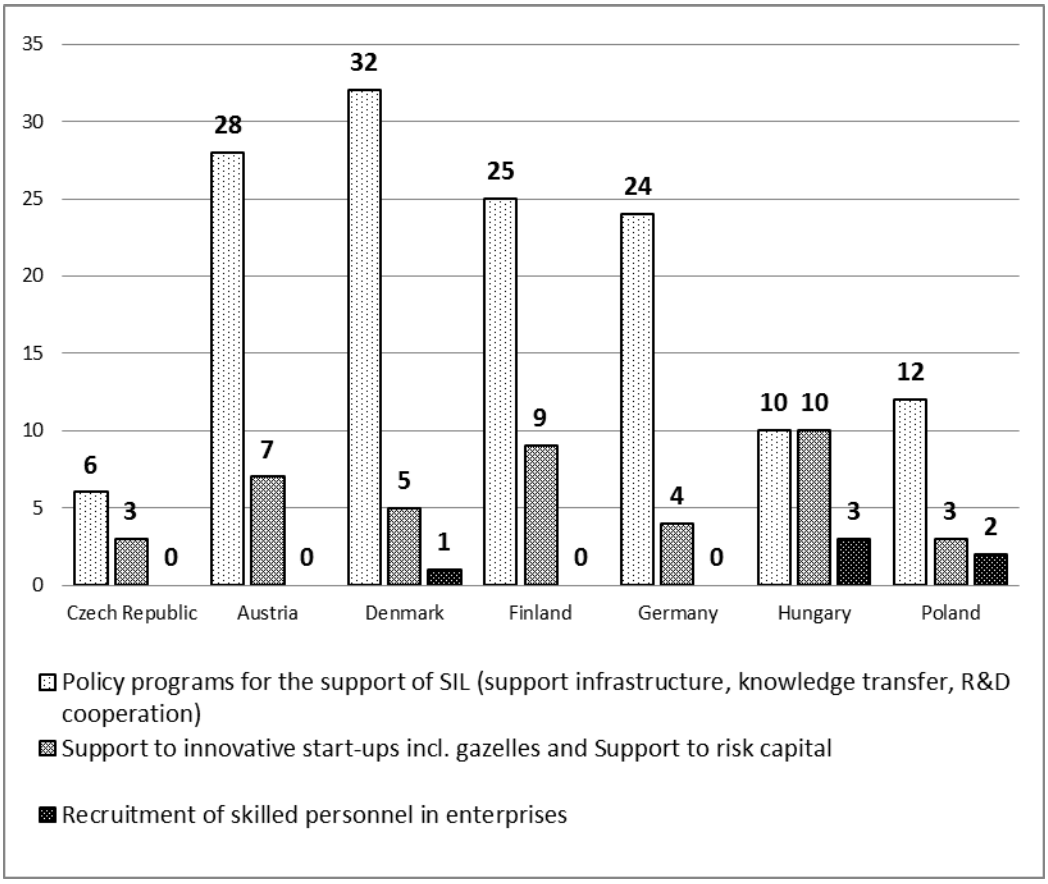
Figure 10 provides an overview of programmes, distinguishing between three (more general) types: (1) programmes to support infrastructure, knowledge transfer and R&D cooperation, (2) programmes to support human resources and (3) programmes to support innovative start-ups and risk capital.

Because of constraints on data availability, and hence comparability of policy programmes, the comparison is restricted to a simple accounting exercise: how many programmes are in place to foster different dimensions of SIL? Of course, this does not account for the public resources devoted to each of these programmes.

5 The Czech Republic's situation is covered in more detail in a subsequent chapter.

6 The comparison of measures causes some problems. Nevertheless, it provides a rough picture of the degree of differentiation and orientation of national innovation policies. A few remarks must be made about these problems: (1) Problems in interpretation: less can be more – simply counting the number of programmes might not be an adequate strategy for detecting policy priorities, but the differentiation expressed by the number of programmes may lead to potential gaps and provide hints for improvements. (2) Problems in comparison: in some cases, ProInno provides very detailed information, while in other instances, a number of stand-alone programmes are clustered together. Several programmes have already been phased out according to the database. However, comparing some of the information on termination provided at ProInno with the information on the websites of the respective programmes reveals that programmes have frequently been prolonged. Taking into account the sheer number of programmes and language barriers, a detailed investigation into programme periods is out of reach. Dealing with these problems, we decided to include even those programmes that have already been phased out according to ProInno. Hence, the table presents the stocks of policy measures in the selected policy fields. (3) Remarks on selection strategy: programmes that only provide support for participating more intensively in other support programmes, e.g. the European Framework Programmes, have been ignored. Programmes which are obviously in an inappropriate section have also been excluded. To avoid double counting, policy programmes citied in more than one section of policies included in this study have been allocated to the most appropriate section.

Figure 10: Number of policy support programmes for different SIL



Source: Pro Inno Policy Trendchart, Categories included: (1) 2.2.1 Support infrastructure (transfer offices, training of support staff), 2.2.2 Knowledge Transfer (contract research, licenses, research and IPR issues in public/academic/non-profit institutes), 2.2.3 R&D cooperation (joint projects, PPP with research institutes); (2) 4.3.1 Support for innovative start-ups incl. gazelles, 4.3.2 Support for risk capital; (3) 3.3.2 Recruitment of skilled personnel in enterprises.

The evidence shows that in CR, compared especially with countries such as Austria, Denmark, Finland, and Germany, significantly fewer programmes exist. Furthermore, the relatively high importance of European Structural Funds is obvious from the implementation of the Operational Programmes. A closer look at these programmes of the CR focusing on SIL will be presented in subsequent chapters.

The previous discussion already demonstrated the comparatively low level of venture capital investments in the CR. There seems to be no particular emphasis regarding public policy support for the important SIL due to early stage venture capital investment and high-tech start-ups. It becomes evident that the small number of implemented programmes is heavily dependent on European structural funding.

Another line of support is addressing the capabilities for SIL – especially expressed by qualified human resources. In this regard, provision of support for developing relevant skills and support for recruitment (and the subsequent interaction between science and industry) are amongst the most important elements. This dimension seems not to be addressed at all in the CR. From several international studies, however, evidence appears indicating that human resources are the core factor in these interactions – especially when it comes to regional developments (Hofer et al. 2004). Positive effects of qualified people on absorptive capacities are even multiplied in this way.

Taken together, the emerging picture is quite clear: The CR has, both in relative and in absolute terms, very few public support programmes to foster SIL. Given the nascent character of the CR's national innovation policy, an interpretation in the sense of an optimal policy that favours few but very efficient and effective programmes is unwarranted.

2.4 Résumé – emerging issues?

Taken together, the comparisons of SIL with the selected countries lead to the following conclusions:

- Human capital with tertiary qualification as an important ingredient for intense SIL is relatively scarce compared to transitional and advanced economies.
- The CR's public science sector in general and measures mirroring the absorptive capacities of industry appear above countries such as Hungary and Poland, but below countries such as Austria, Germany, Finland and Denmark. However, industry structure appears quite favourable for SIL since employment in high-tech manufacturing is relatively high there, but in reality, activities in the high-tech sector are sometimes low value-added (i.e. assembly activities) in the CR. Also rather negative is the low share of knowledge-intensive service sectors.
- While other R&D indicators show a middle position of the CR between the other transition economies and the more advanced economies, this is not the case for cooperation intensities and SIL in R&D. Here, the CR shows a lower or equal level to that of the other transition economies.
- Prague is the dominant centre of the national research system. The importance of the CR's capital is much higher than is the case for the capital regions in the other countries. At the same time, business researchers are rather evenly spatially distributed compared to other transition countries. While the associated agglomeration economies of Prague are an important asset, it must be ensured that SILs cross regional boarders with minimal friction.
- Evolution of industry – despite a relatively good ranking in terms of low barriers for entrepreneurship and a favourable environment for start-ups, limits are appearing due to an underdeveloped market for venture capital.
- Compared to other countries, the CR carries out very few policy programmes that might support relatively weak SIL. No programme exists that fosters technology transfer via human capital mobility.

3. The CR's knowledge production system

The analysis of SIL in the CR's R&D&I system reveals the need for an understanding of industrial and science structures, hence an overview of the knowledge production system. In this area, innovation activities have to be distinguished from pure R&D activities. In order to generate innovation, additional elements from the knowledge value chain are used. Innovation means implementing some new or improved products, processes, new marketing methods or organisation in business[7]. Therefore, innovation activities comprise much more than just R&D (e.g. entrepreneurship or the promotion of products).

As is known from the literature (Bozeman 2000, Polt et al 2001), linkages between science and industry are influenced by nationwide circumstances:

[7] In accordance with OECD classifications

- the structures of the research and business sectors, their R&D efforts and behavioural routines for cooperation – implying the consequences of creating long-term path dependencies – create the necessary potential for linkages
- the prevalent needs of industry regarding production factors and services based on R&D build necessary incentives
- conditions influence competitiveness
- the milieu (including "cultures" and applied measures) generated by public support of SIL provide supportive or hindering conditions

Apart from these general relations, regional differences in the CR have their influences on the established SIL patterns (Žižalová 2010, Blažek and Uhlíř 2007).

The following descriptions and analyses in this section are based on data provided by the Czech Statistical Office, Eurostat and the OECD.

According to studies (e.g. European Commission 2009), it is argued that the CR is currently changing from an economy-driven to an innovation-driven system. In this respect, SIL becomes a core element, and absorption capacities in industry have to be developed as much as favourable structures supporting interaction between the science and industry sectors.

In the following sub-chapters, descriptions and reviews seek to embed linkages between science and industry into a broader picture. Firstly, structural characteristics and specialisation patterns, enhanced by indications of competitiveness, provide the background for assessing the existing potential for SIL. Collaboration patterns, detected by R&D funding flows and statistics, highlight issues regarding MNEs and regional distributions.

3.1 Industry patterns and R&D[8]

The analysis of SIL must take into account the national/regional industrial structure and its characteristics. The potential for relations between research organisations – either public or private – and companies depends on the roles in value-chains and main determinants of competitiveness (e.g. mainly serving highly valued parts based on knowledge intensity or producing parts based on scale economies and low unit costs). The more an industry evolves towards higher knowledge intensities (e.g. expressed by higher R&D intensities[9]) based on science,[10] the higher the importance of opportunities to link up with developments in science. Hence, the potential for collaboration between the science and industry sectors increases and becomes the core element for competitiveness (e.g. pharmaceuticals).

While industries may become more knowledge-intensive, it is not at all clear to what extent this has an impact on the national economy. Therefore, the industry's position in the national economy must be analysed. The following sub-chapters thus explore structural characteristics of CR industry concerning contributions to gross value added, business expenditures on R&D, specialisation and competitiveness indicated by FDI stocks and revealed in comparative advantages – RCA.

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[8] The term "industry" includes all classes of productive activities – not just manufacturing.

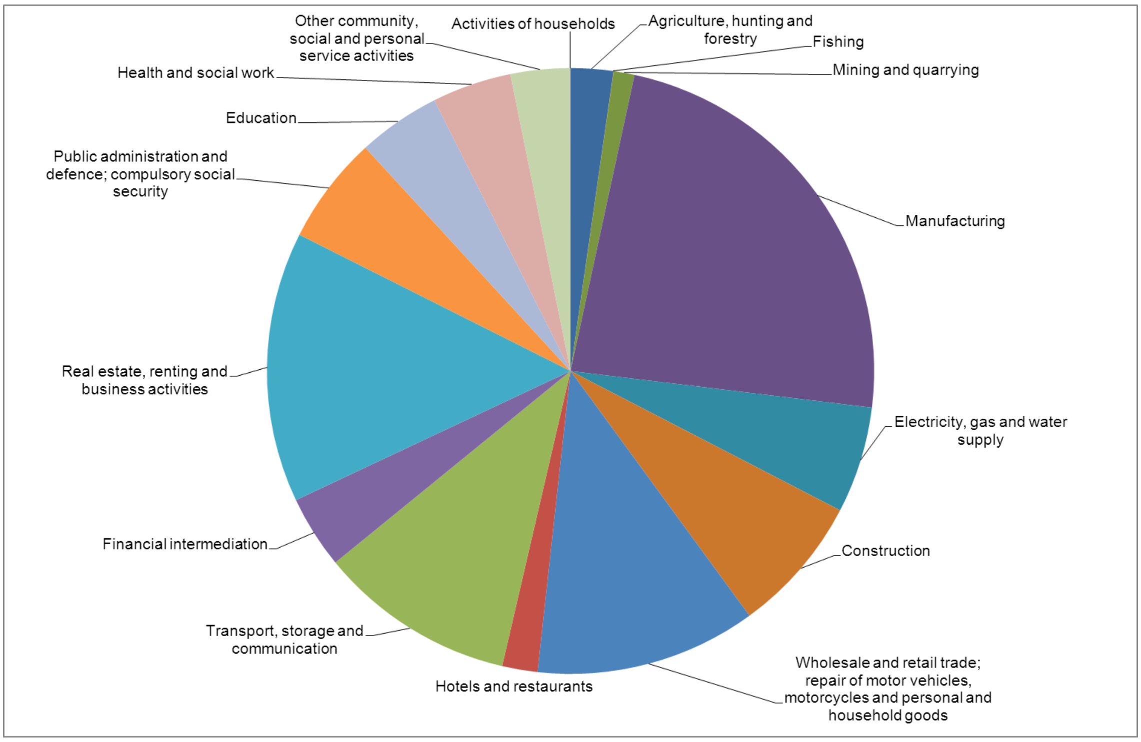
[9] Knowledge intensity does not only mean R&D, but may include other services (e.g. marketing, design) too. Furthermore, the remark must be made that knowledge appears in different forms, e.g. codified, tacit, embodied, secret and public (Foray 2006).

[10] A first classification of industries according to their need for science links was developed by Pavitt 1984.

3.1.1 Industry and R&D expenditures: structure and growth

As displayed in Figure 11, the largest income contributors (gross value added)[11] to the CR's industrial structure are "manufacturing", "real estate, renting and business activities"[12] and "wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods".

Figure 11: Share of gross value added according to industry (2009)



Source: Eurostat [2011], calculations JOANNEUM RESEARCH

Related to the fact that "manufacturing" is responsible for about 2/3 of R&D expenditures in the business sector (see Figure 12), it becomes evident that an R&D-driven growth in the CR's economy is closely related to industries represented in "manufacturing".

We observed the highest shares of gross value added in the following industries: "manufacture of motor vehicles, trailers and semi-trailers" (3.02%), "manufacture of machinery and equipment n.e.c." (2.76%) and "manufacture of fabricated metal products, except machinery and equipment" (2.53%).

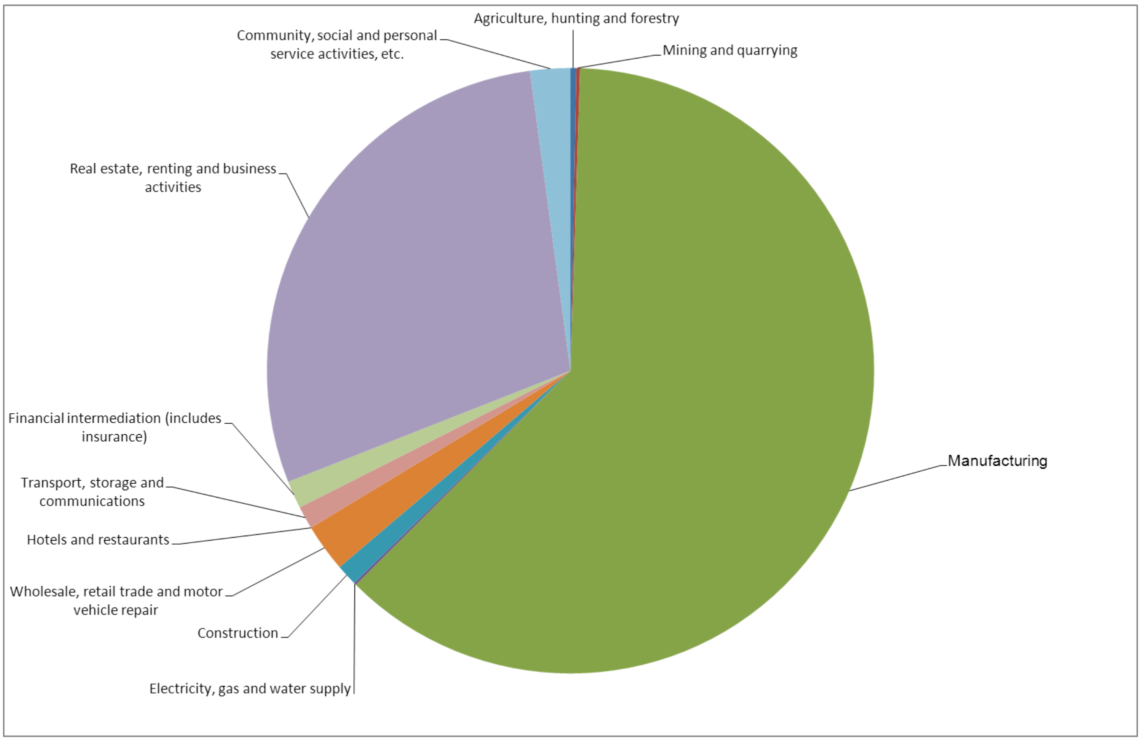
Within "manufacturing", the lion's share of approximately 24% is accounted for by the "manufacture of motor vehicles, trailers and semi-trailers" – definitely the leading industry, and from the innovation system's perspective a core element. With average annual growth rates of gross value added (2001-2009) of about 8.5%, the "manufacture of motor vehicles, trailers and semi-trailers" ranks in the TOP 3 of "manufacturing". According to information from CzechInvest (2010b), the CR is the world's fourth most attractive automotive location. The CR's automotive industry did not only manage privatisation and massive FDI inflow between the 1990s and today, accompanied by an extensive growth, but could also be developed by a functional upgrading – represented by the establishment of new R&D centres (Pavlinek et al

[11] One-digit level NACE

[12] Including „research and development" with a share of 0.32% in 2008.

2011). Nevertheless, a closer look reveals this upgrading to be limited to Skoda and a small group of major foreign-owned first-tier suppliers.

Figure 12: Share of BERD according to industry (2009)



Source: Eurostat [2011], calculations JOANNEUM RESEARCH

The other industries with the largest shares of R&D expenditures (BERD) were “machinery and equipment, n.e.c.” (8.34%) and “chemicals and chemical products” (6.30%) in 2009 – with “machinery and equipment, n.e.c.” (2.76%) among the largest contributors to gross value added (1.11% for “chemicals and chemical products”) – and both industries with a long-standing tradition in the CR.

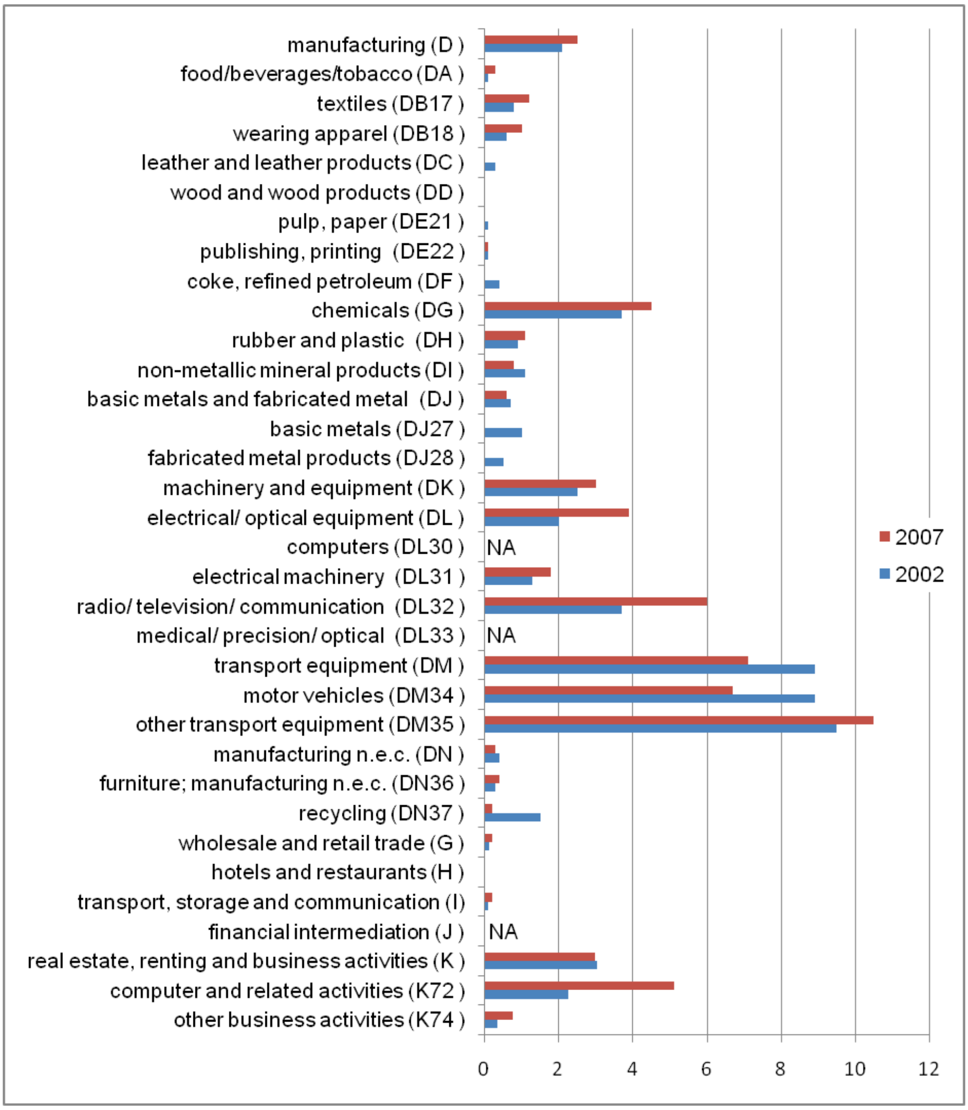
Growth figures show that these structures may change in the future, and hence cause some reorientations in the innovation system. A few industries indicate relatively high average annual growth rates (between 2001 and 2009), both in gross value added and BERD:

- “Medical, precision and optical instruments, watches and clocks” (6.13%/30.48%)[13],
- “Office, accounting and computing machinery” (8.29%/28.98%),
- “Rubber and plastics products” (8.99%/16.21%) and
- “Electrical machinery and apparatuses n.e.c.” (4.50%/15.03%).

These four industries (2009) represent approximately 4% of gross value added and 12% of BERD (compared to “motor vehicles, trailers and semi-trailers” with 3.02% and 23.45% respectively) – still behind the above mentioned leaders in shares.

13 First figure in brackets indicates average annual growth rate of gross value added, and the second figure average annual growth rates of BERD.

Figure 13: R&D intensity (R&D expenditure in % of value added) according to industry; CR 2002 and 2007



Source: Eurostat [2011]; calculations Joanneum Research; NACE K73 (research and development) excluded from figure due to extreme values

A complementary and growing industry in the service sector is “computer and related activities”, with average annual growth rates (2001-2009) of gross value added of 11.49% and BERD of 29.83%.

These observations point to a growing part of the industry related to the “ICT” paradigm – a structural change which will take time and will depend on available resources – mainly well educated people.

A comparison between 2002 and 2007 shows that the manufacturing industry has increased R&D intensities, but that the industry with the largest share in R&D (“motor vehicles”) has significantly reduced its R&D intensity.[14] On the other hand, “electrical/optical equipment”, “radio, television, communication” and “chemicals” show larger increases – and especially in the service sector, the “computer-related activities” (see Figure 13).

14 Automotive industry shows pro-cyclical R&D investments.

Comparing the patterns with other countries[15], it becomes evident that a decrease in R&D intensity in the "manufacture of motor vehicles, trailers and semi-trailers" is a more general phenomenon in Europe. The global crisis hit this industry very hard – and indeed caused the dip in R&D intensity (European Commission 2009).

A more diverse result between countries appears in the industries "chemicals", "electrical and optical equipment" and "radio, television and communication". From a global perspective, these industries are mainly represented by multinational enterprises, and according to their strategic adaptations, locations will change in the global value chains of these industries (Yrrkö et al 2011). "Computer and related activities" in the service sector are in accordance with the other countries studied, representing an increase of R&D intensities.

In conclusion, manufacturing is dominant in the CR in terms of value added and business R&D. Dynamics appear due to the restructuring in the CR's industries, related to the "ICT paradigm". This sector reveals increasing R&D activities, while in more "mature industries" (e.g. motor vehicles), R&D is no longer exceptional. Nevertheless, the figures have to be treated with caution, as there may be considerable diversity between enterprises in the different industries (e.g. with Skoda representing about 75% of R&D expenditures in "motor vehicles"). Such a concentration of R&D appears typically in almost all industries and can also be observed in other countries. Only a small sample of enterprises inside an industry has high R&D intensities (see, for example, results from the Austrian Research and Technology Report 2010).

3.1.2 Specialisation patterns of the CR's industry

In order to detect specialisation patterns in the CR's industry, and hence comparative advantages, the revealed comparative advantage (RCA) has been 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.[16]

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 compare countries and objectives directly.[17]

We have to take into account the fact that specialisation is a relative term. It shows in which areas a given country is specialised compared to the benchmark. The benchmark might be the world, a selection of countries (e.g. EU-15/EU-27) or a single outstanding country in terms of R&D performance (best practice benchmark). The selection of the benchmark has, of course, a severe impact on the "specialisation"

15 Comparisons were made with the 6 selected countries as explained in chapter 2

16 It is defined as

$$iA_{ki} / \sum_{ik} A_{ki}$$

$$A_{ki} / \sum_{k} A_{ki} / \sum$$

$$RCA_{ki} = 100 \tanh \ln$$

(Grupp 1997: 213).

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.

For more information, see Final Report on Public R&D Expenditure in Section 3.3.2

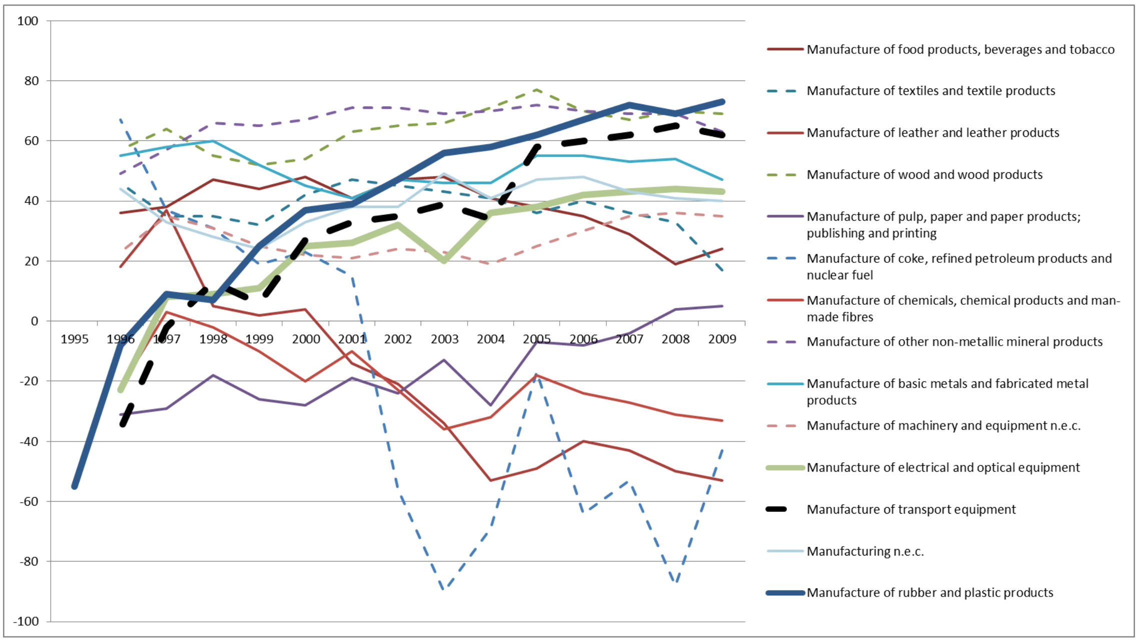
17 However, this normalisation excludes size effects, which have their role in science.

result, but at the same time the selection of the benchmark is heavily influenced by the availability of data.

We looked again at gross value added of industries compared to EU27 and found an indication about the industries in the CR which are represented to a much higher degree than in the benchmark, and hence may also represent a competitive advantage. Furthermore, tracing the time series from 1995 to 2009 gives an impression of changes and, at the same time, of path dependencies.

Related to Figure 14, RCA of gross value added in manufacturing shows that the specialisation patterns are changing. While industries such as the "manufacture of transport equipment" (including motor vehicles etc.), "manufacture of electrical and optical equipment" and "manufacture of rubber and plastics products" have become a specialisation in the CR, other industries such as the "manufacture of chemicals and chemical products and man-made fibre" or "manufacture of coke, refined petroleum products and nuclear fuel" are fading out as a specialisation. Behind this changing specialisation, a massive FDI inflow in the case of transport equipment (especially in the automotive industry) was apparent, meaning that this specialisation is caused by an advantageous situation in the CR for this industry. A long-standing tradition in engineering in this sector and the excellent technical education in combination with low unit costs form the background to this. Consequently, this specialisation was also accompanied by the establishment of automotive technology centres by global players (e.g. Mercedes-Benz – see CzechInvest 2009).

Figure 14: RCA of gross value added, 1996-2009



Source: Eurostat [2011], calculations Joanneum Research

Another industry with increasing RCA is the "manufacture of rubber and plastics products". This industry is closely connected to the automotive, food and electrical engineering industry, producing packaging for these industries. The traditional chemical industry and its knowledge stock, the increased demand of the connected industries and the excellent public research institutes[18] provided all necessary requirements for developing this industry towards a specialisation.

18 The Institute of Chemical Technology has a long tradition and is amongst the largest education institutes in this sector in Europe.

The third industry, the “manufacture of electrical and optical equipment”, also has connections to the automotive industry – the auto-electronics suppliers, according to Czech Invest (2009a, 2009b). Furthermore, the CR’s electrical industry is based on a long tradition and some exceptional research results.

Overall, it becomes evident that the current specialisation in the CR’s industry finds its core element in the automotive industry. Closely connected industries such as rubber and plastics or electrical equipment managed to find ways to use these relations when growing – based on solid traditions.

Even though the chemical industry seems to be losing ground in these developments, it must be mentioned that intensive activities in the biotechnology industry are taking place (Blažek and Žížalová 2010). Furthermore, we observed a rather stable specialisation regarding industries such as “wood and wood products”, “other non-metallic mineral products”, “basic metals and fabricated metal products” or “machinery and equipment”, while a decline in specialisation was observed in industries such as “leather and leather products” or “coke, refined petroleum products and nuclear fuel”. Overall, this supports the view of an evolving economy (European Commission 2009) containing parts which are still economy-driven and working on pre-existing traditional knowledge bases, and another part consisting of innovation-driven industries.

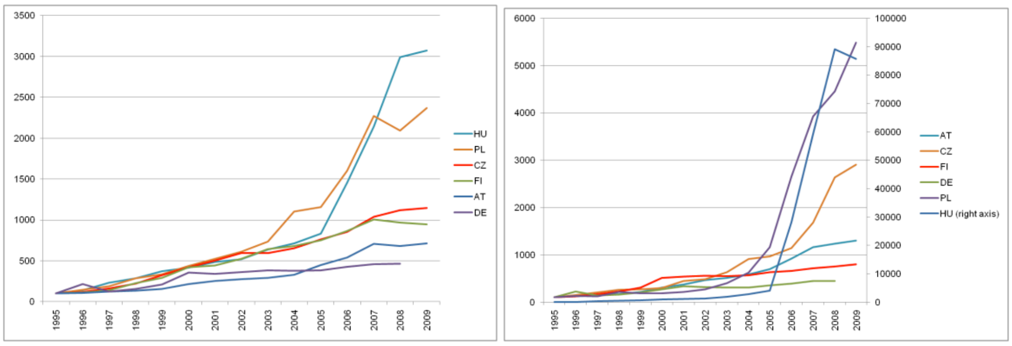
3.1.3 International competitiveness – FDI and foreign trade

In terms of international competitiveness, an advantageous position is indicated by the FDI flows (OECD 2011). The more attractive the location, the more FDI is usually attracted. Furthermore, FDI attracted may include some regional headquarter functions, which may have positive effects on SIL as a consequence. On the other hand, inward FDI is often accompanied by centralising strategic activities (e.g. R&D activities) in the home country. This causes a distribution of R&D activities which makes the host country more dependent on the home country of the FDI, as local embeddedness may not be supported.

In a lot of cases, strategic decisions regarding R&D&I activities are made in the home country of the MNE. Local R&D activities are often continued for adaptations to local markets only – which, as a consequence, reduce the potential for more highly valued SIL (at least for the national public research organisations). Only in a few cases do local business R&D units of multinationals receive the status of a centre of excellence in the global organisation – a position which was accomplished by several companies in the automotive sector in the CR (CzechInvest 2009).

While inward FDI positions are an indication for advantages of the location (nation or region), outward FDI may represent “headquarter” situations. In this respect, either a nationally owned company invests outside the country in order to expand its production, or a foreign-owned company (former inward FDI) gains central responsibilities (a kind of “headquarters”) and expands on that. As R&D activities are often combined with such “headquarter” functions, outward FDI is also a sign of potential SIL.

Figure 15: Growth of inward FDI positions (stocks) and outward FDI positions (stocks), 1995-2009 (1995=100), selected countries



Source: OECD 2011; calculations Joanneum Research

Comparing the inward FDI positions of selected countries shows that the CR ranges amongst the most attractive countries. It appeared as attractive as Finland and was only quite recently outperformed by Hungary and Poland. Nevertheless, there is a continuous increase in FDI stocks observable. According to information from CzechInvest (2009), the automotive industry is now largely foreign-owned due to FDI activities which frequently expanded existing manufacturing plants or set up enterprises to start as suppliers for particular manufacturers (e.g. Bosch).

Concluding from the argument above, one would expect somewhat less potential for SIL. However, the automotive industry in particular has gained many students and graduates from the technical education system, and all technical universities have their project relations with companies from the automotive sector (see CzechInvest 2009).

Regarding the outward FDI position, the CR was able to follow a considerable and continuous increase – and was only outperformed by Poland and Hungary.

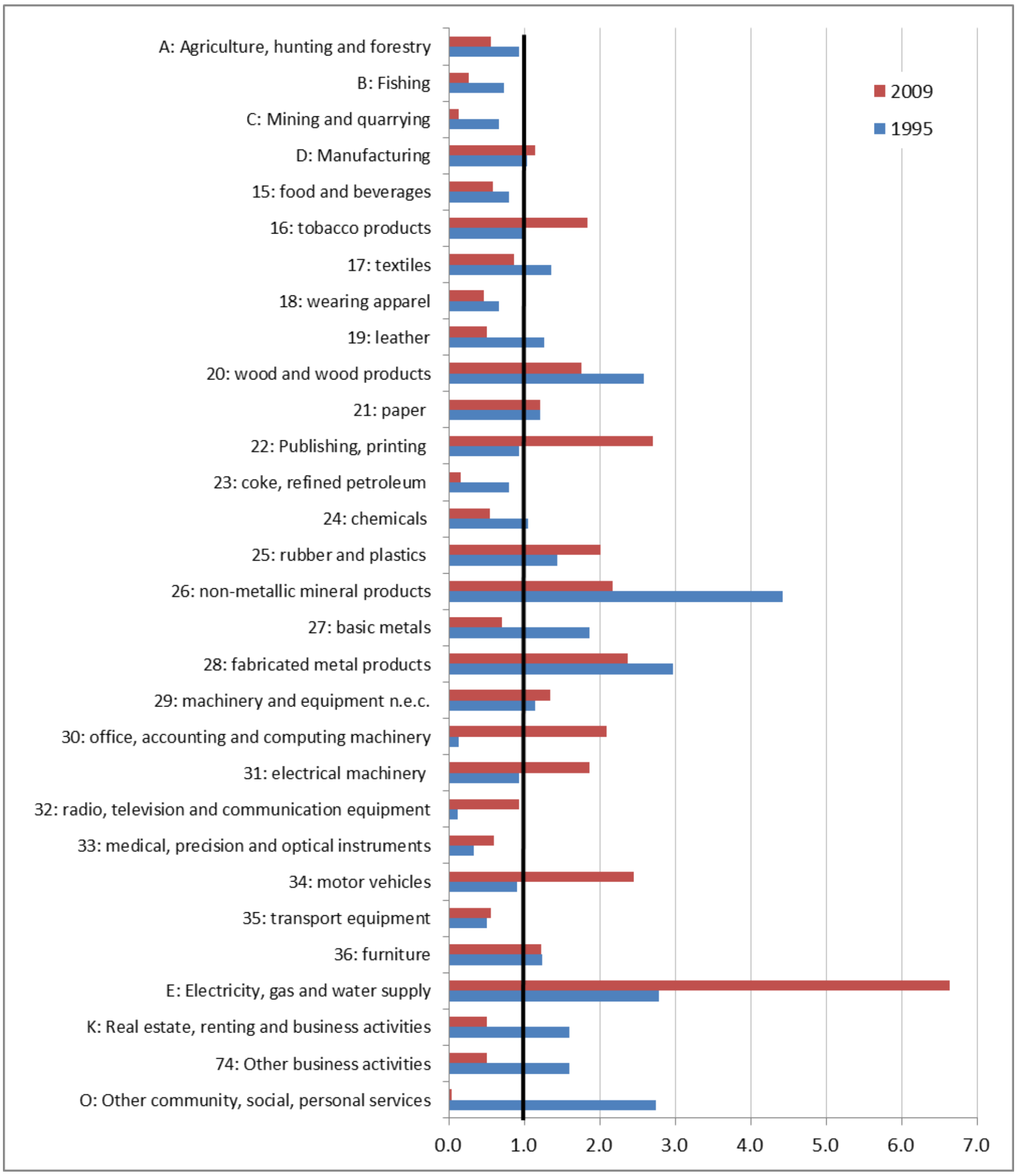
Overall, FDI activities are at the highest level first of all in services, and secondly in manufacturing (in the “motor vehicle” and to a lesser extent in the “metal products” and “chemicals” industries) according to OECD data. “Chemicals” also shows an increase in outward FDI, but manufacturing as such has lost momentum in outward FDI compared to increasing outward FDI developments in Hungary and Poland.

Another indication for competitiveness is trade structures. Exporters have to find their customers in an environment of international competition. This means that increasing shares of exports are accompanied by competitiveness within the producing industry. Therefore, a RCA analysis provides pointers for advantages – and, combined with the other indications (such as R&D intensities etc.), provide information as to what extent this competitiveness may be based on R&D&I efforts (Figure 16). Innovation activities are typically positively related to export activities – and exports stimulate further innovation. The removal of barriers to innovation encourages internationalisation efforts, and the elimination of barriers to internationalisation may foster innovation activities in companies (Reinstaller et al, 2010).

Comparing developments in RCA between 1995 and 2009 gives some hints as to which industries the country has been specialising in according to export structures. It is clearly indicated that in metals industries, RCA has been massively reduced, while in “motor vehicles” - but also in industries related to “electronics” and in “rubber and plastics” - substantial increases are observable.

Again, evidence shows that the newly developed and established industry specialisation – based on national comparative advantages (unit costs and cumulated knowledge stocks) and the related FDI activities – developed along with increased competitiveness of these industries, indicated by trade patterns. Openness of the country and external influences (i.e. FDI inflows and related practices) supported this growth.

Figure 16: Revealed comparative advantage[19] (by ISIC) for the CR in 1995 and 2009



Source: OECD [2011]; calculations Joanneum Research

3.1.4 Summary of the industry pattern

Taking all the calculations and observations from above together, the "manufacture of motor vehicles, trailers and semi-trailers" appears to be the most important industry – being amongst the highest contributors to income and R&D. Furthermore, this automotive industry is connected to the electrical equipment industry and the rubber and plastics industry, with the other industries gaining shares in the specialisation

19 The revealed comparative advantage (RCA) measures the intensity of trade specialisation of a country within a region or the world (here: within the OECD for trade of goods). Calculation: export share of an industry of the total exports (of goods) of a country divided by the export share of this industry of the region or the world (here: OECD). If the RCA takes a value of less than 1, this implies that the country is not specialised in exports of this industry. The share of this industry within the total exports of goods of this country is less than the corresponding OECD share. Similarly, if the index exceeds 1, this implies that the country is specialised in this industry's exports (OECD.stat 2011).

pattern of the CR. These industries have also been heavily addressed by FDI – and a substantial part of the automotive industry, for example, is now foreign-owned. Consequently, R&D&I activities are significantly determined and decided upon from outside the CR.

In addition, industries such as the "manufacture of machinery and equipment" and "manufacture of chemicals and chemical products"[20] are important contributors to R&D (and income in the case of machinery and equipment), with moderate growth rates in BERD (and highest growth rates in value added in the case of machinery and equipment). These industries are representatives of the traditional industries. They build the backbone of the system, as the path-dependent accumulated knowledge, engineering tradition and education constitute well established complementary elements. They form the comparative advantages of the CR's innovation system.

Another interesting industry is office machinery and computers, contributing to value added and BERD only with a small share, but having high rates of BERD growth. This industry developed from a traditionally highly innovative electronic sector, based on engineering education and research, and gained momentum in the 1990s when FDI in the automotive industry was accompanied by suppliers of auto-electronics.

According to RCA in trade, office machinery, electrical machinery and motor vehicles show the highest competitiveness. This means that industries which include the largest shares of foreign-owned companies build the internationally most competitive segment. Interestingly enough, one can see from R&D figures that these industries are also becoming more R&D-intensive, and hence hold increasing potential for collaborations between the science sector and industry.

3.2 Public research organisation patterns

The CR's public research sector consists of research institutes from the Academy of Sciences (ASCR), institutes of universities and public research institutes (ERAWATCH 2010) – similar to most other countries.

As mentioned in the concept section, transfer of knowledge between science and industry may be channelled through different lines. These include collaboration in R&D projects, personnel mobility, co-operation in training and education and commercialisation efforts (e.g. spin-offs). In the case of SIL, the development of capacities for cooperation and transfer of knowledge via different channels (e.g. qualified human resources or collaborative research activities) is most important.

In this respect, analysis here largely overlaps with other work packages of the audit – especially regarding human resources, bibliometric results and governance. The following sub-chapters merge information in order to sketch structures and the performance of the public research sector, which helps to reveal SIL-relevant patterns.

3.2.1 Public research organisations and capabilities for knowledge transfer

Similar to other countries, the CR's public research scene consists of diverse organisations related to the higher education sector – these currently include 26 public higher education institutions with 333,580 students (2009) and 45 private entities with 56,357 students (2009) providing tertiary education (CZSO 2010). Three main types of *universities* produced 69,647 graduates (2009):

- Traditional universities (e.g. Charles University in Prague or Masaryk University in Brno, with traditional faculties such as medicine, science, humanities etc.) – producing approximately 30,000 graduates;
- Technical universities (e.g. Czech Technical University in Prague, Technical University of Ostrava or Brno University of Technology with technical disciplines) – producing approximately 18,000 graduates;

20 Which include pharmaceuticals

- Specialised universities in selected fields (e.g. Czech University of Agriculture in Prague or the University of Economics in Prague).

The higher education organisations were focused on education in the communist era, and only during the last two decades have they been catching up impressively in research activities, currently with a size of about 19,000 researchers.[21]

The other large research organisation is the *ASCR,* related to the government sector, having been more or less the sole producer of basic research in the communist era. The Academy currently employs nearly 7,000 staff and consists of 53 research institutes which are divided into three scientific domains (ASCR 2009):

- Domain of Mathematics, Physics and Earth Sciences;
- Domain of Chemical and Life Sciences;
- Domain of Humanities and Social Sciences.

Another category consists of the *institutes related to ministries*. There are currently 19 in existence (14 in Prague, 3 in Brno, 1 in Teplicy and 1 in Vyškov). Their research is steered by interests from the respective ministries.[22]

SIL was also promoted during the communist era. Central state-owned research institutes existed with which companies were forced to cooperate. Nowadays, universities and ASCR institutes are the most important partners for firms.

In contrast to other countries, there are no large public research institutes dedicated to applied research (i.e. Germany – Fraunhofer, Finland – Technical Research Centre of Finland (VTT), Austria – Austrian Institute of Technology (AIT)). Therefore, it is even more important to promote SIL among the existing institutions while introducing more flexible organisational structures, defining responsibilities concerning SIL for all institutions in the research system (universities, academy, private research organisations) and developing appropriate policy measures to support SIL (programmes, tax incentives, etc.).

Furthermore, the *private research organisations* have to be mentioned, as many of them were previously public research organisations. Most of these research organisations are currently members of the Association of Research Organisations,[23] which unites bodies involved in applied and/or commercial R&D. These organisations have seen the most substantial structural change in recent decades, evolving from sectoral research institutes conducting applied research for the industry towards privatised institutes – often without adequate public support. Consequently, a lot of these institutes reduced or gave up their research activities due to a lack of demand and switched to small manufacturing, the provision of services, sales activities, or in some cases simply managed by renting out their equipment and real estate which they had gained in the privatisation process. The number of privately owned research institutes is currently around 60, about a half of the number of those active prior to 1990. Not all of them are actively involved in R&D; however, they have kept the name of a research institution (AVO[24]).

In some cases, spin-offs from large enterprises were founded as private R&D organisations during the privatisation process of the 1990s (e.g. the former research department of Škoda Plzen, called Škoda výzkum (engineering), or the former R&D department of Vítkovice Steel, called MATERIÁLOVÝ A METALURGICKÝ VÝZKUM s.r.o. in Ostrava (ERAWATCH 2010).

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21 Full time equivalents (FTE)

22 ERAWATCH country profile Czech Republic: http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=4&countryCode=CZ

23 www.avo.cz

24 AVO – Association of Research Organisations: http://www.avo.cz/index_e.htm

Nonetheless, there are at present a number of very active privately owned R&D organisations working primarily on contract research for industrial partners and/or subsisting on domestic and international R&D grants. The largest numbers are in chemistry, electrical and mechanical engineering; others are in food and agriculture (AVO[25]).

All these private organisations are related to the business sector and have close ties to industry. They are actively participating in public research programmes. Moreover, firms receive grants for innovation activities and subcontract to private research organisations. Therefore, some private research institutes also benefit indirectly from public funding.

The great diversity of research areas and variety in organisation among these institutes prevents the acquisition of detailed information about their contributions to the CR's innovation system without performing case studies. The variety includes institutes only partly involved in production, with sizes ranging from rather large institutes, such as the Nuclear Research Institute ŘEŽ with several hundred researchers, to medium sized institutes such as COMET (research and material testing) with about 50 researchers, and even quite small, highly specialised institutes with only a few employees.

Overall, the public research sector provides research capabilities of some 27,000 researchers[26] and about 10,000 technicians, including a slight shift from the government sector (e.g. ASCR) to higher education (i.e. universities) resulting from a decrease of R&D personnel in the government sector.[27] This public research base[28] is highly concentrated around Prague (54% of R&D personnel[29]) and Brno (18% of R&D personnel). Almost three quarters of all public research capacities (researchers) are located in/around these two centres, while capacities in the business sector are less locally concentrated. Consequently, this produces a need for a high level of extra-regional collaboration between science and business – producing a "Prague" effect, with a tendency of enterprises to seek R&D partners in Prague.[30] Another centring effect is observable in the case of graduates, where the greatest concentration of students relative to the contribution to the national economy is located in Brno.[31]

An important element for knowledge transfer is graduates from tertiary education. Here, statements of shortages in graduates (ERAWATCH 2010) appear, despite the fact that the number of university graduates (including PhD) in the CR has been growing more rapidly than the EU 27 average in recent years (almost doubling from 2000 to 2010), although the number is still significantly lower than the EU27 average. This becomes more important when one acknowledges that only a very low share of research personnel with a PhD prefer the research career because of good employment conditions (10%) and because of good financial conditions (3%) (CZSO 2008), while the latest analysis from the Research Institute of Labour and Social Affairs (Vavrečková 2008) shows that more graduates in the fields of manufacturing and electrics, pharmaceutics, and economics or ICT are still needed on the labour market.

Similar to the EU27 average, one-third of all university students in the CR are in technical and natural science fields. Although in relative terms the number of technical and natural science students appears acceptable, in absolute terms, the number is very low. The CR currently reaches a significantly lower share of graduates

25 AVO – Association of Research Organisations: http://www.avo.cz/index_e.htm

26 By occupation in the government sector and the higher education sector in 2009

27 More detailed information regarding the funding, performance and steering of all public research organisations is provided in the respective work packages

28 Government sector and higher education sector

29 Full time equivalents 2009

30 These observations are also supported by a study by Zizalova (2010).

31 See work package about human resources

in the technical and natural science fields per 1000 inhabitants between 20 and 29 years of age. Moreover, an ageing effect is observed, with a higher share of technical graduates in the population from 25-64 than the EU average – pointing to a challenge for the innovation system.

The CR's public research sector underwent a structural change which generated an increasing number of researchers in the past decade and an enormous growth of graduates, both indicating the evolving of a widening capacity for research and potential SIL. But recent developments are dampening over-optimistic expectations, as ageing effects appear in engineering and the capacities (number of researchers) in the public research sector are stagnating.

3.2.2 Research and innovation performance

Based on the results of other work packages on bibliometrics (WPg) and IPR (WP d,iii) of the audit, evidence in research and innovation performance of public research organisations could be gathered.

The *research performance* clearly showed some substantial changes in the CR's public research system:

- International visibility of Czech researchers' output increased considerably, as did the quality over the last decade.
- In this respect, an increasing trend towards international and national cooperation could also be observed.

While universities and research organisations represent almost half of the publication production, it is also interesting to see that private companies participate in around 4% of this production.

Another result highlights the highly concentrated production of publications, with the ASCR participating in more than 45% of all scientific publications from the country, followed by Charles University in Prague, which participates in around 25%. Masaryk University, the Institute of Chemical Technology in Prague, the Czech Technical University in Prague or Palacky University in Olomouc also produced more than 3000 publications during the period 1993-2009.

We observed an interesting development in which the ties of Czech scientific organisations, both within the CR and internationally, have grown over time, while the most "isolated" research (expressed by single address papers) is left. The most important findings were:

Production in international collaboration usually has a normalised impact (CPP/FCSm) close to or above 1 (being thus classified as "average" or "high"). It is remarkable that the production in international collaboration of the hospitals is the only sector with a normalised impact well above the international level ("high").

International collaboration gathers the highest share of publications for most of the institutions. However, several exceptions can be mentioned, such as the Palacky University in Olomouc, the University of South Bohemia in Ceske Budejovice, or the University of Pardubice among others, where the percentage of publications in *national collaboration* is higher than for the other cooperation types.

The increase of international collaboration as well as the level of production in international collaboration is higher for universities and research organisations (mainly the ASCR), while national collaboration has a major importance for hospitals, governmental institutions and especially companies.

Some universities and institutes were already well linked into the international R&D networks and their share of international collaboration has not evolved very much over time (this is the case for the ASCR –global-, Charles University in Prague or the Institute of Physics of the ASCR). Other institutions, however, show a remarkable growth in the share of international collaboration during the period of analysis, for example the Czech Technical University in Prague. This university saw a very strong increase in the impact of papers in international collaboration during the last years of the period.

A general observation derived from analysis of bibliometric data for main institutional sectors and individual scientific institutes is that the ASCR (as -global- or its institutes) together with Charles University in Prague are normally the leading institutions in terms of production in almost all the fields. Exceptions worth mentioning include:

- The fields of 'economics and business' and 'political science and public administration', where the leading institution in terms of production is the University of Economics in Prague (although with a very low field-normalised impact);
- The fields of 'energy science and technology', 'instruments and instrumentation' and 'mechanical engineering and aerospace', where the Czech Technical University in Prague takes a leading role in the number of publications.

In terms of *innovation performance* (i.e. patents), governmental research institutes as well as universities were each responsible for 2% of patent applications at the European Patent Office in 2006 according to data of the Czech IP office and the Statistical Office of the Czech Republic. Most of the patents were applied for by firms. In general, the number of patent applications increased from 1997-2009. In 1997, universities only applied for eight patents, while in 2009 the number rose to 136, with a strong increase since 2005. Governmental R&D institutes applied for ten patents in 1997, while in 2009 the number increased to 72. Data on utility models behave similarly. In short, in terms of innovation outputs, public research organisations are only responsible for a small part. Nevertheless, universities have outnumbered the ASCR in terms of patents and utility models. But one has to keep in mind that patents and utility models are only performance measurements for very specific disciplines. An in-depth analysis of patenting activities in the CR is part of the IPR working package in Final Report on IPR in Section 2.1.

3.2.3 Summary of the public research sector

Analysis of public research sector developments shows that:

- The structure of players underwent substantial changes, including the implementation of research activities at universities (which had just had an education function before – and this research role is largely growing), and tremendous changes in the landscape of former (sectoral) research organisations (with most privatised and developing towards other activities), with the only relatively stable organisation being the ASCR;
- There is also a massive concentration of institutes from the public research sector in Prague, including the largest (and best ranked) universities (Charles University Prague, Czech Technical University Prague and also the Institute of Physics of the ASCR) and another centre in (around) Brno;
- Numbers of graduates are growing rapidly, but engineering and natural sciences are not the most rapidly growing educational fields – similar to many European countries. It becomes even more evident that a previously high share of engineers and natural scientists is now characterised by an ageing phenomenon, and as a consequence may dry up an important channel for innovation activities and SIL;
- From bibliometric analyses, it appears that Czech researchers' output has increased and evolved towards excellence criteria – accompanied by intensified international and national cooperation in research.[32] This development has generated very internationally visible institutes, also creating pre-conditions for

[32] See also work packages about international cooperation

establishing knowledge-intensive enterprises. Nevertheless, information gathered from interviews suggests that cooperation and knowledge transfer with domestic enterprises or spin-offs[33] is rarely implemented.

3.3 Collaboration patterns and determinants

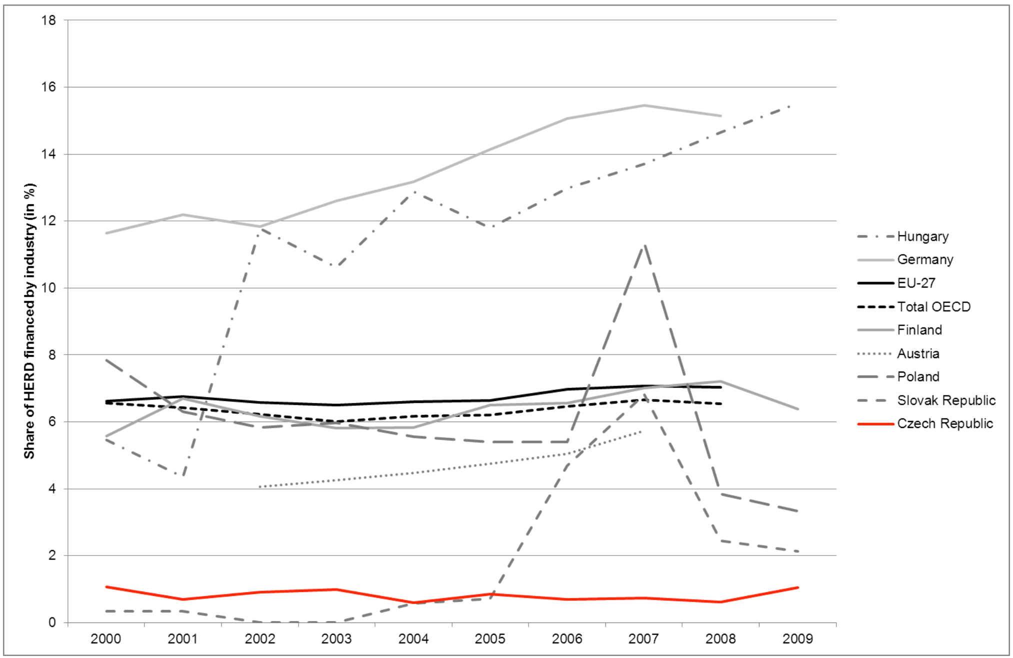
Collaborations between science and industry are considered as key factors fostering innovation activities. Recent developments in theorising argue for a more heterogeneous characterisation of channels and players involved. The creation of innovations may be a result of science, technology and innovation efforts (e.g. in pharmaceuticals with clear scientific goals), but may also be generated from doing, using and interacting (e.g. in the case of machinery equipment) (Jensen et al 2007). Consequently, collaboration between science and industry differs in importance for innovation activities in business.

3.3.1 R&D funding flows

Cross-sectoral funding flows[34] 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) – and to what extent innovations in industry may be science-based or a consequence of interactions with other players.

Indications in figures of R&D expenditures from industry-funded research activities in the higher education sector (HERD) (see Figure 17) and the government sector (GOVERD) (see Figure 18) mark less intensive relationships. Evidence provided presents almost separated pillars in the innovation system:

Figure 17: Share of HERD (%) financed by industry (2000-2009)

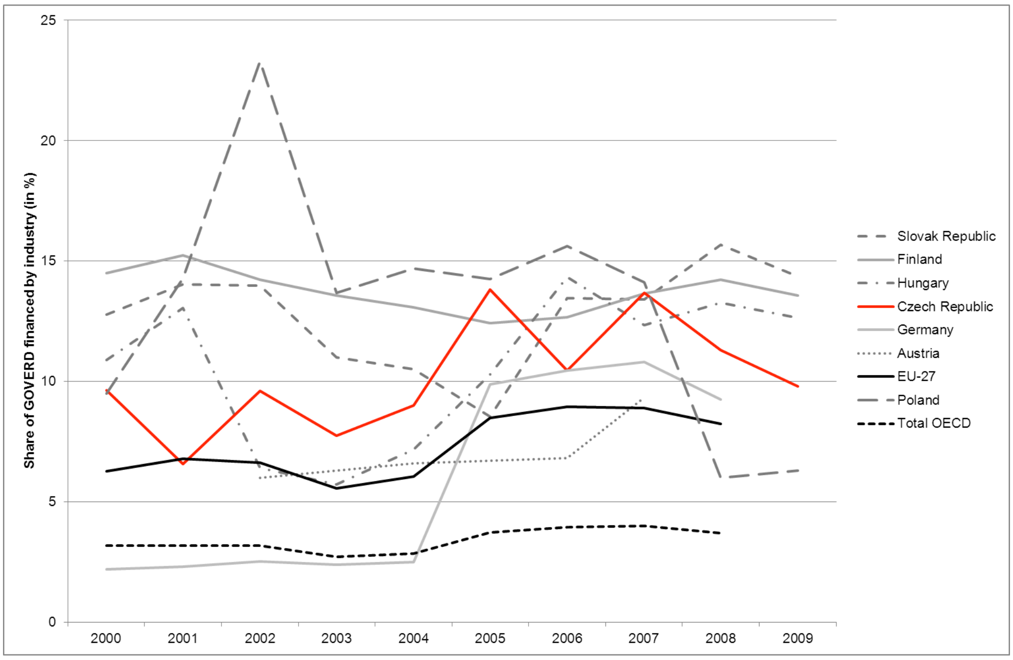


Note: Interpolation of values for Austria for 2003 and 2005
Source: OECD, Main Science and Technology Indicators, [February 2011]; calculations Joanneum Research

33 We could only observe a few spin-offs from universities and the ASCR, e.g. from the Czech Technical University in Prague according to interviews or the Institute of Molecular Genetics of the ASCR, v.v.i. (http://www.img.cas.cz/news/onas/Aplikace-cz.html)

34 While these flows are analysed in more detail in Final Report/WPa by focusing on funding structures, here the focus is more on relations between the sectors (i.e. science and industry).

Figure 18: Share of GOVERD (%) financed by industry (2000-2009)



Note: Interpolation of values for Austria for 2003 and 2005
Source: OECD, Main Science and Technology Indicators, [February 2011]; calculations Joanneum Research

Business enterprises provide only a very small amount of their R&D expenditures to the public research sector, causing an extremely low share of HERD financed by industry (see Figure 17), but reaching relatively high shares of GOVERD financed by industry (see Figure 18), while most is spent on R&D in the business sector itself. On the other hand, public expenditures are mainly directed to the public research organisations. One has to be critical about the high share of GOVERD financed by industry, as it also includes the income generated by licences. In the ASCR, 13.2% of the overall budget is from licensing. This success can be primarily traced to the licensing activities of one institute, the Institute of Organic Chemistry and Biochemistry (IOCB). 98% of ASCR licensing income is derived from a set of patents on anti-retroviral drugs for NIV and hepatitis, developed and licensed by the IOCB. Detailed information on this special case is available in Final Report on IPR in Section 2.3.2. This means the share of GOVERD generated by contract research of industry members is lower. Unfortunately, there is no distinction in the official statistics between the two funding sources available.

Table 2 shows the share of R&D in higher education (according to scientific field) that is financed by the business sector and international sources in 2001 and 2008. In 2001, the share of business funding was the highest in agricultural sciences (which, however, plays a minor role in total R&D expenditure/funding) and engineering. By 2008, the share of business-funded engineering R&D in higher education had been reduced markedly, while medical and social sciences received clearly higher funding in 2008 than in 2001.

Table 2: Selected funding sources of R&D in higher education according to 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

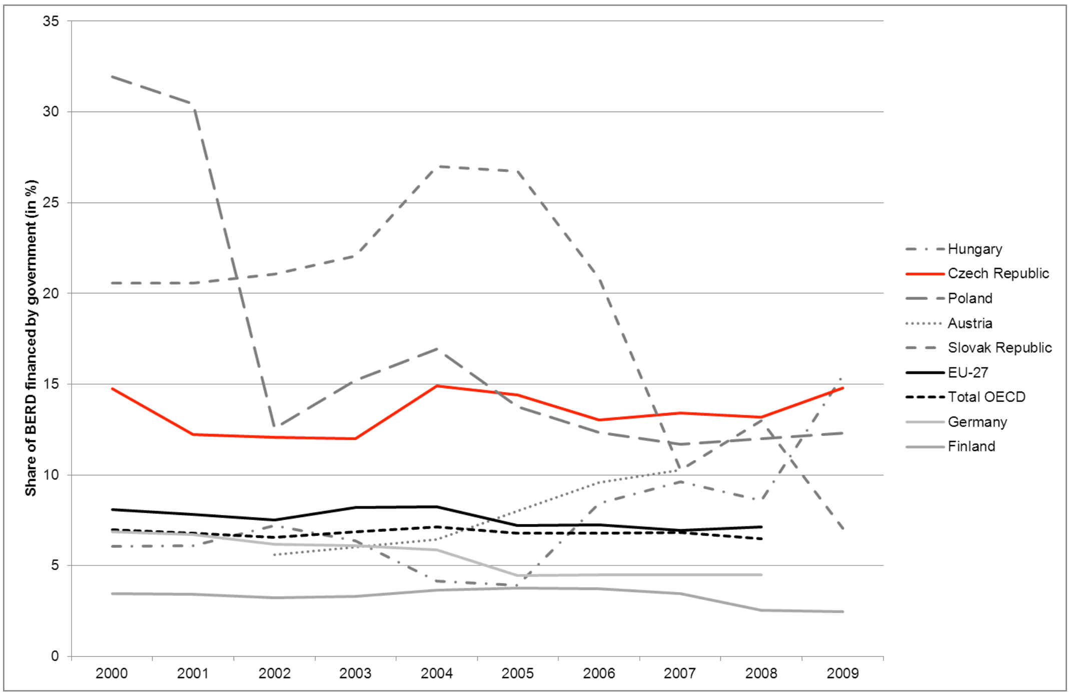
Source: OECD Research and Development Statistics downloaded 12/2010

Engineering shows a trend towards higher international funding while reducing domestic shares. This picture is attributed to the FDI activities and developments towards excellence in the public research sector. Seeking excellence ("the science frontier") incorporates only limited compatibility with R&D&I activities at the lower end of the R&D value chain in the CR's industry. Consequently, public research sector institutes mainly sold their expertise to foreign enterprises (as mentioned in interviews), but also gained funding from abroad through increased participation in EU programmes. Although engineering still accounts for the largest sum of funding from business in universities, it seems that domestic enterprises are becoming less committed in terms of funding – which may have consequences for SIL. In the case of natural sciences, participation in EU programmes seems to produce significant funding from abroad.

In contrast to the rather small amount of business-funded R&D in the public research sector, a relatively high share of government funding of R&D performed in the industry is evident (see Figure 19) and supports the evolving structure towards higher R&D intensity and a more internationally competitive industry.

Funding streams draw a picture of separated pillars – on the one side the public research sector and on the other side the industry sector, with smaller cross-funding.

Figure 19: Share of BERD (%) financed by the government (2000-2009)



Note: Interpolation of values for Austria for 2003 and 2005, for Poland 2008
Source: OECD, Main Science and Technology Indicators, February 2011; calculations Joanneum Research

3.3.2 Cooperation patterns of SIL

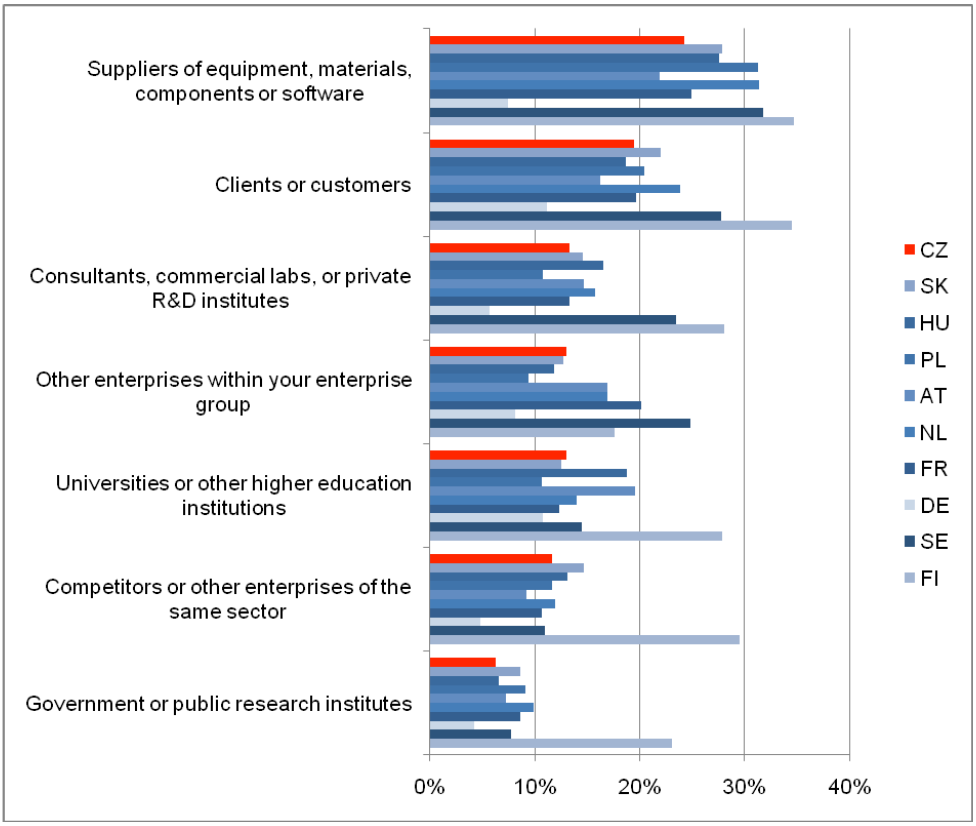
In order to analyse collaboration patterns in innovation activities, data from the Community Innovation Survey (CIS) 2008 were used, covering the period 2006-2008.[35]

The questionnaire survey revealed that companies carry out their innovation activities mostly in-house or in collaboration with other private companies. While approximately 80% of the companies carry out joint innovation activities with other private companies, only about 20% of them indicated knowledge co-operation with either university or research institutes (see Figure 20).

Overall, enterprises collaborate on innovation most frequently with suppliers (24%), followed by clients (20%), other enterprises within the group (14%) and consultants or commercial laboratories/private R&D institutes (14%). Universities (12%), competitors (12%) and public research organisations (8%) are less often named. With this ranking, the CR does not differ too much from other EU countries, but cooperation in general is significantly higher in other countries (e.g. in Scandinavia), and the CR belongs to the middle or low-end group regarding cooperation with public science players (see Figure 20).

35 These data are available in two different formats, firstly as aggregated statistics provided by Eurostat (for the 25 Member States and two associated countries), and secondly 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 their 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 between domestic and foreign enterprises, but do not provide detailed NACE categories (one digit level B – N only).

Figure 20: Share of innovative enterprises that have innovation cooperation with (domestic or foreign) partners (2006-2008) (selected countries)



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

Source: Eurostat [2010], CIS2008; calculations JOANNEUM RESEARCH

Broken down into industries, the highest shares of collaboration with universities or higher education institutions are in: transport equipment, electrical equipment, basic metals, architectural/engineering/testing and R&D, advertising and market research, and computer, electronic and optical products – pointing mainly to those industries which have adopted to the new specialisation pattern of the CR's industry.

Interestingly enough, old structures partly remain when institutes from the public research sector have their main collaboration partners in "private" research institutes – in the past having been the sectoral branch institutes building the bridge to industry. To some extent, this "old" pattern also appears when collaboration of innovative enterprises with universities is more frequent than with government or public research institutes. Those observations taken together would address questions concerning the current positioning in the value chain of innovation activities of the different players from the public research sector.

Table 3 shows two important features of SIL in the CR. Firstly, there is a clear size effect not only in SIL, but in innovation cooperation in general. Larger enterprises (>=250 employees) are more likely to be involved in innovation cooperation. This holds for all types of cooperation with partners. This would suggest that cooperation patterns may be largely dependent on the size pattern of industries, i.e. industries with a higher share of large enterprises are more prone to SIL.

Secondly, there are significant differences in patterns of cooperation between domestic and foreign enterprises in relation to the domestic R&D sector. Domestic innovative enterprises are much more often involved in collaborations with domestic R&D organisations. On the other hand, domestic and foreign enterprises collaborate to a very similar extent with value-chain partners (suppliers and buyers). This suggests that SIL is primarily a feature of domestic enterprises – as an important complementary source of knowledge for domestic enterprises in addition to value-chain links. According to these results, foreign enterprises are integrated to a much smaller extent into the domestic national innovation system.

Table 3: Share of innovative enterprises collaborating with the following partners (according to location and size)

Cooperation partner		size (employees)			
		9-49	50-249	>=250	Total
n		*675*	*941*	*737*	*2,353*
Any external partner	domestic & foreign	31.4	42.1	59.8	44.6
Public research infrastructure (universities or public research institutes)	domestic & foreign	14.4	18.9	33.0	22.0
	domestic	14.1	18.4	32.6	21.6
	foreign	1.5	3.0	4.6	3.1
Universities or other higher education institutions	domestic	13.3	16.8	30.9	20.2
	foreign	1.2	2.8	4.1	2.7
Government or public research institutes	domestic	6.8	8.6	12.6	9.4
	foreign	0.3	0.5	1.4	0.7
Suppliers of equipment, materials, components or software	domestic	20.0	26.0	37.9	28.0
	foreign	9.2	14.8	30.5	18.1
Clients or customers	domestic	17.5	17.4	27.5	20.6
	foreign	9.5	13.4	26.2	16.3
Competitors or other enterprises of the same sector	domestic	9.8	8.8	12.8	10.3
	foreign	4.2	6.5	12.9	7.8
Consultants, commercial laboratories or private R&D institutes	domestic	11.1	17.5	28.8	19.2
	foreign	2.2	4.9	9.5	5.6

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

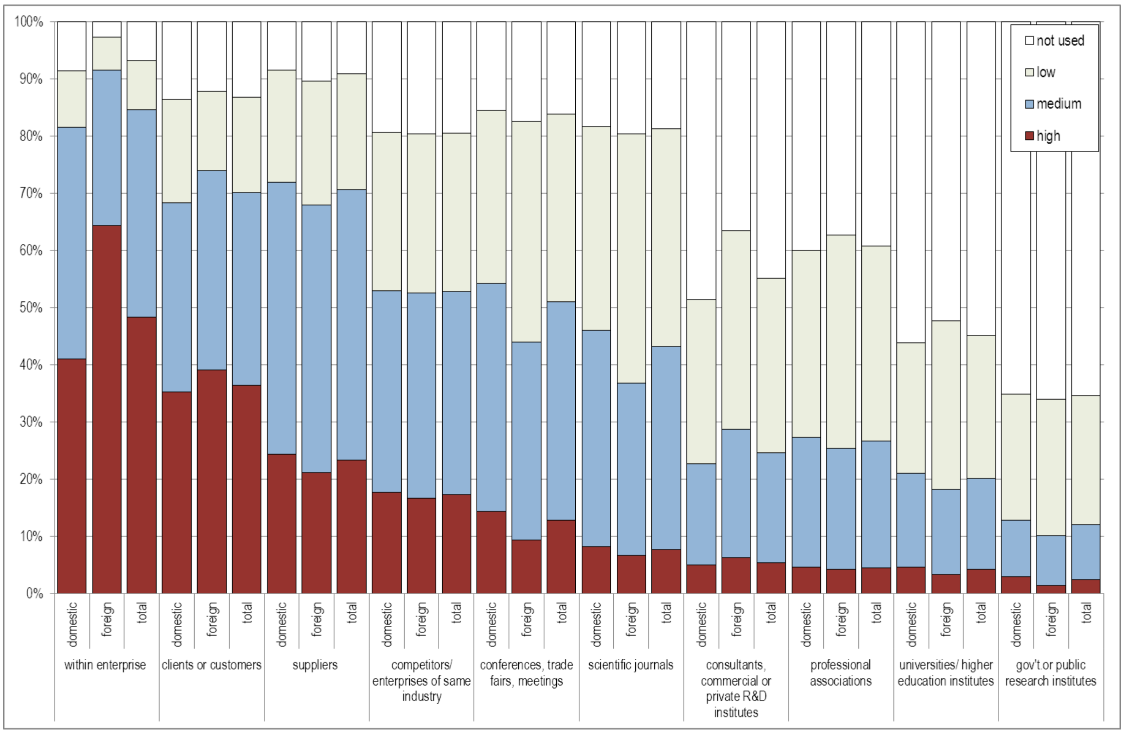
Source: CSU, CIS2008; calculations Joanneum Research

CIS data also show that the sector "professional, scientific and technical activities" (including the now privatised research organisations) seems highly networked, having highest shares with all kinds of players. While supplier relations are above average in "electricity, gas, steam" and "water supply, sewerage, waste management", client relations appear most important in services such as “information and communication” or “financial and insurance activities”.

These relations have their legitimisation to some extent in their information role. In Figure 21, different information sources are listed. While for most sources the differentiation between domestic or foreign is not really discriminating, in the case of information from “within enterprise”, the related parts abroad have a highlighted role.

Furthermore, the evidence gives information sources which could be characterised as “non-public science” a much higher weighting than the public R&D system. Here, questions about the transfer of R&D results to the business sector arise – and would suggest following argumentations such as (1) public R&D base organisations do not have such close interactions with the business sector or (2) innovation activities and competitiveness of the business sector is not so much based on R&D activities as on other influences.

Figure 21: Importance of different sources of information for innovation according to ownership



Source: CSU, CIS 2008; presentation Joanneum Research

Overall, the collaboration patterns underscore the less developed SIL, despite the fact that evolving industrial specialisation in the automotive and electrical industries are characterised by the highest shares of collaboration with the public research sector. The other important facts are an observable size effect (the larger the enterprise, the more likely science-industry cooperation is), a domestic effect (foreign ownership seems to reduce science-industry cooperation) and a structural effect (“old” structures of division of labour in R&D activities are still in place – with the exception of universities, which have developed their research activities). This produces a need for a closer look at the MNEs.

3.3.3 Multinational enterprises and SIL

Many formerly state-owned Czech enterprises are now controlled by multinational enterprises (MNEs). As these are also the largest companies, and size is an important determinant of SIL (see above), we consider it necessary to explore their influence.

According to the OECD (2010)[36], subsidiaries of multinational enterprises[37] accounted for 50% of production and 46% of value added in manufacturing in 2007 in the CR. With respect to R&D, MNEs are responsible for 55% of expenditure and 43% of researchers (2007). The most important sector is the manufacture of motor vehicles, which accounted for 38% of total R&D expenditures in manufacturing in 2007 (OECD ANBERD 2009). The share of MNEs in the national total in this sector is very high: 95% of R&D investment (2007). In machinery and equipment (15% of total R&D expenditure), the share of MNEs is 47%, while in chemicals (9%), it is 69% etc. These findings are supported by detailed firm-level R&D investment (Table 4) according to the EU Industrial R&D Investment Scoreboard (several years). This table shows that the major company R&D investors in the CR are foreign-owned companies.

Table 4: The largest R&D spenders in the CR 2005-2008

	Million Euro				
Company	2009	2008	2007	2006	2005
Skoda Auto AS **	...	203.4	205.3	170.8	186.4
Komercni banka	7.0	...	29.9	28.1	...
Zentiva (now part of Sanofi-Aventis)	...	22.8	20.5	...	...
Cez	20.6	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	...	...	0.01	...	...
Telefonica O2 CR **	...	...	...	0.6	...
Deza	...	...	...	0.4	...
Vitkovice Steel **	...	...	...	0.3	...
Oskar Cesky Mobile **	...	...	...	...	0.3
Cesky Telecom **	...	...	...	...	0.2
NKT Cables **	...	...	...	...	0.1

Note 1: This table also includes 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
Note 2: Cesky Telecom is by now merged with Telefonica O2
Source: EU Industrial R&D Investment Scoreboard 2006-2010.

MNEs (foreign-owned enterprises) have a strong role in the CR's system. Among the largest spenders of R&D in the CR, MNEs are very dominant (subsidiaries of foreign-owned firms are marked with two stars). The largest individual private R&D spender is Skoda (accounted for about 12 % BERD in 2008 and almost 75% of the automotive sector - with 203 Mill. EUR - in 2008), followed by Komercni banka - with 30 Mill. EUR in 2007 - and Zentiva - with 23 Mill EUR in 2008 (marked). Others not mentioned in the EU Scoreboard are Siemens with several R&D centres (energy engineering, IT, automation and controls, transport engineering, lighting, health care

36 Globalisation database, activity of multinationals, inward activity of multinationals (manufacturing)

37 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.

etc.), Honeywell with 3 research centres (automation and controls, security, aerospace), Robert Bosch (diesel engines), IBM with R&D centres (ICT), Continental (rubber and plastics), ON Semiconductor (electronics), Visteon (automotive) and TEVA (pharmaceuticals).

Applying a simple probit model, the likelihood of innovation cooperation of MNEs was estimated while controlling for firm size and sector[38] (sometimes also innovation expenditure and location), explaining types of cooperation.[39]

These calculations indicated some interesting features of MNEs concerning SIL:

- It appears that foreign ownership has a positive and significant effect on international cooperation and negative effects on domestic cooperation with universities and research organisations. MNEs are less likely to cooperate with domestic public research organisations.
- In addition, econometric evidence confirms the importance of size of enterprises for SIL. Enterprises with both a large number of employees and with large innovation expenditures are more likely to enter into SIL. Also, differences between industries and regions are important for SIL.
- Furthermore, calculations show that irrespective of geographical origin, MNEs are less likely to enter into collaborations with domestic research organisations and much more likely to do so with foreign organisations. However, subsidiaries whose parent companies are outside Europe have a significant negative bias towards any type of external innovation collaboration, although they are also more likely to cooperate with international partners.
- Finally, the influence of the level of R&D expenditures (represented by GERD) in the MNE's origin country is estimated. The assumption is that R&D intensity of the home country will affect the propensity of MNEs to enter into SIL in the CR. If an MNE originates from a high R&D-intensity country, it may be less inclined to enter into SIL when compared to MNEs from countries with low R&D intensities. A negative effect of foreign ownership is greater for MNEs from countries with higher GERD (above 2% of GDP) - and presumably good domestic R&D infrastructure. In short, results confirm our hypothesis that MNEs from countries with high R&D expenditures are less likely to enter into SIL than MNEs from countries with low R&D intensities.

From these calculations, the importance of MNEs' subsidiaries regarding SIL becomes evident. MNEs are less inclined to cooperate with domestic universities or research organisations, while MNEs from R&D-intensive countries are even less likely to enter into domestic SIL. If MNEs are locating R&D units in the CR, these activities consist more of the last stages of the internal R&D value chain – and hence needless input from the (excellent) public research sector (Berman Group 2010). On the other hand, MNEs are an important source for international cooperation. This would suggest that policy formation is not to be selective in terms of the geographical origin of MNEs, but instead to be more active in embedding MNEs in local R&D networks.

Even though the share of foreign enterprises collaborating with any domestic partner is higher than that for domestic enterprises, it is important to keep in mind that this is mainly due to firm size and sector affiliation. A simple probit model shows that

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

39 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)

everything else equal foreign ownership has a significant negative association with domestic innovation cooperation with any partner.

Moreover, it has been analysed as to how heavily the largest R&D spenders in the CR profit from the Operational Programme Enterprise and Innovation (detailed introduction in Section 4.3.1.). Table 5 shows the participation of 24 large R&D spenders, including foreign-owned subsidiaries in the CR, in the Operational Programme Enterprise and Innovation. According to data of the MIT in the Priority Axis *Development of Firms* in the programme "ICT Business and Support Services", only 7% of funding flowed to 24 large R&D spenders (2008-2011). In the Priority Axis *Innovation* in the programme "Innovation", 3% of funding was received by 24 large R&D spenders, and in the programme "Potential", 6% was sent to large firms. These shares are perceived as being rather low, which indicates that the programme beneficiaries are not necessarily the largest spenders.

Table 5 Participation of large R&D spenders in Operational Programme Enterprise and Innovation (calls: 2008-2011)

Priority Axis	**Development of Firms**	**Innovation**	
Programme	ICT and Business Support Services	Innovation	Potential
AERO Vodochody **	*	28,956,000	*
NKT Cables **	*	68,000,000	*
Skoda **	25,694,000	*	87,912,000
Siemens **	27,940,000	301,518,000	7,200,000
Honeywell **	52,634,000	24,328,000	114,749,000
IBM **	180,000,000	*	*
Continental Automotive Systems **	*	139,679,000	*
Total funding sum	4,030,157,000	12,235,778,000	3,476,386,000
	7%	3%	6%

Note 1: The following firms have not received any funding so far in the four programmes mentioned: Ceske drahy, Cesky Telecom **, Cez, Deza, Komercni banka, Oskar Cesky Mobile **, Paramo As **, Spolchemie (Spolek Pro Chemickou a hutni vyrobu), Telefonica O2 CR **, Trinecke Zelezarny, Unipetrol **, Vitkovice Steel **, Zentiva (now part of Sanofi-Aventis), Robert Bosch **, On Semiconductors **, Visteon **, TEVA **
Note 2: one star "*" indicates that no funding has been successfully applied for.
Note 3: this table also includes foreign subsidiaries (marked with two stars "**").
Source: MIT Databank

3.3.4 Summary of collaboration patterns

The analysis of collaboration patterns concerning innovation activities in the CR's innovation system produced the following characterisations:

- Funding flows between the public science sector and the business sector suggest a split system with two pillars. This is expressed through the public research sector, mainly publicly financed, and which cannot draw on much funding from industry. There is an important difference between higher education institutes (universities) and government sector organisations (e.g. ASCR), the later receiving a higher share of R&D financed by industry, but this also includes income generated from licences.
- Data from CIS indicate that only approximately 20% of innovative enterprises have cooperation with partners from the public research sector, while an overwhelming share of 80% find partners in the private sector. This supports the low interaction between science and industry, but also points to the important fact

that innovative activities are not only based on R&D. Taking the evolving industry structures into account, one acknowledges that science-based industries (e.g. pharmaceuticals – nowadays appearing in a developing biotech industry) have just a small role. Nevertheless, even when other important industries (e.g. automotive, electrical and optical equipment or rubber and plastics) are, to some extent, basing their knowledge on interactions with other players from the value chain, they are also representing the highest shares of enterprises collaborating with the public research sector.

- Another important characteristic is a size effect – pointing to the fact that larger enterprises are more likely to perform SIL.
- Finally, mention must be made of the important aspect of MNEs. From analysis, they appear to be least connected with the public research sector. Considering the large proportion of foreign-owned enterprises in core sectors (e.g. automotive), this fact is alarming.

3.4 Regional aspects of science-industry interactions

Before looking for some indications of SIL related to regions, a short characterisation is will be provided.[40] Firstly, the share of innovative enterprises expresses the "general attitude" towards innovation – or the predominant competitiveness orientation. Secondly, the shares of enterprises with in-house R&D points to the relevance of companies' own R&D capabilities in innovation activities (e.g. due to tacit elements in knowledge production for innovations or strategic decisions). Thirdly, the shares of enterprises in manufacturing show to what extent the region contains elements of the more "typical" business R&D spender (according to data presented in Chapter 3.1). Fourthly, the share of foreign enterprises is also interesting in this respect, as a lot of industries have high shares of FDI, and the share of enterprises with new-to-market product innovation allows one to draw conclusions concerning the orientation towards innovation competition. In Table 6, above average values are indicated for several regions. Interestingly enough, Prague shows its specific situation, with a high share of enterprises innovating and having in-house R&D, but with a smaller share of companies from manufacturing, and only about average new-to-market product innovations. This just expresses the fact that Prague gained most from FDI in services and is the administrative and service centre (high share of foreign enterprises) of the CR. Nevertheless, we must keep in mind that the largest part of the public science sector is located in Prague – and in Brno.

40 A development towards a more important role for regional innovation policy is analysed by Bla□ek and Uhlí□ 2007 (Regional Innovation Policies in the Czech Republic and the Case of Prague: An Emerging Role of a Regional Level?). Studies of the innovation potential of regions include Pokorný et al 2008.

Table 6: Characterisation of NUTS4 regions

NUTS 4	Share of enterprises with technological innovation[1] (in % of all enterprises)		Share of enterprises with in-house R&D (in % of all innovative enterprises)		Share of enterprises with new-to-market product innovations (in % of all enterprises with product innovations)		Share of enterprises in manufacturing (in % of all enterprises)		Share of foreign enterprises (in % of all enterprises)	
	%	n (all enter-prises)	%	n (innov ative enter-prises)	%	n (enterpris es with product innov.)	%	n (all enterp rises)	%	n (all enter-prises)
Hlavní město Praha	40.3	1,498	63.9	604	62.4	433	20.0	1,498	34.6	1,498
Středo český kraj	34.8	707	54.9	246	62.7	161	43.7	707	21.1	707
Jihoče ský kraj	35.5	358	55.1	127	62.7	83	49.4	358	20.4	358
Plzeňs ký kraj	37.0	359	51.1	133	67.4	89	47.9	359	25.1	359
Karlov arský kraj	30.9	194	38.3	60	54.8	31	52.1	194	16.5	194
Ústeck ý kraj	33.9	436	54.7	148	70.2	104	46.3	436	19.3	436
Libere cký kraj	34.2	228	55.1	78	65.5	55	50.0	228	20.6	228
Králov éhrade cký kraj	39.4	284	52.7	112	62.8	78	50.0	284	15.8	284
Pardu bický kraj	42.0	293	62.6	123	71.1	83	51.2	293	16.4	293
Vysoči na	37.2	242	61.1	90	67.2	67	60.3	242	12.8	242
Jihom oravsk ý kraj	41.3	705	58.8	291	66.3	190	38.9	705	19.1	705
Olomo ucký kraj	38.4	352	55.6	135	51.6	95	46.6	352	14.2	352
Zlínsk ý kraj	36.4	434	62.0	158	70.5	112	49.1	434	9.4	434
Morav skosle zský kraj	36.6	692	60.5	253	60.5	177	43.6	692	12.6	692
Total	**37.7**	**6,782**	**58.4**	**2,558**	**63.9**	**1,758**	**40.8**	**6,782**	**21.1**	**6,782**

Note: grey cells indicate a value above the column average; [1] product, process, ongoing or abandoned innovations

Source: CSU, CIS 2008; calculations Joanneum Research

The regions are also characterised by differences in their patterns of collaborations with the different players. Comparing the regions, collaborations with the public research base (i.e. universities or research institutes) is surprisingly below average in Prague (see Table 7). Based on interviews, the "other side" (public sector base) mentions an outward orientation, as they see collaboration partners as mostly from industry outside the CR.

A few regions (e.g. Středočeský kraj, Jihočeský kraj, Karlovarský kraj and Ústecký kraj) have general low interaction patterns between (possible) innovation partners, which are supported by indications in Table 7 showing low shares of technological innovations and in-house R&D.

Some other regions seem to consist of relatively more collaborative innovative enterprises (e.g. Pardubický kraj, Vysočina, Jihomoravský kraj, Olomoucký kraj and Zlínský kraj).

Table 7: Share of innovative enterprises which collaborate with the following domestic partners on innovation (according to partner category and NUTS4 location of the firm)

NUTS4	domestic partners								*n*
	any	public research base[1]	university	research institute	supplier	client	competitor	consultant	
Hlavní město Praha	41.6	19.0	16.6	9.8	30.0	22.5	11.6	19.4	*604*
Středočeský kraj	39.4	18.3	17.1	6.5	25.6	17.1	7.3	18.3	*246*
Jihočeský kraj	32.3	14.2	14.2	7.1	18.9	15.0	7.9	17.3	*127*
Plzeňský kraj	36.1	23.3	21.8	12.0	21.8	20.3	10.5	18.8	*133*
Karlovarský kraj	28.3	8.3	8.3	3.3	20.0	6.7	1.7	13.3	*60*
Ústecký kraj	35.8	16.9	15.5	8.8	24.3	13.5	6.8	16.2	*148*
Liberecký kraj	41.0	21.8	20.5	6.4	23.1	21.8	3.8	19.2	*78*
Královéhradecký kraj	38.4	17.9	17.9	5.4	27.7	21.4	9.8	16.1	*112*
Pardubický kraj	48.0	27.6	27.6	8.9	31.7	24.4	12.2	19.5	*123*
Vysočina	42.2	23.3	22.2	14.4	34.4	20.0	16.7	22.2	*90*
Jihomoravský kraj	45.4	28.2	27.8	12.0	28.9	21.3	12.7	20.3	*291*
Olomoucký kraj	41.5	23.7	21.5	9.6	27.4	18.5	10.4	23.0	*135*
Zlínský kraj	46.8	27.8	26.6	10.1	32.9	28.5	12.0	22.2	*158*
Moravskoslezský kraj	41.1	19.4	17.8	7.5	27.3	20.9	8.7	17.8	*253*
Total	**40.9**	**21.0**	**19.7**	**9.1**	**27.6**	**20.4**	**10.1**	**19.1**	***2,558***

Note: grey cells indicate a value above the column average; [1]university or research institute
Source: CSU, CIS 2008; calculations Joanneum Research

In addition to the share of innovative enterprises that collaborated with the different partners, the CIS also asked enterprises about the most important cooperation partner. Overall, suppliers and clients as well as enterprises within the group are dominant. Having said this, in some regions universities are highly ranked, for example in Liberecký kraj (22% of all responding enterprises name it the most important partner category) or Jihomoravský kraj (17%), even though the number of cases is rather low in some regions.

Summing up these observations, clear evidence appears for Prague and Brno as centres of innovative enterprises, with higher shares of foreign enterprises indicated for Prague (mainly due to services sectors). Interestingly, both indicate the lowest shares of enterprises in manufacturing.

3.5 Résumé – the 'observable' pattern?

The descriptions and analysis in the chapters above have come up with an overall pattern of SIL:

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

- Analysis of industry revealed the "manufacture of motor vehicles, trailers and semi-trailers" to be the most important industry, being amongst the highest contributors to income and R&D. This industry confers with the other industries gaining shares in the specialisation pattern of the CR (electrical equipment industry and rubber and plastics industry). An important characteristic of these industries is the high share of FDI. This refers to R&D&I activities that mainly take place outside the CR. In that case, the R&D activities performed in the CR are in most cases at the last stages of internal R&D value chains – a fact that hampers SIL with the public research sector. These industries suffered less from global crises (according to production data from CZSO), but on the other hand, there are also few firms within this industry group which have global R&D centres located in the CR (also in case of foreign subsidiaries). Even so, they sometimes do not find adequate quality and availability of researchers in the CR to cooperate with. They use the links to foreign universities and R&D centres available through the MNEs' headquarters.
- Representing the traditional specialisations of the CR, important industries such as the "manufacture of machinery and equipment" and "manufacture of chemicals and chemical products"[41] are important contributors to R&D (and income in the case of machinery and equipment). They are well established, representing the highest numbers of enterprises, but having just moderate growth rates in BERD. Their innovation activities are not always based on science (with exceptions in pharmaceuticals and chemicals) but on the path-dependent accumulated knowledge, their engineering tradition and education as well established complementary elements (which have formed the comparative advantages of the CR's innovation system) – nevertheless not fully exploiting the SIL potential.
- Another interesting industry is office machinery and computers, contributing with only a small share to value added and BERD, but having high rates of BERD growth. This industry developed from a traditionally highly innovative electronic sector, based on engineering, education and research. According to Czech Invest (2009a, 2009b), the industry gained momentum in the 1990s when FDI in the automotive industry was accompanied by suppliers of auto-electronics and the need to upgrade production towards higher productivities (i.e. automisation).
- According to RCA in trade, office machinery, electrical machinery and motor vehicles show the highest competitiveness. This means that industries which include the largest shares of foreign-owned companies build the internationally most competitive segment. Interestingly enough, R&D figures show that these

[41] Which include pharmaceuticals

industries are also becoming more R&D-intensive, and hence hold increasing potential for collaborations between the science sector and industry.

(2) Public science sector patterns as a background for potential SIL:

Analysis of the public research sector developments shows that

- The structure of players underwent substantial changes, including the implementation of research activities at universities (which had just had an education function before – and this research role is largely growing) and tremendous changes in the landscape of former (sectoral) research organisations (with most privatised and developing towards other activities), with the only relatively stable organisation being the ASCR;
- There is also a massive concentration of institutes from the public research sector in Prague – including largest (and best ranked) universities (Charles University Prague, Czech Technical University Prague and also the Institute of Physics of the ASCR) and another centre in (around) Brno;
- Numbers of graduates are growing rapidly, but engineering and natural sciences are not the fastest growing educational fields – similar to many European countries. It is becoming even more evident that a previously large share of engineers and natural scientists is now characterised by an ageing phenomenon and, as a consequence, may dry up an important channel for innovation activities and SIL;
- From bibliometric analyses, it appears that the output of Czech researchers has increased and evolved towards excellence criteria, accompanied by intensified international and national cooperation in research.[42] This development has generated very internationally visible institutes, also creating pre-conditions for establishing knowledge-intensive enterprises. Nevertheless, information gathered from interviews state that cooperation and knowledge transfer with domestic enterprises or spin-offs[43] are rarely implemented.

(3) Cooperation patterns:

The analysis of collaboration patterns concerning innovation activities in the CR's innovation system produced the following characterisations:

- Funding flows between the public science sector and the business sector suggest a split system with two pillars. This is expressed through the public research sector, mainly publicly financed, and which cannot draw on much funding from industry There is an important difference between higher education institutes (universities) and government sector organisations (e.g. ASCR), the latter receiving a higher share of R&D financed by industry.
- Data from CIS indicate that only approximately 20% of innovative enterprises have cooperation with partners from the public research sector, while an overwhelming share of 80% find partners in the private sector. This supports the low interaction between science and industry, but also points to the important fact that innovative activities are not only based on R&D. Taking the evolving industry structures into account, one acknowledges that science-based industries (e.g. pharmaceuticals – nowadays appearing in a developing biotech industry) have just a small role. Nevertheless, even when other important industries (e.g. automotive, electrical and optical equipment or rubber and plastics) are, to some extent, basing their knowledge on interactions with other players from the value chain, they are also representing the highest shares of enterprises collaborating with the public research sector.

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42 See also work packages about international cooperation.

43 Only a few university spin-offs are observable – e.g. from the Czech Technical University in Prague according to information from interviews.

- Another important characteristic is a size effect – pointing to the fact that larger enterprises are more likely to perform SIL. Finally, mention must be made of the important aspect of MNEs. From analysis, they appear to be least connected with the public research sector. Considering the large proportion of foreign-owned enterprises in core sectors (e.g. automotive), this fact is alarming.

(4) Regional patterns:

- Summing up these observations, clear evidence appears for Prague and Brno as centres of innovative enterprises, with higher shares of foreign enterprises indicated for Prague (mainly due to services sectors). Interestingly, both indicate the lowest shares of enterprises in the manufacturing sector.

4. Policy-related framework conditions

This chapter deals with the policy-related framework conditions of SIL in the CR's R&D&I system. They foster and stimulate SIL. Important components include the legislation and regulations, but also the overall settings concerning governance structures and public measures.

4.1 The framework for science-industry linkages

The most important legal document of the last 5 years, the National Innovation Policy of the CR for 2005-2010, has now been replaced by the National R&D&I policy 2009-2015. Nine (broad) main objectives are guiding policy – with SIL related to one goal:

Utilize the R&D results in innovation processes and enhance the co-operation of the public and private sector in R&D&I

But establishing and intensifying links between the public research sector and the business sector for gaining value added from technology and knowledge transfer is a multifaceted endeavour. SIL depends on opportunities, characterised by satisfactory personnel and infrastructural conditions, as well as the absorptive capacities in the business sector. Legislation and regulation with an impact on the different channels of SIL (e.g. human resources, R&D collaborations etc.) may work in hampering or supportive ways – which, as a consequence, would mean that a broad sample of policy fields has to be taken into account. We focus here only on selected important elements such as human capital and funding – as derived from literature and interviews.[44]

We see human resources[45] as being the most important element for the following reasons:

- If the CR is aiming for a knowledge-based and innovation-driven economy (TrendChart 2009), SIL becomes a core feature – with competent and qualified human resources as its fundamental element.
- Furthermore, the CR has already started to use EU structural funds for implementing and installing new research infrastructure, consequently creating a demand for qualified staff in this realm.

Satisfactory personnel structures means having qualified and trained researchers able to cope with the needs of more applied research activities and the project management included. Furthermore, the incentive structures of their career and affiliations must work supportively.

To some extent, the conditions for researchers are not seen as being appropriate (ERAWATCH 2010). Career requirements include quite long and intensive paths, with

44 Analyses of governance mechanisms and IPR rules are conducted in other work packages.

45 A much more in-depth analysis of human resources is conducted in another work package.

quite high teaching loads or other coursework in doctoral training. Furthermore, there is no coherent policy supporting the cooperation between science and industry in this respect, hence reducing opportunities for researchers. Consequentially, this causes brain-drain and a partly low stock of research capacity. It is argued that there is a low share of labour costs in R&D expenditures, which corresponds with low salaries of researchers – amounting to a level of 30% of the EU 15 countries. As a consequence, scientific work lacks social prestige, causing brain-drain. This enhances the issue of the low number of researchers (ERAWATCH 2010).

Results from the analysis of human resources[46] support this view and show that there are only a few programmes in place to support SIL with the potential of spill-overs for human resources (e.g. additional qualifications such as operational skills, advanced manufacturing and technician skills necessary for high-level, value-added activities in emerging sectors or project management for innovation and R&D for new products, process and technique development). It also reduces opportunities for the evolving of start-up activities, as the necessary skills as well as relations and experience with industry are missing.

This is rightly approached by the R&D policy agenda – but not properly implemented:

"To embed systemic instruments that support the interconnection of institutions pursuing R&D&I and higher education institutions into an overall system of financing R&D&I in the CR, either at the level of international excellence or in direct commercial innovations." (White Paper on Tertiary Education 2009)

Another important element is funding conditions. As decisions for R&D&I activities include many risks, they are heavily dependent on easily accessible funds[47] – either public or private. The CR managed impressive growth of business expenditures in R&D (reaching a share of about 55% GERD in 2009) – a development which was supported by fiscal policy. Support from public measures had a positive effect, expressed by the relatively high share of public funding towards the business enterprise sector. This public funding is largely attributed to the private R&D service sector, consisting to a large extent of former sectoral branch institutes (see Section 3.2). On the other hand, the relatively high institutional funding[48] is not geared towards SIL (e.g. there are no SIL-based indicators for universities or the ASCR for the distribution of institutional funding).[49]

Tax deductibles represent indirect measures of fiscal policy. According to the Law No. 669/2004 on tax incomes in the CR, 100% of the R&D outcomes can be deducted from the tax base. Donations to cover expenses for education and R&D can be deducted from the tax base as well. Donations can reach a maximum of 5 % of the tax base. Overall, this represents quite a generous solution in international comparison (OECD 2010) and provides limited steering effects. Right now, amendments to the Act on Income Tax are in preparation for the Ministry of Finance. The amendments foresee an extension of the existing support for in-house R&D, adding tax deductibles on the R&D purchased from universities and other public research organisations. In the currently pending amendment to the Act on Income Tax (not yet approved), the following adjustments are proposed: (1) Expenditures (costs) on R&D eligible for deduction from the tax base should be extended from the following services purchased from public universities or academies to activities that are included among the eligible costs (i.e. the experimental and theoretical work, design and construction work, calculations, design technology, manufacturing a functional prototype or sample product or the certification of the results achieved through R&D projects). So far, income tax has not been deductible for services purchased from private research

46 See work package on human resources.

47 The analysis of funding structures is conducted in another WPa

48 See work package about funding structures.

49 See work packages about governance.

organisations. This point is the main topic of the discussion within the research community. (2) The deduction rate for expenditures on R&D projects should be extended. It is proposed to increase the deduction rate to 110% for R&D expenditures that exceed the total expenditures on R&D carried out in the previous period. We believe this is a good step forward, but we could imagine starting a discussion on whether to include tax incentives for joint projects, PhD funding, employees with joint positions etc.

Important elements for structural developments are new high-tech companies. External financial sources (i.e. risk capital) are a major ingredient. In this typical field for venture capital, conditions in the CR are unsatisfactory. Although venture capital funds (Czech private equity and venture capital association) exist, the use of R&D funded by venture capital is still at a very low level in the CR. The causes can be seen both in legislation and tax laws (existence of multiple taxation and strict regulation of investment of pension funds and insurance companies) as well as in demand for this type of financing (business fear of losing independence). There are no fiscal incentives for venture capital investors in the CR either (ERAWATCH 2010).

It is foreseen that by the end of 2011, the R&D Council (Action no. A 4-8) should assess the legal, financial and other options for the establishment of venture capital with the participation of private and public funds. Meanwhile, the MIT is working on the seed fund initiative. It is obvious that the MIT (together with CzechInvest and the Czech Moravian Guarantee and Development Bank), while preparing such a scheme, has to assess the legal, financial and other conditions for the establishment of a VC fund with public and private sources.

Consequently, we see constricting influences on SIL from a less attractive public research sector environment for researchers and a lack of incentives in institutional funding.

Furthermore, a working team is on the way to formulating the National Priorities of Oriented Research. They primarily identify research goals, which are to be achieved by 2030. To our knowledge, the priorities are going to be of a thematic rather than a functional nature, although the appropriate background documents prepared for the priority setting project strongly emphasise the research and application potential of the CR as well as current and potential linkages between public research and industry. SIL have the potential to become a priority in the CR. The process itself creates space for intensive discussion on establishing linkages between science and industry, since representatives of both the public research sector as well as of business and industry generally will be present in the expert panels.

4.2 Public (national) programmes aiming at fostering science-industry linkages

It must be stated first of all that public programmes to support SIL are rare, even though the new National Policy of Research, Development and Innovation in the CR for 2009-2015 emphasises collaborative research. For further investigations, we distinguish between national and EU structural fund sources – the former mostly oriented towards project funding, while the latter supports infrastructures and includes regional bias (excluding Prague from application). European Structural Funds measures are implemented by Operational Programmes, including measures to set up infrastructure for R&D&I – which should support SIL as a prerequisite.

4.2.1 Programmes being phased out

Only a few measures have been oriented towards science-industry cooperation. When studying the programmes, we must mention that labour costs are not included in many programmes. Salaries of researchers are assumed to be paid from other sources. Only recently has this issue been addressed. Therefore, the funding increases drastically in some programmes over time.

Amongst SIL-related programmes, the following are being administered by the Ministry of Industry and Trade (MIT):

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

Table 8: 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), another programme to support SIL in a more indirect way, also finished in 2010, but there will be a continuation of the programme's idea in the TIP programme. This programme was focusing on the support of SMEs in order to increase their productivity and competitiveness through 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 businesses themselves and do not have to integrate public research players into collaboration.

Table 9: 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)

Programmes administered by MEYS

(1) Research Centres 1M (2005-2011) support effective collaboration between R&D institutions and users of their R&D results. It also aimed to develop human resources and the creation of collectives capable of supporting collaboration between the academic and application spheres.

The programme aimed for the concentration of research capacities into centres which should ensure an effective transfer of R&D results produced in particular research stages to institutions being able to utilise them. The programme had two specific priorities:

- To ensure effective collaboration between R&D institutions and users of their R&D results;
- 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.

4.2.2 Planned and newly implemented programmes

Currently, a replacement of programmes supporting SIL is taking place. Amongst current programmes, the following can be mentioned when looking for SIL support:

(1) The current programme TIP is foreseen for the period 2009-2017. This programme replaces the former TANDEM and IMPULS programmes. The programme aims to promote R&D projects carried out in phases prior to the entering of the new product (new materials and products, new advanced technologies, new information & controlling systems) into the market, which does not have to include SIL. Each project must 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 as to the constitution of the project teams (e.g. collaboration industry-research) nor to 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 from their own private funds or other private funds. TIP has no specific focus on SIL, but delivers indirect support.

(2) Moreover, the newly installed Technology Agency CR is responsible for several new programmes, which are (partly) addressing SIL:

- ALFA programme

The Alfa Programme is running from 2011 to 2016 and was the first programme created and implemented by the Technology Agency. This programme is supporting projects of applied research and experimental development similar to the TIP programme. Collaborative research is amongst the main objectives of the programme. It therefore demands that at least 10% of project costs be at the participating research organisations. The science-industry cooperation is supported rather indirectly through evaluation criteria of projects. Intensity of effective cooperation between science and industry is one of the evaluation criteria.[50]

- Centres of Competence

Most recently, a new programme (the programme „Centra kompetence“ – Centres of Competence) of the Technology Agency aiming at strengthening SIL (2012-2019) was approved by the government, and calls are expected by late spring. Two-stage calls of this programme will be launched in 2011 (spring), 2013 and 2015.

[50] See Technology Agency (http://www.tacr.cz/programmes-of-ta-cr/)

The programme focuses on supporting the establishment and operation of centres of research, development and innovation in advanced industries with high application potential and prospects for a substantial contribution to increasing the competitiveness of the CR

Objectives:

- strengthening the long term cooperation between public research organisations and the private sector
- creating strategic partnerships between public research and industry in order to transform R&D results into innovation successfully
- strengthening the interdisciplinary R&D activities
- creating conditions for human resources development (focus on young researchers) and mobility of researchers between public research and industry

It is estimated that there will be support for around 30 centres containing at least 3 enterprises and one public research organisation. The programme is approved for the period from 2012 to 2019. The total budget amounts to 6 billion CZK for the whole period.

The consortium has to ensure 30% co-financing from private resources. Aid intensities will be calculated for single participants in the consortium based on state aid rules (Community Framework).

This programme may also be seen as a successor of the Research Centres 1M programme.

Table 10: Comparison Research Centres 1M and Centres of Competence

	Research Centres 1M	**Centres of Competence**
Applicants	Consortia (no limits)	Consortia (at least 1 public research organisation and 3 independent enterprises) or Companies established by at least 1 public research organisation and 3 independent enterprises)
Funding rate	up to 90 %	up to 70 %
Expected results	applied results, although publications are also accepted	at least one applied result
Selection criteria	past research results of applicants were stressed (weight 25 %)	emphasis on strategic research agenda (research plan), organisation structure of the proposed centre and potential for successful implementation (commercialisation) of research results
Evaluation	no explicit framework for mid-term and ex-post evaluation in the programme	emphasis placed on mid-term evaluation (after 4 years), ex post evaluation and evaluation of impact of particular projects (centres) 3 years after the projects finish
Collaboration	no explicit privilege	effective collaboration according to the framework is privileged by a higher funding rate (up to 70 %)

Source: provided by TC ASCR

This overview of programmes supportive for SIL clearly indicates the limited considerations. Contrary to the new strategy, the TIP programme does not require science-industry collaborations – as opposed to the former TANDEM and IMPULS programmes. Also, in the ALFA programme, science-industry cooperation does cause additional points in the evaluation and selection process of projects, but is not mandatory.[51]

The real exception will be the new competence centres[52] programme managed by Technology Agency, which foresees mandatory SIL. Even though SIL is targeted in the new national policy, we have not seen many supportive measures on the national level.[53]

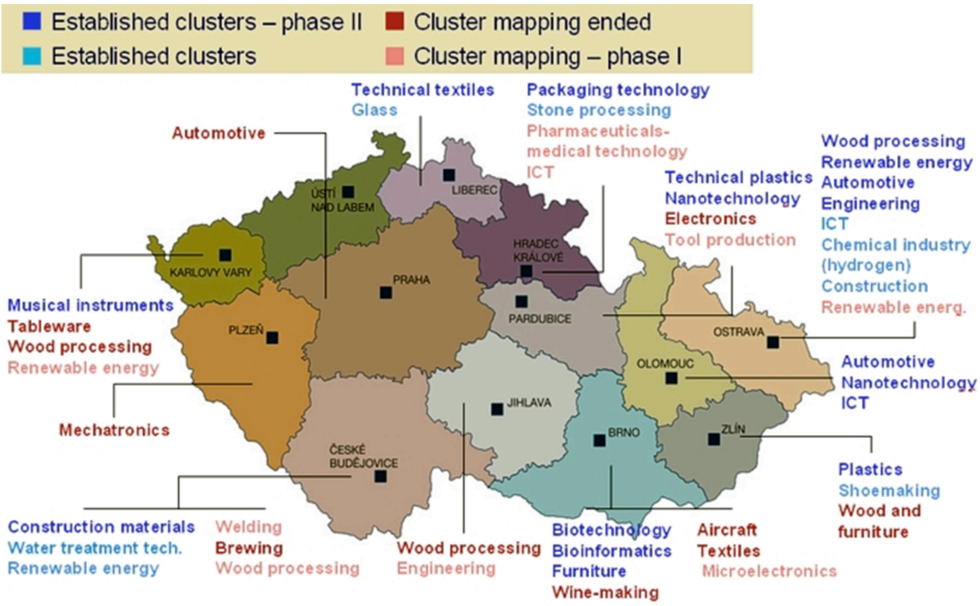
4.3 Public (SF-based) stimulations through implemented intermediary structures

4.3.1 Operational programmes for the installation of intermediary structures

The EU structural funds Operational Programme Enterprise and Innovation (OPEI) and Operational Programme Research and Development for Innovations (OPRDI) provide support for SIL-related activities. The first includes programmes aiming for SIL, while the second contains funding for the installation of large R&D infrastructures:

(1) Firstly, the programme Cooperation (190 Mio Euro) of OPEI supports the set-up and development of regional, national as well as international collaborative groups — clusters, technology platforms and other cooperation projects. This programme substantially enhances the support of the previous programme, Klastry.[54]

Figure 22: Clusters



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51 However, more than 90% of projects funded have SIL according to information from interviews.

52 This programme is aimed at financing projects – which means a differentiation from centres financed by operational programmes. These finance set-up costs only to a very limited extent (200,000Euro) (including types of personal costs), while emphasis is placed on infrastructural investments.

53 Perhaps foreseen measures such as innovation vouchers will work supportively – especially for SMEs.

54 See: http://www.czechinvest.org/data/files/cooperation-406.pdf

Source: provided by TC ASCR

During the last decade, clusters have been high on the agenda. Clusters are seen as a development of cooperative groupings consisting of associating enterprises in a given field, regional authorities, universities, research and other institutions in the region. Typically, a cluster builds a formalised legal entity from a minimum of 15 members (including a research institute – either from a university or other) to cooperate in joint projects. These clusters are managed by teams of up to 5 persons.

Performed evaluations[55] state limited performance in terms of transfer of technologies, but show an increase in cooperation between universities and companies. Nevertheless, there are huge differences between regions and industries.

The other instrument applied from the OPEI cooperation programme is technology platforms (with approximately 8.2 Mio Euro spent). They are intended to develop sector groupings by associating key decision-makers in the branch at the national level in order to develop research agendas. So far, 19 projects have been selected (with a budget from OPEI of about 190,000 Euro on average). As they are still in their first three-year project cycle, impacts are not known, but it can be observed that their emphasis on science-industry networking has resulted in several research agendas.

(2) The programme Prosperity (429 Mio Euro) of OPEI offers support for developing science and technology parks and technology transfer centres.

Science and technology parks are installed to provide infrastructure for innovative SMEs. Table 11 gives an impression of the regional distribution. This evidence shows that the infrastructure has expanded – and finds, again, centring on Prague and Brno. Overall, 60 institutions (innovation infrastructure= have been established in the CR. Among them are science and technology parks, knowledge transfer centres, business incubators and technology centres. 4796 jobs have been created in the firms using the innovation infrastructure.

55 See TC ASCR, 2008 and Berman Group, 2009

Table 11: Innovation infrastructure (abbrev. II) in the Czech regions

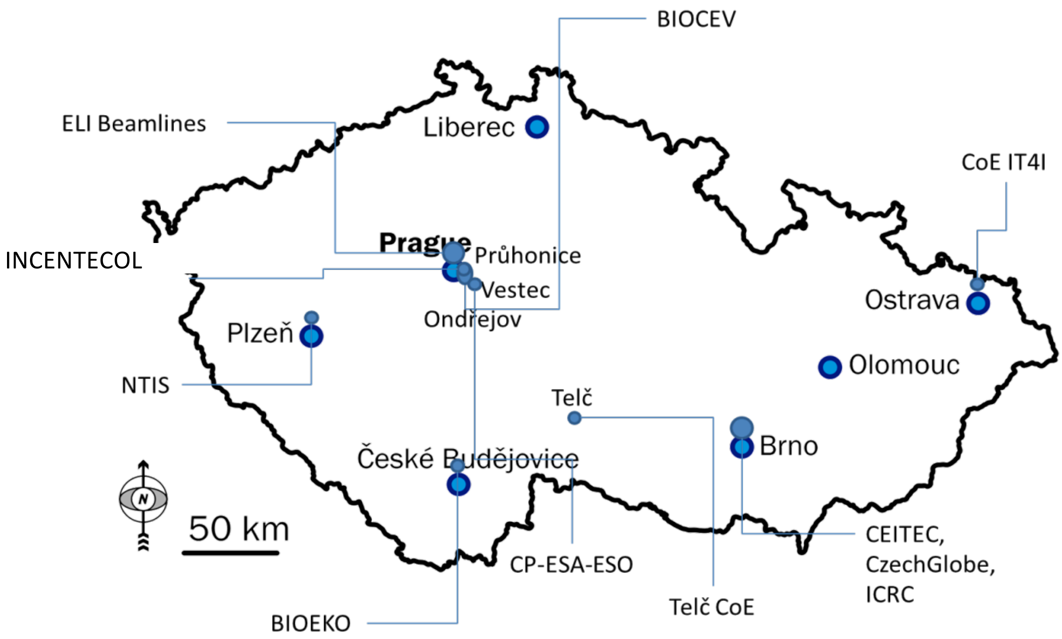
Region	Number of II	Number of II per 100,000 residents	Number of science and technology parks	Number of knowledge transfer centres	Number of business incubators	Number of technology centres	Area			Number of organisations (business, research institutions)	Staff working in firms based in II	
							m2	%	Per 100,000 residents		Number	%
Praha	6	0,48	1		5	3	34,908	21,20	2795	154	623	13.00
Stredocesky	11	0,88	6		4	3	38,107	23,20	3055	33	254	5.30
Jihocesky	6	0,94	4		1	1	5,787	3,50	908	27	152	3.20
Plzensky	2	0,35	2		1	1	6,760	4,10	1182	35	71	1.50
Karlovarsky	1	0,33				1	2,811	1,70	914	11	30	0.60
Ustecky	2	0,24			1	1	6,817	4,10	815	21	192	4.00
Liberecky	1	0,23	1				600	0,40	137	3	16	0.30
Kralovehradecky	2	0,36		1		1	4,150	2,50	749	28	163	3.40
Pardubicky	1	0,19				1	10,634	6,50	2060	0	0	0.00
Vysocina	2	0,39	1		1		4,256	2,60	826	42	172	3.60
Jihomoravsky	6	0,52	1	1	6	1	7,391	4,50	642	162	1 609	33.50
Olomoucky	5	0,78	2	1	4		6,930	4,20	1079	35	273	5.70
Zlínsky	7	1,18	3	2	5	1	11,346	6,90	1920	59	115	2.40
Moravskoslezsky	8	0,64	3	2	5	1	24,049	14,60	1928	101	1 126	23.50
Total	**60**	**0,57**	**24**	**7**	**33**	**15**	**164,546**	**100**	**1566**	**711**	**4796**	**100**

Note: Data on size, number of organisations and staff include approximately 75% of subjects and include 8 upcoming STP/CTT/BI/TC. Red markings indicate the values below the national level average.

Source: Science and Technology Parks CR (in Czech), own investigations.

(3) The programme of "European centres of Excellence" (685,4 Mio Euro) of OPRDI managed by MEYS is among the largest, aiming for unique, high-quality R&D infrastructure. In the first and only call for Centres of Excellence, 15 applications were submitted. After a first round of evaluation, 11 centres passed the application panel. After a second round of review by an international panel, 8 centres were finally recommended. In Figure 23, the Centres of Excellence after the first round of review by the application panel are indicated. After the second round, 3 centres were rejected by the international panel (CP-ESA-ESO, INCENTECOL, BIOEKO). The 8 successful centres are distributed evenly, but with a bias towards Brno with 3 locations. It will be interesting to see to what extent these excellence centres can contribute to a more intensified SIL. Internationally well known research institutes already exist which are now becoming involved in these centres. Consequently, the currently biased orientation (towards international, high-impact research collaboration) may not change towards higher degrees of domestic/local interactions with industries, but it may at least result in well trained researchers. The entire programme is described in detail in Final Report on Public R&D Expenditure in Section 5.4.2.

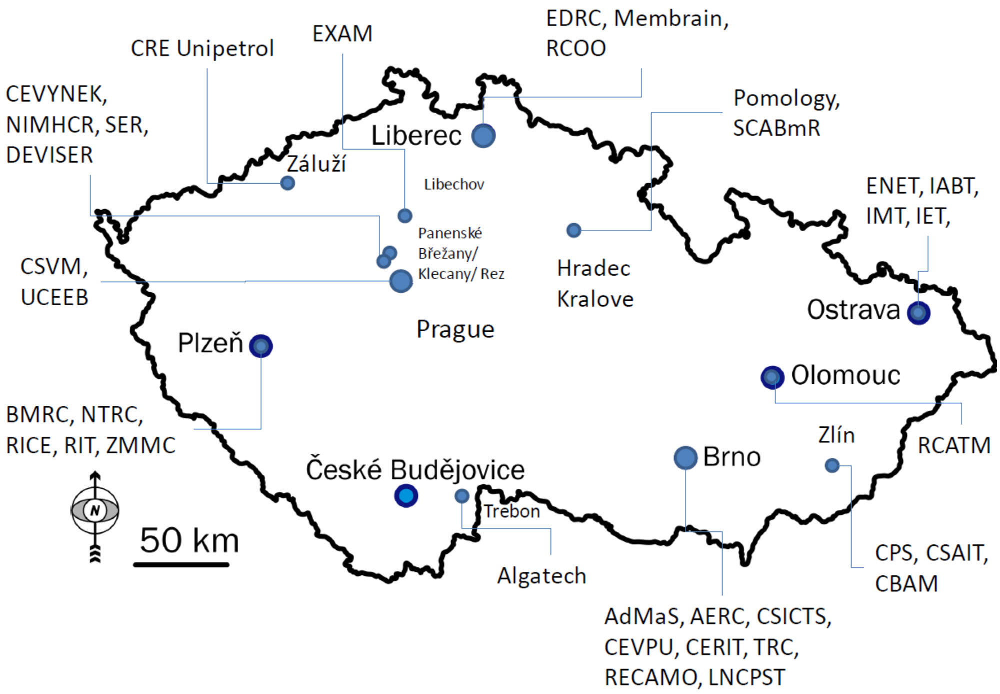
Figure 23: Eleven Centres of Excellence recommended after the first round of review by an application panel



Source: www.msmt.cz/strukturalni-fondy/seznam-projektu-postupujicich-do-mezinarodniho-hodnoceni, calculated by CHEPS.

(4) The programme "Regional R&D Centres" (685,4 Mio Euro) of OPRDI will become the other influential source for changes in R&D infrastructure. Regional R&D centres are intended to support knowledge transfer and knowledge generation specific to the region. After the first call, 52 applications were submitted. A first round of review recommended the establishment of 36 regional R&D centres (see Figure 24). A second round of international review finally selected 22 R&D centres to receive support.

Figure 24: Regional R&D centres recommended after the first round of review by an application panel



Source: www.msmt.cz/strukturalni-fondy/seznam-projektu-postupujicich-do-mezinarodniho-hodnoceni, calculation CHEPS.

Considering the large investments, it can be expected that these centres will have an impact on the development of the R&D&I structures in the future – and it is not fully clear as to whether they are weakening or strengthening the system (there may be a risk of high concentration of national funding sources). The R&D centres are distributed throughout the CR, but there is a concentration in Brno, Ostrava and north of Prague. There is the potential that regional disparities will be reduced, but this greatly depends on the performance of R&D centres, which remains to be seen in the future. They also have the potential to build the bridge between Prague as a scientific centre and firms that are more equally distributed around the country. The transfer of knowledge from the scientific hub of Prague to other areas in the CR can be eased. Moreover, SIL could be enforced because regional R&D centres would have to earn a considerable amount of funding for operations from non-public sources, which should motivate them greatly to collaborate effectively with industry. The entire programme is described in detail in the Final Report on Public R&D Expenditure in Section 5.4.2.

Both programmes – Centres of Excellence and Regional R&D Centres – predominantly aim to establish huge R&D infrastructures. In addition, attention must be paid to the attraction of top researchers affiliated with these infrastructures in order to generate finally a knowledge-based economy.

(5) Another priority axis in OPRDI is "Commercialisation and popularisation of R&D" (213 Mio. EUR). MEYS has just closed the call in the OP Research and Development for Innovation in the priority area 3.3 "Centres for technology transfer", where 18 project applications in total have been submitted – 11 by the major non-Prague universities (Prague is not an eligible region for this OP), 3 by public research institutes, 1 by a hospital and 2 by other private research organisations. The total

funding applied for amounts to almost 820 million CZK (approximately 33 million EUR).[56]

(6) Within the OPEI, a new programme is in preparation: "Seed fund". The preparation started at the end of 2010 within an internal working group of the MIT. The MIT intends to establish a fund (public or public/private) that will be obliged to make private equity investments into the technologically oriented SMEs in the initial phase. Due to the many legislative issues, the final concept and structure of this fund is still being discussed. Together with the establishment of the seed fund, support of accompanying advisory activities for SMEs is planned (coaching, business plan preparation etc.). The third axis of the whole concept will consist of provision of guarantees for private equity investments. These guarantees are supposed to be provided by the Czech Moravian Guarantee and Development Bank (a state-owned bank established in order to support SMEs). There is around 1.4 billion CZK devoted to this initiative. Some of the supporting actions within this initiative shall be launched by the end of 2011 (support of advisory services), and some after clarifying legal conditions for establishing the seed fund with the use of public resources.

(7) Within the OPRDI, a new programme is in preparation: "Pre-seed financing". Preparation of this concept was launched by the MEYS in the spring of this year. It is supposed to be a programme in which grants will be awarded to individual projects (or groups of projects) in a pre-seed phase for commercialisation activities. The support also aims to establish and develop internal systems for commercialisation at universities and public research institutes. There is around 1 billion CZK devoted to this initiative. The programme shall be launched at the beginning of next year.

Furthermore, technology transfer offices (TTO) have already been established. The establishment of TTOs followed different paths (e.g. with assistance of ERDF in the programme period 2004-2006 or OPRDI in the programme period 2007-2013, etc.) They are intended to be the main department for R&D commercialisation within the research organisation. Researchers are obliged by law to announce any R&D result to the research organisation they work for first. Only if the research organisation is not interested in the results may the researcher use it personally. From interviews, however, statements showed that researchers sometimes implement transfer of technologies or knowledge on their own and do not use the TTO services. Research organisations therefore have only limited information on successful transfers of technologies[57].

4.3.2 Summary and researchers' assessment of public measures

Despite the national strategy, analysis produces the observation that only few national programmes for direct support of SIL are in place, while most public funding of SIL-related activity is channelled through Operational Programmes from SF. Consequently, this influences the regional distribution (including the determinant that Prague has only very limited resources from the SF programmes) and places an emphasis on infrastructure (either represented in the development of new centres of different types or of implementing organisations for interaction and knowledge transfer – i.e. clusters, technology platforms and TTO).

Due to limited evaluations and newly emerging structures from programmes just being implemented and started, an assessment is not possible. Consequently, one of the conclusions may be to stabilise and freeze the supporting system for several years in order to see what effects appear. What can be said now is that the supporting structure has its limits regarding the support of collaborative research projects.

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56 For more information (in Czech) see: http://www.msmt.cz/pro-novinare/prenos-poznatku-a-inovaci-z-vedeckeho-vyzkumu-do-praxe?lang=1

57 See Berman Group 2009 for South-Moravia

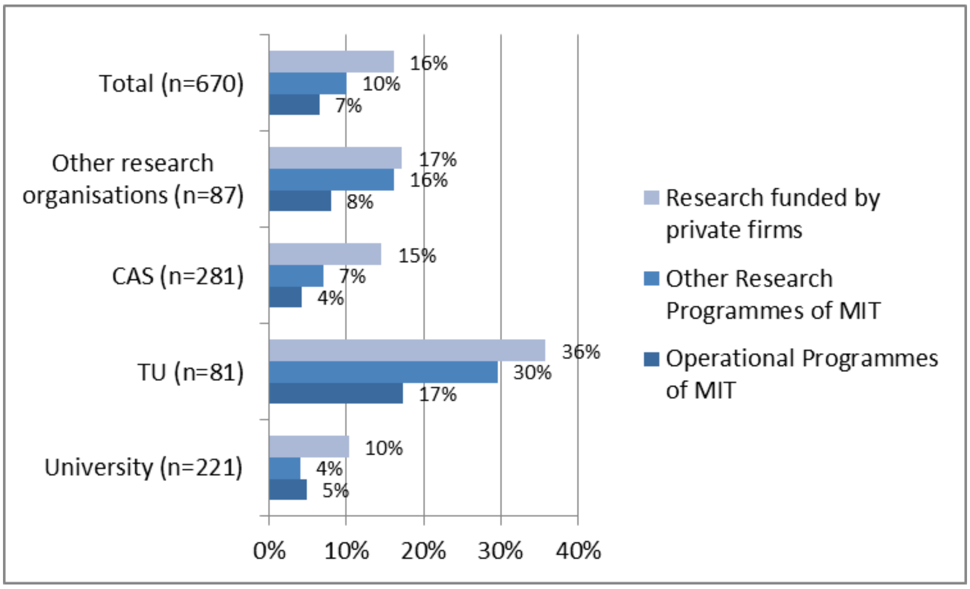
Even though new programmes have been developed and prepared recently, there is still little emphasis on programmes promoting the horizontal mobility of human resources.

Furthermore, some patterns regarding participation and assessment of the public programmes can be derived from the survey conducted.

Even though the number of responding researchers is not the highest, it becomes evident that researchers from technical universities represent the highest participation rates in programmes from the MIT – these include TANDEM and IMPULS (nowadays TIP) (Figure 25). There is also the largest share of research funded by private enterprises, signalling a closer relationship to companies than to the other public research organisations.

Researchers from technical universities are also benefiting to a larger extent from research funded by private enterprises than researchers from the other public research organisations – but not when it comes to Operational Programmes.

Figure 25: Participation of researchers in programmes of the MIT and funding of private enterprises according to research organisations



Source: Data based on own survey conducted in International Audit CR [2010]

The distribution according to disciplines underscores these relations from technical universities (with their focus on engineering – typically industry-oriented). Industry research shows first of all the highest shares of researchers involved in programmes from the MIT or funded by private enterprises, while other disciplines (e.g. agriculture) have substantially lower shares.

On the other hand, participation of enterprises in programmes of MEYS (Table 12), which are overwhelmingly designed to support personal excellence in research, is low. Only 6% of the surveyed enterprises participated in Operational Programmes and 9% in other MEYS programmes. Nevertheless, enterprises indicate an impressively high share resulting in large or very large benefits for research.

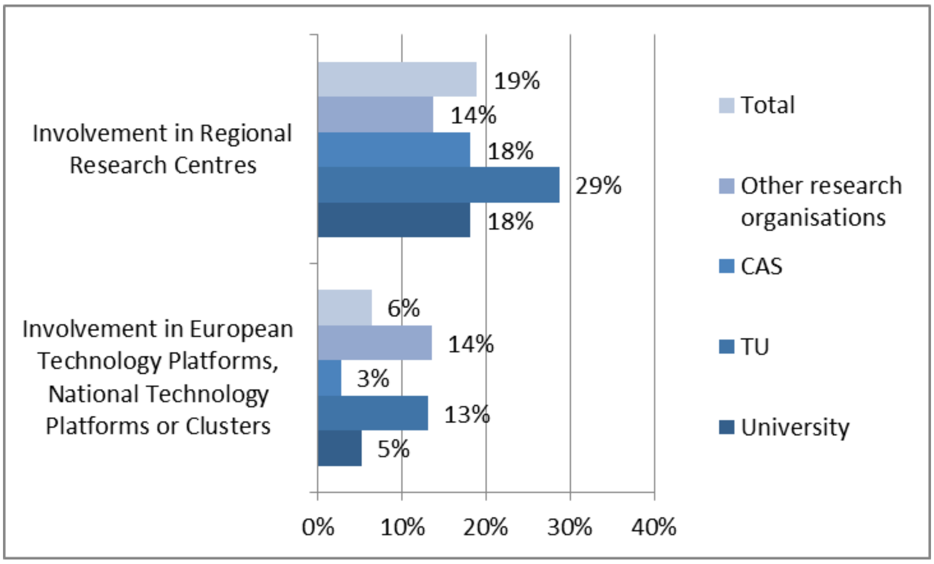
Table 12: Participation of enterprises in programmes of MEYS and benefit

	No. of enterprises participating in MEYS programmes	**%**	**% with large or very large benefit for research**	
Operational Programmes of MEYS	9	6%	7	78%
Other Programmes of MEYS	14	9%	12	86%
Total	160	100%		

Source: Data based on own survey conducted in International Audit CR [2010]

Technical universities are also participation with a higher share in regional R&D centres and in technology platforms and clusters (see Figure 26).

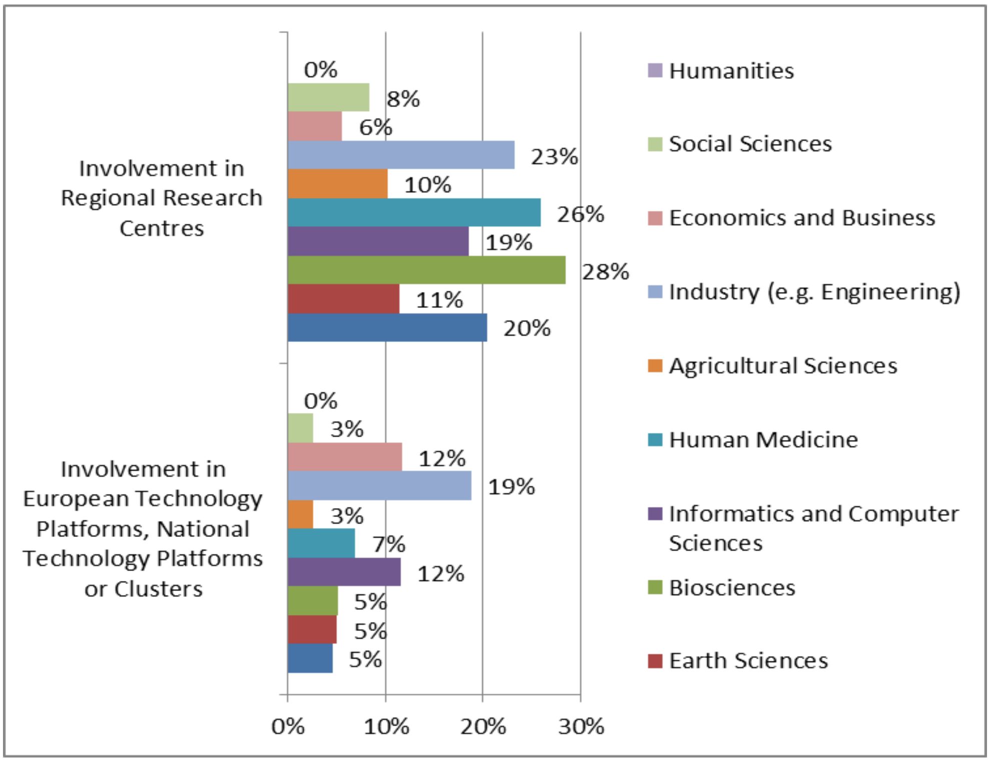
Figure 26: Share of researchers participating in public initiatives according to research organisation



Source: Data based on own survey conducted in International Audit CR [2010]

Concerning the distribution of disciplines of participating researchers in the regional R&D centres, bioscience and human medicine have highest shares – together more than 50 % – followed by industry (i.e. engineering). In contrast to this is the situation in technology platforms and clusters. Here, industry (i.e. engineering) and informatics have highest shares. This observation may be attributed to the different types of organisation of research and innovation activities in the respective fields of science (see Figure 27).

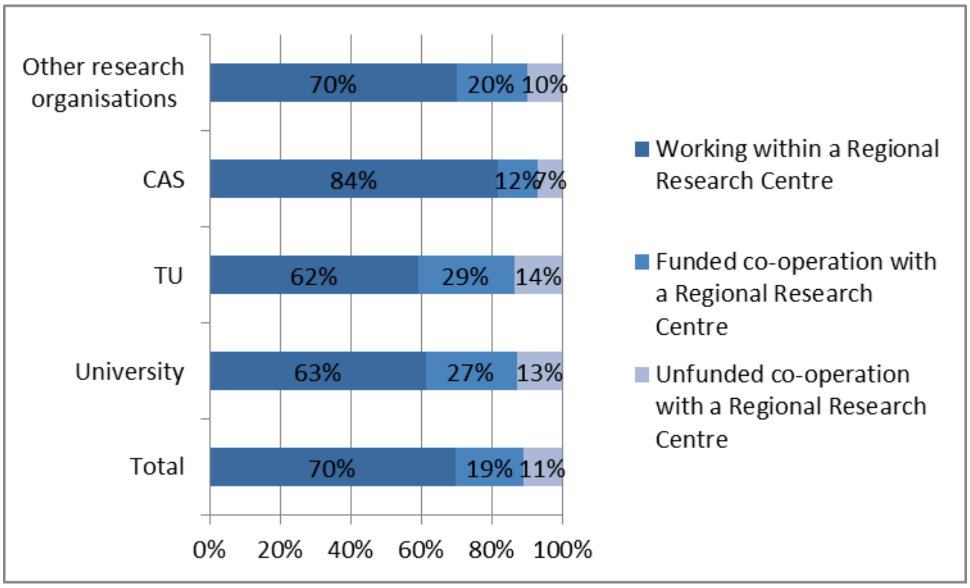
Figure 27: Share of researchers participating in public initiatives according to disciplines



Source: Data based on own survey conducted in International Audit CR [2010]

The distribution according to research organisations, with their different foci, aligns with this view. The ASCR, consisting of a large share of institutes from natural science (e.g. bioscience), shows the highest involvement in regional R&D centres, while Technical Universities with typical institutes from engineering appear with the lowest (see Figure 28).

Figure 28: Researchers' involvement in Regional Research Centres according to research organisations



Note: Share is related to those researchers participating in Regional Research Centres.
Source: Data based on own survey conducted in International Audit CR [2010]

4.4 Résumé – successful public support and framework? Shortcomings, gaps and needs

The overview of the policy-related framework conditions for SIL produces some interesting results:

(1) Firstly, one can observe some framework conditions not favourable for SIL. In the case of human resources, conditions for researchers, characterised by relatively low salaries and less social prestige, are causing a brain-drain. Furthermore, there are no instruments provided to support interconnections between science and industry in order to develop the relevant skills for people.

(2) Secondly, another feature is the low public support of SIL – expressed by very few programmes with a sole focus on SIL. Only a few public programmes are aiming for direct science-industry cooperation;

(3) Thirdly, policy measures implemented to support SIL are lacking some long-term stability – which is necessary for the evolving of trustful and complementary interactions between science players and industry.

(4) Fourthly, there is no coherent and systematic support of the transfer of scientific results into industrial application: while support for different types of infrastructural investments is provided from Operational Programmes, joint projects are not directly and systematically supported, although their performance contracts sometimes include contract research.

(5) Fifthly, from the survey results, a pattern appears which shows that technical universities are closest to industry (at least in terms of privately funded projects);

(6) Sixthly, the different public measures are matching the needs of different disciplines to varying extents, and hence the research organisations are including such fields of sciences.

But there are also some doubts as to whether the entire current infrastructure is being fully utilised. An important part of this infrastructure is based on Operational Programmes, either from the Ministry of Industry and Trade or the Ministry of Education, Youth and Sports, and has resulted in the creation of several kinds of institutions – R&D centres, clusters, technology platforms, innovation centres etc. Nevertheless, it is not fully clear as to whether these implemented measures have been successful in increasing SIL. There are also doubts about the absorptive capacities and demands for financial and human resources regarding these measures.[58]

5. The stakeholders' view in science-industry interactions

5.1 Introducing survey characteristics of enterprises, researchers and research directors

5.1.1 Introduction

Science-industry linkages in the CR are not systematically monitored. The Technology Centre of the Academy of Sciences has some sort of overview of ongoing activities, but it is not specifically targeted towards observing SIL.

Given the range of channels used to transfer knowledge from science to industry and the other way around, the multiple players and institutions, and the number of supporting programmes and initiatives, it was necessary to conduct a survey asking enterprises, researchers and directors of research organisations in what way they are

58 See Berman Group 2009.

involved in SIL. Only this allowed us to obtain an overview of ongoing activities. This also provides us with the opportunity to match answers and assessments to explore the crucial problems. Table 13 summarises the number of responses for each survey. As expected, the response rate of enterprises (7%) is lower than that of researchers (26%) and directors (22%). The survey was launched in the summer 2010 and was open for about six weeks.

Table 13: Types of surveys and number of responses

	No. of responses	Size of population	Response rate
Enterprises	160	2454	7%
Researchers	689	2636	26%
Directors	74	343	22%

Source: Data based on own survey conducted in International Audit CR [2010]

The following three subsections introduce major characteristics of studied players and institutions to provide a feeling for the sample and framework for assessment of findings. Not every table and figure ends up with the total number of responses due to missing values in some answers. For relative values, we decided to take the number of valid responses to a question as a reference parameter to allow comparisons between categories.

5.1.2 The enterprises survey

Sample composition

The firm sample includes all types of companies, i.e. SMEs, large, national, foreign-owned, etc. This implies that it also includes the private 'non-profit' research organisations that were not officially recognised as being private research institutes. The main sources were the Czech Technology Profile Database, the database of the Research Organisations' Association, the R&D&I Information System and the Register of Economic Subjects. Therefore, enterprises in the sample are more oriented towards innovation than the Czech average. This is important when interpreting findings of the survey.

Main activity

The majority of enterprises in the sample are from the manufacturing sector (45%), including mining and quarrying, manufacturing, electricity and water supply. The second biggest group is R&D services with 18%. The high share of R&D services mirrors the positive sample composition towards innovative enterprises. About 11% belong to the ICT sector and 8% to the construction sector.

Origin and markets

27% of the enterprises interviewed are located in Prague, 14% in Plzen, 12% in the South Moravian region, 7% in the Moravian Silesian region and 7% in the South Bohemian region.

90% of the enterprises are Czech enterprises (local = headquarters of this enterprise or enterprise group are located in the CR), only 10% are international (firm belongs to an enterprise group and has its headquarters abroad). About 30% of large enterprises are of international origin, but for micro, small and medium-sized enterprises, the share of international enterprises drops to 5-8%. There is hardly any difference between sectors.

Firm size

Enterprises had to indicate their size according to employment. In total, 28% of the surveyed enterprises are micro enterprises with 10 employees or less. 25% are small enterprises (11-50 *employees), 31% are medium-sized (51-250 employees) and 16% are large enterprises (250+* employees). This pattern differs among sectors.

Manufacturing enterprises are larger on average. Their share of micro enterprises is lower, but the share of large enterprises is higher. The construction and ICT sector contains more than 40% micro enterprises. Apart from manufacturing enterprises, in all other sectors more than half of the enterprises have only 50 employees or less.

Human resources

The human resources of enterprises are described by the share of university graduates. In total, half of the enterprises have a share of highly qualified employees of lower than or equal to 20%. 27% of the enterprises indicated having more than 50% highly qualified people. This number differs considerably between sectors. Whereas in enterprises of R&D services and ICT, highly qualified employees dominate, in construction and manufacturing, the share of highly qualified workers in most enterprises is lower than 20%.

5.1.3 The researchers survey

Sample composition

Researchers are affiliated with research institutes of the ASCR, other public research institutes and other state research bodies (including hospitals). The central database of R&D projects (http://www.isvav.cz) contains both targeted as well as institutional funding from all of the 26 providers of public R&D funding in the CR, and was crucial for contacting researchers. In the second step, a few other significant individual researchers were added to this database.

Research organisation, research group and position

Researchers had to indicate the types of research organisations with which they are associated. A distinction between primary research organisations and others was made. 33% of the surveyed researchers indicated their primary affiliation to be a university, 12% a technical university, 42% ASCR and 13% another research organisation.

45% of the researchers indicated having at least a second affiliation. Researchers who are primarily associated with the ASCR have the highest share of second affiliation – 47% (university 38%, technical university 41%, others 54%). The most common pattern is ASCR/university, followed by university/university and other research organisations/university. A combination of research organisation and industry is rare.

Regional dimension

The surveyed researchers are distributed across different regions in the CR. The majority of researchers (56%) are located in Prague. Another 14% are located in the South Moravian region and 6% in the Central Bohemian region. All other regions account for a percentage ranging from 2-5%. The distribution of researchers does not correspond with the distribution of enterprises. Whereas Prague is home to the lion's share of researchers, this is not the case for enterprises. SIL are very much focused on human interaction. This is often a matter of spatial proximity, which is difficult to realise when enterprises and researchers are unequally distributed over space.

Group size and funding

A working group was defined as a group of people working in the same institute/department on related research topics. Consequently, a research group consists of senior researchers, post-docs/researchers, PhD students, master students and technical/administrative staff. The *average working group size* is 16 people, according to research organisations this means: university – 19, technical university – 22, ASCR – 13, other research organisations – 16. In general, working groups at universities and technical universities are much larger and include a mixture of researchers, master students and support staff. The working groups at the ASCR are much smaller and have fewer support staff.

Discipline

The research groups work within different disciplines. The largest share of research groups surveyed is from biosciences, followed by physics (16%), industry research (12%) and human medicine (11%). Over 50% of the surveyed research groups in natural sciences such as physics, earth sciences and biosciences are located in the ASCR. Altogether, more than half of the research groups surveyed belong to technical universities. Research groups related to agriculture are affiliated with universities or other research institutes. Research groups in humanities are mainly located at universities or the ASCR, and research groups of all other disciplines are predominantly associated with universities.

Human resources

It is assumed that individual characteristics of researchers influence the activity and interest of individual researchers in the transfer of knowledge to industry.

Data also showed the ageing science body in the CR. 12% of all researchers interviewed were older than 65 years. They were trained and educated during the communist era of the CR. 42% of researchers are 50-65 years old. They had finished their professional education (e.g. PhD, PostDoc) in the former Czechoslovakia, but to be successful they had to adapt to the new, transformed system. Researchers between 35 and 50 years of age were educated in the transforming or new education system, and people below 35 years (12%) are representatives of future researchers and professionals.

As SIL always require team abilities, researchers were asked to indicate their research efforts in teamwork. People indicating that they work on their own "often" or "always" (on a Likert Scale) are labelled as "*work-alone* researchers". The share of researchers with a work-alone attitude is highest at universities (48%), followed by the ASCR (34%). People at the technical universities (24%) seem to work more often in teams.

5.1.4 The directors survey

Research organisation

The directors survey intended to gain information on larger research units in the CR rather than on individual behaviour of researchers. The so-called directors' population includes deans of faculties, vice rectors of research and science, directors of the ASCR, hospitals etc. and rectors of universities. For simplification, the respondents are referred to as directors. 33 of the 74 respondents (45%) are from universities. This includes 7 replies from technical universities. 31% of the respondents are affiliated with the ASCR as the primary research organisation and 24% work for other research organisations. The share of university answers corresponds with the researchers survey. The share of ASCR answers is higher in the directors than in the researchers survey.

Human resources

Directors were asked to indicate how long they had already worked in research organisations: half of the directors have been working there for more than 20 years. In the ASCR, this share increased to 78%. The share of directors working in their research organisation for less than 10 years is extremely low in all research organisations. Job mobility seems to be low. New faces and new ideas seem to have a low penetration rate, especially in the ASCR. Having people in managing and decision-making positions who joined the organisation more than 20 years ago (before 1991) might influence attitudes and efforts towards SIL.

5.1.5 Summary: profile of enterprises and researchers

For the **firm** survey, mainly innovative enterprises were selected. The surveyed enterprises come from various sectors, for example manufacturing, R&D services, ICT, construction. Enterprises are distributed all over the CR. However, manufacturing was the dominant sector. Most of the enterprises are SMEs (<= 250 employees). The knowledge intensity of enterprises differs greatly between sectors. Whereas the share of highly qualified workers in ICT and R&D services is high, it is not the case in manufacturing and construction. Performing SIL might become difficult in manufacturing due to the low number of "absorbers". This already shows the different abilities of enterprises to use SIL. Moreover, 90% of enterprises are of Czech origin.

Interviewed **researchers** came from many disciplines. Researchers in the field of biosciences, industry research and physics make up the largest share. These researchers are mainly associated with universities, technical universities and the ASCR as their primary research organisation. However, 45% of researchers have a second affiliation (most people from the ASCR), but hardly anyone is associated with industry. Most of the researchers are located in Prague.

The small working groups are noticeable. The average group in the CR encompasses 16 people. Groups are largest in technical universities (22 people) and smallest in the ASCR (13 people). The ASCR also lacks support staff and master students in their teams.

There has been a raising of the awareness of the ageing structure of researchers in the CR. 50% of the interviewees are older than 50 years. Team skills necessary for SIL have also been evaluated. In total, 38% of the researchers follow a work-alone attitude, which might raise difficulties regarding teamwork with people from industry.

Respondents of the **directors** survey came mainly from the ASCR and universities. Working experience in their affiliation is mainly large, which also indicates low job mobility.

5.2 Motives and incentives for science-industry linkages

5.2.1 Motives for SIL

The motives for SIL provide information on (1) what kind of motivation is driving people from industry and research to cooperate, (2) whether these motives are "sustainable" for long-term cooperation and (3) whether they can be influenced by public programmes and initiatives.

We divided motives of *researchers* into those of an intrinsic nature, motives showing the pure practical use of SIL and motives that actually go beyond the research cooperation and aim for networking.

The main motive of researchers to cooperate with industry is the *access to funding for own R&D activities* (contract research) without a programme (62%). The second most important driver is because *framework conditions of specific research programme require it* (52%). Working with industry partners is very much funding-driven. Within the perspective of "sustainable" and long-term cooperation, there is a risk that researchers might not be eager for industry funding if they have other sources. Overall, intrinsic motivation (44%) for SIL is of lower relevance, but it is still of third importance for researchers. 69% of researchers at technical universities and 51% of other research organisations work with industry because they want to *gain industrial knowledge and expertise*. However, this motivation does not drive people from the ASCR and universities to a great extent. *Career development* (15%) is hardly a motivation for SIL. This already provides a hint that incentive structures at research organisations do not encourage SIL. Having *access to industrial networks* (42%) is to some extent driving people in universities, technical universities and other research organisations.

A comparison of **research organisations** tells us:

University: 61% of the researchers work with industry to fund their own research, but perceive this mode as being only moderately effective. 44% work within SIL on a programme basis, which leads to higher satisfaction. Intrinsic motivations also apply for 42% of the researchers and reach high scores in satisfaction. Networking (for access to the industrial community, but also to potential employers for students) is a good motivation for nearly half of the researchers.

Technical universities: In general, researchers at technical universities are more highly motivated to work within SIL than in all other research organisations. Their main driver is access to industrial knowledge (69%). This ranks even higher than funding motives. Access to the industrial community is also a motivation for half of the researchers.

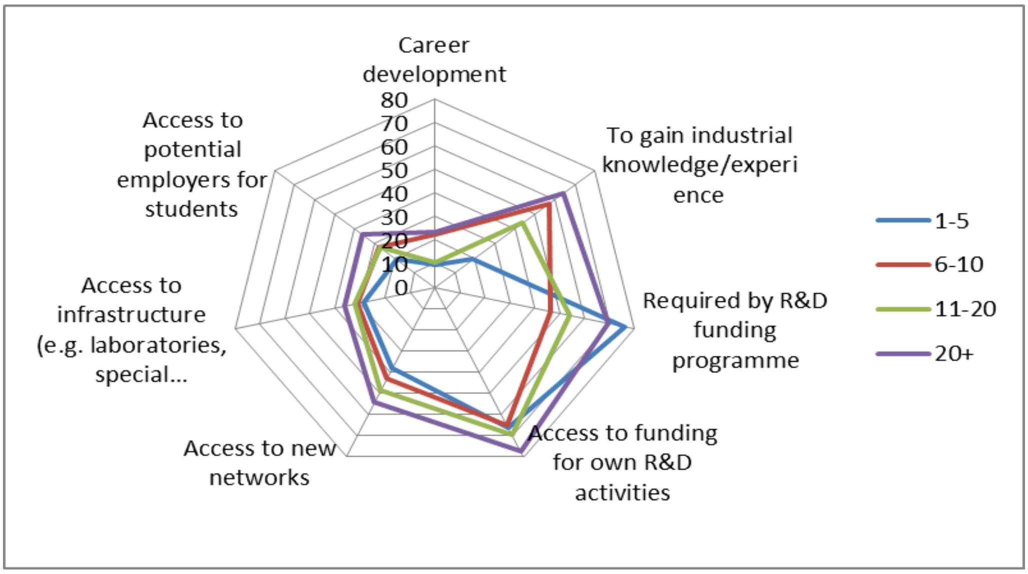
ASCR: For ASCR researchers, funding seems to be the only motivation to work with industry. Intrinsic motivation or networking motives are, at most, mentioned by 1/3 of the researchers.

In conclusion, (industrial) research funding is the main driver for researchers to cooperate with industry, but also leads to satisfying results once the cooperation has started. Intrinsic motivation to gain industrial knowledge is a driving force for researchers at technical universities and university researchers, but not so much for people from the ASCR.

If SIL is strengthened, about half of the researchers from technical universities and almost that many at universities become active when interesting cooperation promises new knowledge. This is probably the best motivation for establishing sustainable SIL. Public initiatives supporting this type of research probably do not reach researchers at the ASCR. All researchers can be motivated by additional funding from industry. To ensure satisfaction, programmes seem to be more supportive than pure contract research.

We can also see how **working group size** affects the motives. Figure 29 reveals that motives, like networking (access to industrial community, access to potential employers for students) or intrinsic drivers (career development, gaining industrial knowledge), are more often named if the research group is larger. The smaller a group, the more often motives can be reduced to access to funding alone. Consequently, this is also related to findings above, for example research organisations such as technical universities more often have larger groups than the ASCR. However, it could be empirically shown that larger groups provide better conditions to explore SIL and go beyond the funding motive to experience advantages of SIL (as the funding motive is not the most "sustainable" motive).

Figure 29: Motives of researchers for SIL and working group size



Source: Data based on own survey conducted in International Audit CR [2010]

We also asked *enterprises* about their major motive for cooperating with research organisations. To set this into perspective, we compared this with the major motives for engaging in R&D cooperation with other enterprises (suppliers, customers, competitors, etc.). The rationale behind this is to identify motives that specifically drive enterprises towards research organisations. Table 14 outlines the major motives of enterprises for cooperating with research organisations and other enterprises. In general, motives have been classified into efficiency motives (decrease costs, risk and time, access to infrastructure), quality motives (access to scientific knowledge, access to highly qualified people) and networking motives (access to scientific or industrial community respectively). The findings are very straightforward:

- *Quality-oriented motives* are the main drivers for R&D cooperation with both *research organisations* and other enterprises, although the weighting is much greater for research organisations. About 30% of the enterprises are motivated to work with research organisations to have access to scientific knowledge and highly qualified workers. As a reminder: the sample composition is weighted towards innovative enterprises.
- Enterprises' motives for engaging in R&D cooperation with *other enterprises* are more often based on *efficiency motives*. 20% of enterprises want to decrease technological, scientific or market risk. Another 12% want to decrease costs and 11% want to decrease the running time of projects.

Motives to collaborate with enterprises and research organisation differ. Enterprises do not look for "cheap" research in research organisations, but rather for quality.

Table 14: Motives of enterprises to cooperate with research and other enterprises

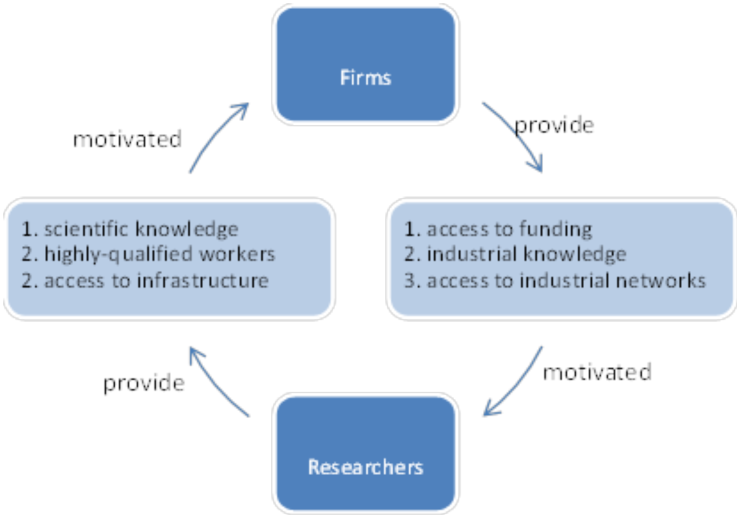
	Enterprises*		**Research***	
	Frequency	% of responses	Frequency	% of responses
Efficiency motives				
Reduction of R&D costs	18	12%	8	6%
Reduction of risks (technological, scientific, market)	30	20%	9	6%
Reduction of R&D project run time	17	11%	6	4%
Access to infrastructure (e.g. laboratories, special equipment)	15	10%	24	17%
Networking				
Access to networks (national and international)	19	13%	14	10%
Quality motives				
Access to scientific knowledge	29	19%	42	30%
Access to highly qualified workers	22	15%	38	27%
Total	150	100%	141	100%
*Only enterprises with industry and research cooperation				

Source: Data based on own survey conducted in International Audit CR [2010]

Figure 30 shows how the different streams of drivers are interrelated. Whereas some motives of enterprises and researchers find corresponding aspects on the other side (e.g. both look for the exchange of knowledge), which is a crucial point for cooperation, the ranking of motives does not yet correspond (e.g. enterprises look first for scientific knowledge, but researchers look for funding). Moreover, researchers are motivated to integrate themselves into the industrial community, whereas enterprises do not rank the access to scientific networks as a motivating factor, which could lead to an equal exchange.

For steering SIL, the most important and efficient driving forces must be touched by public initiatives. In the programme designing process differences in motives according to types of research organisations, sectors/disciplines and working group structures must be taken into account.

Figure 30: Motivation of enterprises and researchers for cooperation in R&D

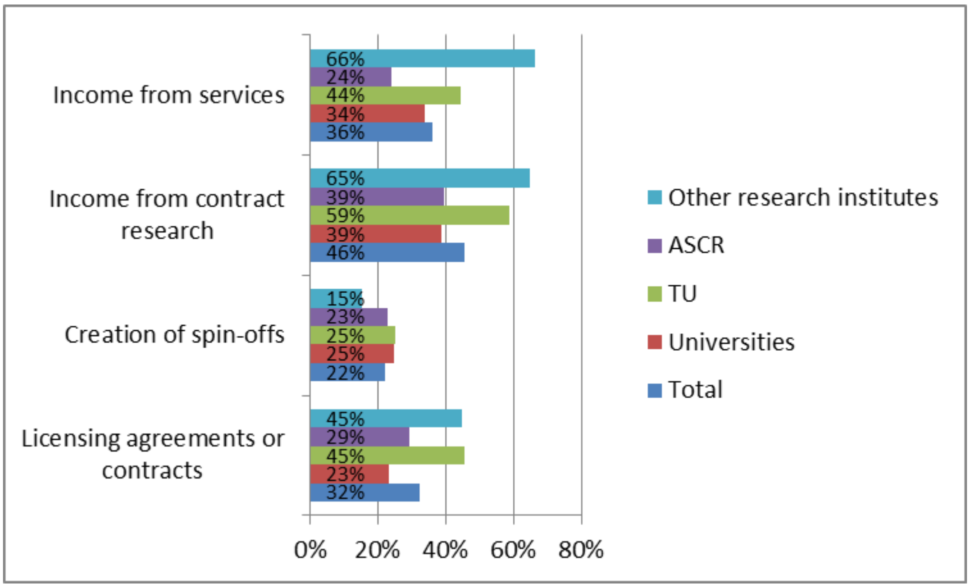


Source: Own figure, data based on own survey conducted in International Audit CR [2010]

5.2.2 Incentives for SIL

Incentivising SIL is an option for research organisations to move their researchers towards more cooperation with industry. We asked researchers and directors to assess the *importance* of specific research results in their own research organisation. This provides information about what research results are supported/incentivised by the different research organisations.

Figure 31: Share of researchers ranking research results as "highly important" or "very highly important" according to research organisation



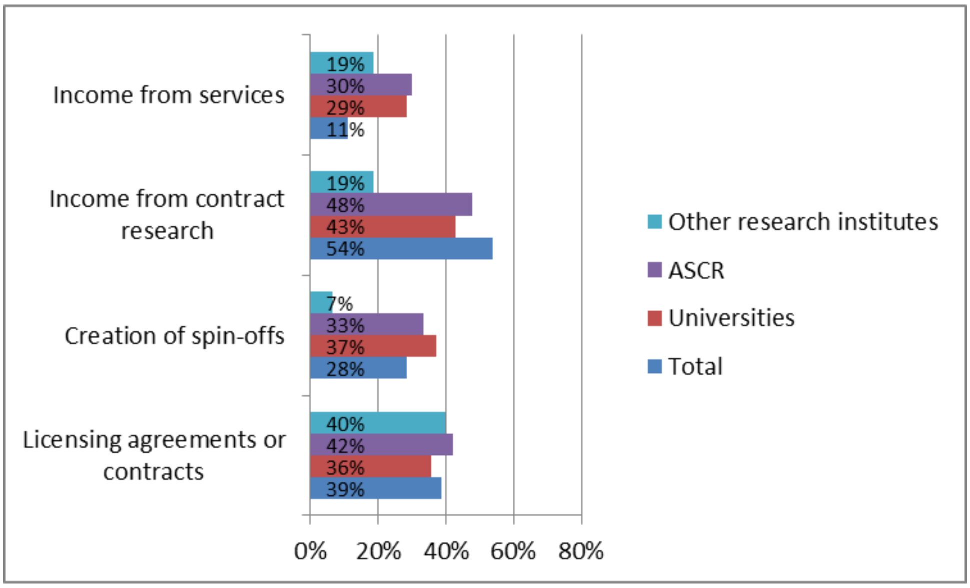
Source: Data based on own survey conducted in International Audit CR [2010]

Researchers and directors were asked to assess the importance of a list of research results. A Likert Scale was used from (1=not important to 5=very important). The list of items includes criteria used in the evaluation methodology, but extends it. As research organisations have their own criteria/keys for how to distribute the institutional funding internally, this question showed us whether SIL are incentivised in the specific research organisations – formally or informally. Writing for any kind of journal article/publication is of high or very high importance (scale 4 or 5) for about 3/4 of researchers and directors. Patents are important for about half of researchers and directors. A few items were also related to SIL. It was asked whether research organisations support the transfer of knowledge from science to industry using licensing agreements, research contracts and service contracts, or supporting the creation of spin-offs (Figure 32). Figure shows the same for directors. In general, all items rank much lower than publications or patents. They are compared to other research results of low or very low importance.

However, there are still differences between the items. Overall, directors consider SIL to be slightly more important than researchers do. In total, contract research and service contracts seem to be the most incentivised efforts for SIL in the perception of researchers. Spin-offs are hardly supported by any type of research organisation. Interestingly, directors have a slightly different perception of this. In their view, contract research and licensing are mostly incentivised, whereas service contracts and spin-offs are often irrelevant. There seem to be perceived differences between directors and researchers. Perhaps the maintenance of SIL receives positive support from research organisations, but researchers do not know about the importance (communication issue), or do not want to know.

Taking the different research organisations into account, researchers in *technical universities* consider SIL to be most incentivised. In general, this pattern is followed by *universities* with slightly lower numbers.

Figure 32: Share of directors ranking research results as "highly important" or "very highly important" according to research organisation



Source: Data based on own survey conducted in International Audit CR [2010]

NOTE: WHAT WORKS ELSEWHERE

International Comparison: The 2009 "Expert Group on Knowledge Transfer" of the European Commission published its final report in November 2009. Part of the report is "an evaluation of incentives and policies that affect research institutions' knowledge transfer activities, at researcher and management level" (Bekkers, R. 2009). Specific knowledge transfer channels of particular relevance for SIL have been studied according to their incentive options on an individual level and on an institutional level. Sources of incentives could come from the research organisation as such or from policies and include, for instance:

- Guest lecturers from industry
- Allowing part-time positions to give time for entrepreneurial activities
- Staff mobility programmes
- Encouraging spin-offs
- Financing/equity in spin-offs
- Individual funds
- Funds for mixed uni/firm PhD

The experts strongly recommend looking at the advised incentives.

5.2.3 Summary: motives and incentives

The most important motive for researchers for engaging in R&D cooperation with industry is funding-oriented, especially at the ASCR. For researchers at technical universities and universities, gaining industrial knowledge and experience is a second motivation. On the other hand, enterprises are motivated to work with research organisations because of quality-driven motives (access to scientific knowledge, highly qualified people). The survey also showed that research organisations do not stand in competition with R&D partners from industry. Enterprises' motives to engage in R&D cooperation with other enterprises are mainly efficiency-driven (decrease cost, time and risk). Apart from individual motives, research organisations can set incentives and support measures for SIL. As we could learn from the survey, publications (~75%) and patents (~50%) are perceived as being strongly incentivised by researchers. In comparison, for research organisations, measures to support SIL are hardly important. If so, research and service contracts seem to be most desired by research organisations, whereas spin-offs and licensing agreements do not receive much support in the perception of researchers. A distinction according to types of research organisations showed that technical universities and universities provide more incentives than the ASCR. Interestingly, the perception of researchers and directors (especially at the ASCR) differs significantly when the importance of SIL measures is assessed. This needs to be questioned.

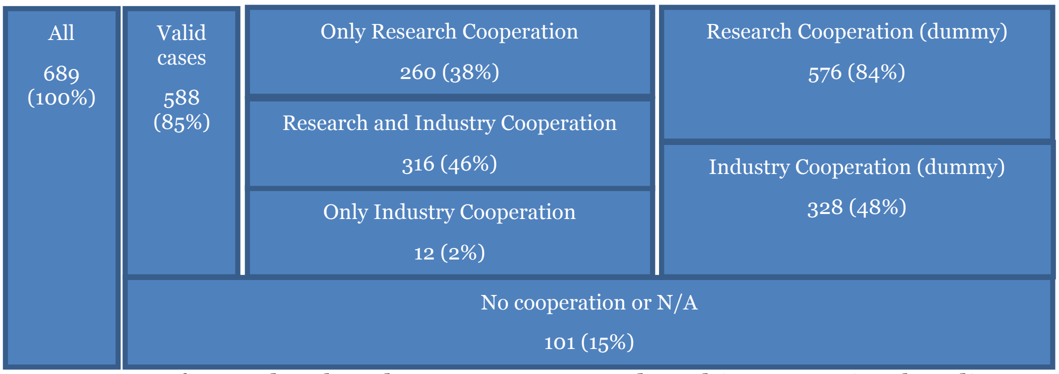
These findings can be linked to the structural conditions in the different research organisations. On the one hand, technical universities are carrying out industry research, work in large research teams and have higher shares in applied research. Researchers at technical universities have a higher intrinsic motivation to work with industry and, at the same time, SIL are perceived as being supported/incentivised by the technical universities. On the other hand, there is the ASCR, mainly working in natural sciences, having small research teams and focusing on basic research. Researchers at the ASCR are mainly motivated to work with industry to receive additional research funding. An incentive structure of the ASCR to support SIL is virtually non-existent. A specialisation of research organisations in different types of research, disciplines and working modes seems to exist, which influences the attitude to and support of SIL.

5.3 Cooperation pattern of science and industry: institutional and regional perspective

5.3.1 Modelling science-industry cooperation

This section provides an initial overview of the cooperation pattern of researchers and enterprises. On the *researchers* side, out of 689 researchers, 588 (85%) provided information on their cooperation behaviour. 260 out of 689 (38%) researchers only have cooperation with partners from the scientific community. 2% of researchers only have R&D cooperation with partners from industry and 46% collaborate with both – partners from the scientific as well as from the industry community (Figure 33). To distinguish between the behaviour of researchers with and without industry cooperation, we combined information in a new way. We created two groups – researchers with scientific cooperation and researchers with industry cooperation. Researchers who indicated collaborating with both sides are counted in both groups. Almost all researchers (576 of 689 - 84%) have partners in the scientific community. 48% of all researchers work with industrial partners in R&D. This share of researchers seems to be reasonably high and does not show any low performance.

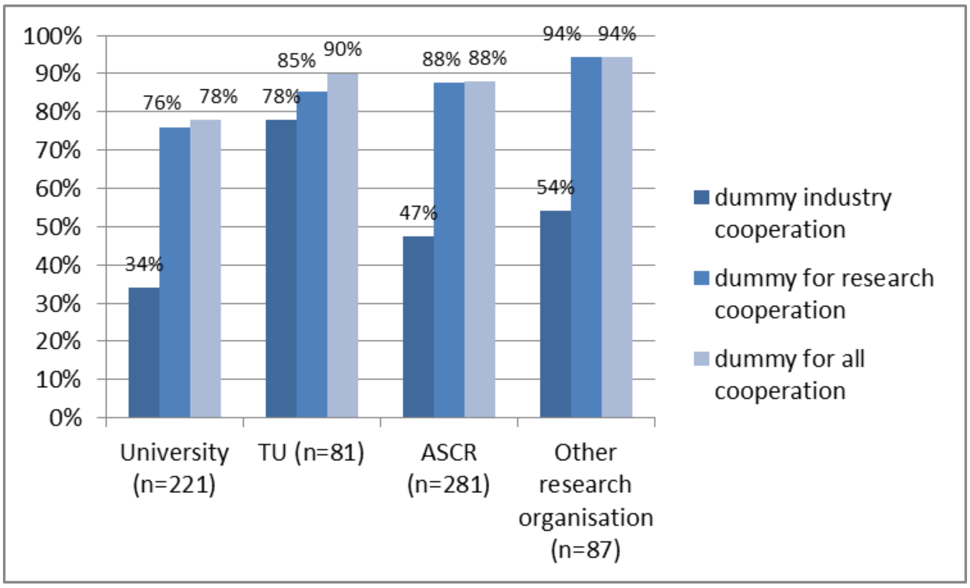
Figure 33: Cooperation model of researchers



Source: Own figure, data based on own survey conducted in International Audit CR [2010]

Figure 34 refers to the cooperation pattern of researchers according to **research organisations**. We can depict from the figure the shares of researchers with industry cooperation, research cooperation and all cooperation (excludes those who do not have any cooperation). At universities, about 3/4 of the researchers cooperate with scientific partners, but only about 1/3 cooperate with industry partners. A comparison with technical universities shows extremely large differences. 85% of researchers at technical universities have research cooperation and 78% have industry cooperation. At the ASCR, about half of the researchers indicated having industry cooperation and 88% scientific cooperation (which is the highest number). Again, the specialisation of research organisations becomes visible.

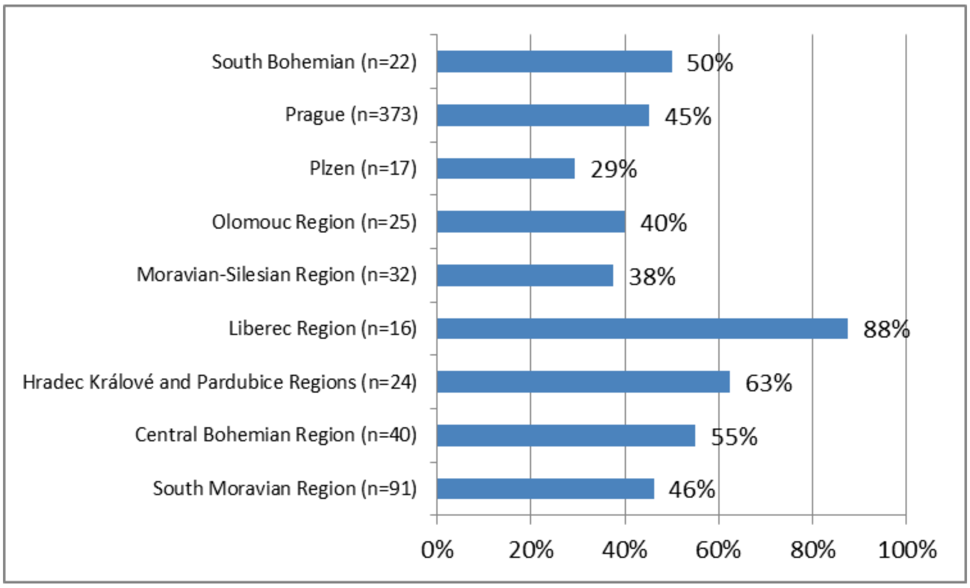
Figure 34: Cooperation pattern of researchers according to research organisations



Source: Data based on own survey conducted in International Audit CR [2010]

The **regional pattern** of researchers involved in SIL is shown in Figure 35. Whereas on average, 48% of researchers are involved in SIL, there are some regions which outperform the average. In Liberec 88% of researchers are involved in SIL, in Hradec Králové and Pardubice 63% of researchers work in SIL, and in Central and South Bohemia 55% or 50% of researchers respectively cooperate with partners from industry. These numbers cannot be generalised, as some regions have a very low number of cases. Therefore, the picture could be biased and should be treated with caution.

Figure 35: Regional distribution of researchers involved in SIL



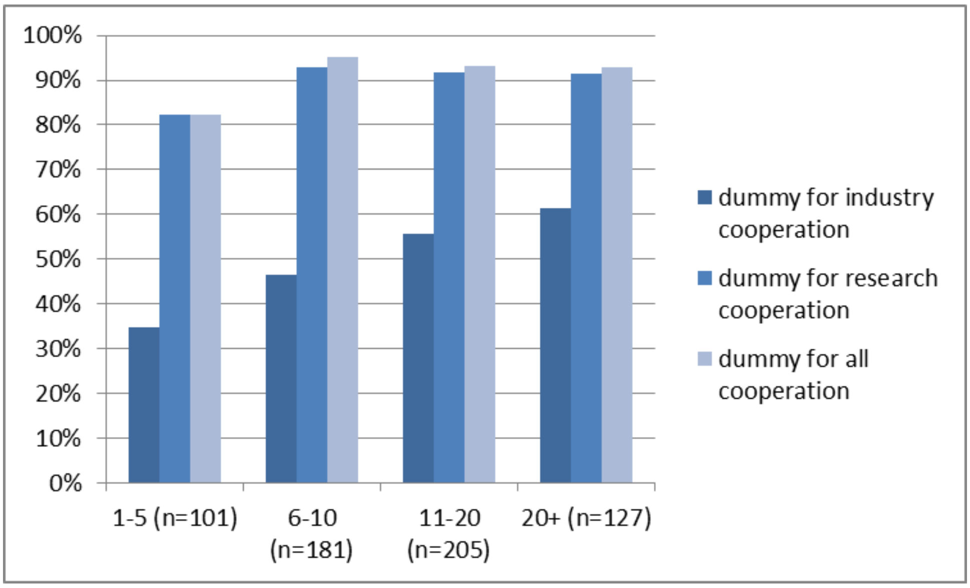
Note: Only regions with more than 15 responses per region

Source: Data based on own survey conducted in International Audit CR [2010]

The cooperation pattern differs significantly between the disciplines. Whereas in fields such as industry research (e.g. engineering) (84%) or informatics (61%), the share of all researchers working with industry partners is very high, this number is much lower in humanities and social sciences due to the different nature of research fields. In agricultural science, there seems to be a strong industry-science connection, with about half of researchers working with enterprises. In natural sciences, the industry cooperation ranges between 45 and 55%. Hence, intensity of cooperation with industry probably depends on scientific fields. What we see is that in some disciplines, SIL are very strong. It is questionable as to whether it is desirable to have strong links in every discipline.

Figure 36 illustrates the cooperation pattern according to **working group size**. As we can already expect from discussions above, working group size affects cooperation patterns. Small working groups (1-5 people) have very little industry cooperation (35%) in comparison to research cooperation (82%). The gap is much smaller for larger working groups. Whereas research cooperation is applied by almost all researchers independently of working group size, industry cooperation increases with working group size. A critical mass of people is obviously needed to work successfully with industry. Moreover, attitude seems to play a role. Researchers with the w*ork alone* attitude more often have no cooperation at all (18%) than those researchers able to work in teams (only 9% with no cooperation).

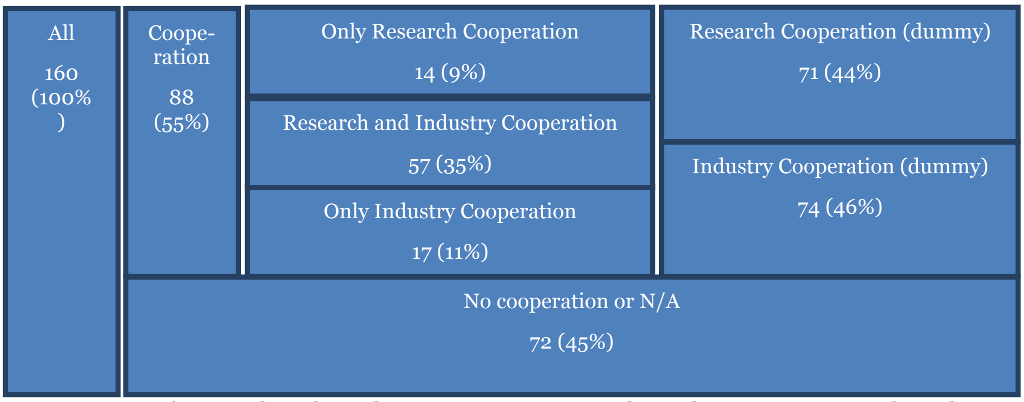
Figure 36: Cooperation pattern and working group size



Source: Data based on own survey conducted in International Audit CR [2010]

The cooperation pattern on the *industry* side can be depicted from Figure 37. Out of 160 cases, only 88 (55%) enterprises with cooperation relations could be collected. 35% of enterprises indicated having cooperation with partners from both the scientific as well as the industrial community. 9% of enterprises have only R&D cooperation with people from research organisations and 11% have only pure industry relations. 45% of enterprises have no R&D cooperation at all or did not indicate anything at all. Applying the same system as for researchers and dividing enterprises into those with industry relations and those with relations to the scientific community (enterprises can be in both groups), we can see that 44% of enterprises apply R&D cooperation with research organisations. 46% of enterprises are involved in R&D cooperation with other industry partners. The number seems to be surprisingly high, but this can be explained by the sample selection. The firm sample is somewhat biased towards innovative enterprises. Therefore, findings cannot be generalised for the entire Czech firm base.

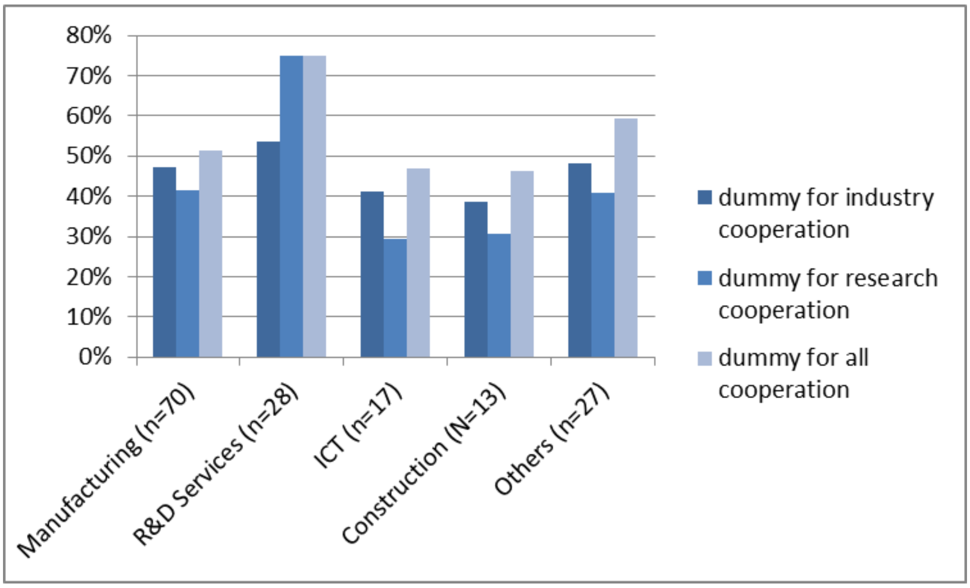
Figure 37: Cooperation pattern of industry



Source: Own figure, data based on own survey conducted in International Audit CR [2010]

Figure 38 illustrates the cooperation pattern according to **sectors**. As expected, R&D services have strong cooperation with research organisations (75%), but also 54% with partners from industry. They see themselves as bridge from science to industry, as they have strong relations to both. In manufacturing, only half of the enterprises have any R&D collaboration at all. Of those that do, 47% work with partners from industry (suppliers, customers, etc.) and 41% work with research organisations. For informatics/computer science (ICT) and construction, the number even decreases to 30%. Apart from R&D services, the share of enterprises working with research organisations ranges between 30 and 40% in the different sectors.

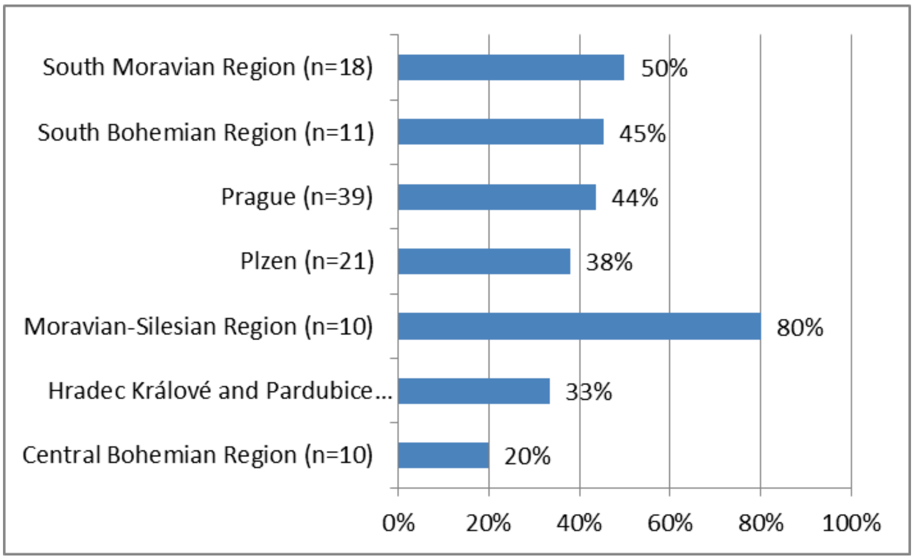
Figure 38: Cooperation pattern of enterprises according to sectors



Source: Data based on own survey conducted in International Audit CR [2010]

Figure 39 illustrates the **regional distribution** of enterprises involved in SIL. Whereas on average, 44% of innovative enterprises are involved in SIL, this number increases to 80% in the Moravian-Silesian region. Enterprises in the Central Bohemian region and the Hradec Králové and Pardubice regions are involved to a lesser extent in SIL. These numbers cannot be generalised due to the low number of observations.

Figure 39: Regional distribution of enterprises involved in SIL



Note: only regions with 10 or more observations per region

Source: Data based on own survey conducted in International Audit CR [2010]

There is, again, a **size effect**. The larger a firm, the more likely it is to cooperate with research organisations. Whereas only 30% of micro enterprises have R&D cooperation with the scientific community, this number rises to 52% for large enterprises. A critical firm size is needed to get the enterprises to start working with research organisations. However, this size effect might already be reached when enterprises grow from micro to small and exceed the number of 10 employees.

5.3.2 Logit models

The analysis of surveys revealed some factors that obviously influence SIL. In the following section, logit models are calculated based on involvement of enterprises and researchers in SIL. Structural variables have been taken as independent variables to distinguish their influences on whether a firm or a researcher is actually involved in SIL. The findings provide information on the parameters that need to be changed if more SIL is desired.

The first logit model tests whether a *firm's* involvement in SIL depends on (1) sectors (manufacturing, R&D service, ICT, construction), (2) firm size, (3) international origin, (4) market share generated in the CR and (5) share of highly qualified employees.

In Table 15, the different computed logit models are described. All models are significant (likelihood ration test). By adding the different variables step by step, one can see the explanatory power of every variable. This is an indicator for whether a variable significantly influences a firm's involvement in SIL.

The *Full Model* has an explanatory power of 21%. There are two variables mainly responsible for increasing the explanatory power of the model: firm size and highly qualified employees. The higher the share of highly qualified employees, the more likely a firm is to be involved in SIL. Moreover, the larger the firm, the more likely enterprises are to be involved in SIL. A critical mass of employees and a higher share of highly qualified employees make a firm more likely to be involved in SIL. If enterprises' activities grow and upgrade along the value chain, more SIL will exist. As the CR is a transforming country, growth began in mass production – low-value activities. On the trajectory curve, the country moved forward and upgraded activities, but there is still some way to go. Helping enterprises to upgrade and grow will turn enterprises more towards knowledge intensity, which will automatically result in more science-industry activities. Preparing for this step raises awareness of enterprises and practising SIL certainly stimulates this development.

It also can also be derived from the model that sectors do not have strong explanatory power. The international origin of a firm (headquarters abroad) indeed has a positive influence on SIL, but this influence is not significant. The other way around, the larger the market share generated in the CR, the more unlikely the involvement in SIL is, but this influence is not significant either.

Table 15: Binary logit model on enterprises' involvement in SIL (dependent variable: dummy enterprises involved in SIL)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Full Model**
Manufacturing firm	-0.492	-0.732	-0.754	-0.830	-0.765
R&D service	0.981	0.858	0.845	0.823	-0.093
ICT	-1.658*	-1.710*	-1.763*	-1.737*	-2.985*
Construction	-1.322	-1.334	-1.325	-1.280	-1.287
Firm size		0.580*	0.540*	0.519*	0.817*
International firm			0.420	0.325	0.504
Market share in the CR				-0.003	0.000
Share of highly qualified employees					0.031*
constant	0.405	-0.838	-0.755	-0.473	-2.109
R²	0.084	0.135	0.136	0.137	0.207
Likelihood Ration Test (sign.)	0.030*	0.004*	0.008*	0.015*	0.001*
Observations	92	92	92	92	92

* significant

Source: Data based on own survey conducted in International Audit CR [2010]

The second model tests whether a *researcher's* involvement in SIL depends on (1) the research organisation in which he/she is employed (university, technical university, ASCR), (2) the field of research (industry research (e.g. engineering), agriculture, informatics), (3) size of the working group, (4) time spent for research and management, (5) years of working experience, (6) international working experience and (7) work alone attitude.

In Table 16, the different computed logit models are described. Again, all models are significant (likelihood ration test). The *Full Model* shows that being associated with technical universities or the ASCR, being a researcher in agriculture and industry research, being member of a large working group, having time to spend for the managing of projects and increasing working experiences are the significant factors for researchers being involved in SIL. To increase the number of researchers involved in SIL would therefore mean giving them extra time to spend for managing projects with industry members, as they work differently to purely research projects. Research organisations must give priority, time and training courses to this. Moreover, organising larger research groups also contributes to more SIL. This probably requires restructuring of research units. Furthermore, giving incentives to researchers with more working experience who are mature in their research career to transfer their knowledge to industry might also increase SIL.

Table 16: Binary logit model of researchers' involvement in SIL (dependent variable: dummy enterprises involved in SIL)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Full Model**
University (dummy)	-0.917*	-0.574*	-0.772*	-0.606	-0.595	-0.594	-0.597
TU (dummy)	0.873*	0.895*	0.716	0.965*	0.925*	0.924*	0.879*
ASCR (dummy)	-0.195	0.315	0.508	0.539	0.613*	0.615*	0.588*
Industry research (dummy)		1.463*	1.599*	1.560*	1.525*	1.523*	1.526*
Agriculture research (dummy)		1.801*	1.860*	1.911*	1.875*	1.877*	1.829*
Informatics research (dummy)		0.421	0.233	0.188	0.199	0.200	0.241
Size of working group			0.649*	0.628*	0.623*	0.623*	0.608*
Time spent for research				0.164	0.151	0.150	0.148
Time spent for management				0.343*	0.359*	0.358*	0.359*
Years of working experience					0.330*	0.328*	0.326*
International experience (dummy)						-0.089	-0.078
Work alone attitude (dummy)							-0.169
constant	0.033	-0.604	-2.330	-3.381	-4.083	-4.071	-3.948
R^2	0.050	0.101	0.154	0.160	0.170	0.170	0.171
Likelihood Ration Test (sign.)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	516	516	516	516	516	516	516

Source: Data based on own survey conducted in International Audit CR [2010]

5.3.3 Pattern of science-industry cooperation

This section offers a view of the SIL pattern – from the researchers' as well as from the enterprises' perspective. It only takes enterprises and researchers with respective cooperation into account.

Researchers were asked what kind of firm they cooperate with. A distinction was made (1) between Czech and international enterprises and (2) between small and medium-sized enterprises (SMEs), large enterprises (LEs) and multinational enterprises (MNEs). Table 17 identifies the share of researchers with industry cooperation in R&D according to their home organisation. 76% of all researchers are involved in R&D collaboration with Czech SMEs. This number grows in technical universities to 83%, in other research organisations even to 87%. The share of researchers at the ASCR with SME cooperation is slightly lower. The second largest share (but far behind) is the cooperation with Czech LEs (35%), whereas technical universities and other researcher organisations contribute the lion's share. MNEs in the CR are addressees of about 1/3 of university and technical university researchers.

Accordingly, technical universities, universities and other research organisations are the largest carriers of SIL in the CR. The ASCR has fewer linkages. Czech SMEs are the main addressees of knowledge transfer.

The picture on cross-border SIL looks different. In general, about 1/5 of researchers work with companies abroad. Again, SMEs are the most important clients for researchers, especially for researchers at universities and the ASCR. MNEs and LEs abroad are mainly addressed by researchers at technical universities and the ASCR.

Knowledge transfer to enterprises in the CR is of higher importance than to those abroad for all research organisations. Technical universities perform best in SIL (nationally and internationally). Links per researcher at technical universities are also highest (2.3), whereas they are lowest in the ASCR (1.7). Data show that the ASCR is seen as being relatively more active in knowledge transfer abroad than to enterprises in the CR, whereas it is the other way around with other research organisations. It is suggested that this could be because foreign enterprises have a greater absorptive capacity in highly specialised areas of research. This makes them more attractive for research institutes in the CR. Again, specialisation in knowledge production and transfer – also from a geographical dimension – could be revealed.

Table 17: Share of researchers with industry cooperation according to research organisation

	University	TU	ASCR	Other research organisation	Total
In the CR					
Multinational enterprises (MNEs)	30%	39%	15%	13%	23%
Large enterprises (LEs)	37%	54%	20%	47%	35%
Small and medium-sized enterprises	75%	83%	68%	87%	76%
Internationally					
Multinational enterprises (MNEs)	14%	22%	21%	11%	18%
Large enterprises (LEs)	11%	19%	19%	11%	16%
Small and medium-sized enterprises	30%	17%	23%	16%	22%
Number of cases	57	54	118	45	274
Responses per Researcher	*2.0*	*2.3*	*1.7*	*1.8*	*1.9*

Source: Data based on own survey conducted in International Audit CR [2010]

The data show that the larger the working group size, the more frequently researchers work with industry. The major change is reached when a working group exceeds the number of 20 researchers. Also, the number of linkages increases significantly when turning to larger groups. A second finding concerns SMEs. SMEs are already taken as clients even if the working group is smaller. 64% of working groups with 1-5 people have collaboration with SMEs in the CR. This number increases with size, but the biggest change takes place if the group number exceeds 10 people. Even if smaller working groups have difficulties serving large enterprises, they can work very well with SMEs.

Enterprises were also asked to describe their cooperation pattern with research organisations. Again, the indicated findings only concern enterprises with research cooperation – in total, 44% of the sample of innovative enterprises. Technical universities (73%), public universities (48%) and the ASCR (31%) are the major partners for enterprises for R&D cooperation in the CR (Table 18Table). Cooperation with international research organisations is applied by about 20-30% of enterprises. These findings differ according to sectors:

Manufacturing: Technical universities are by far the most important partners for manufacturing enterprises (72%), followed by other private research organisations (40%). Public universities and the ASCR account for relatively low shares. Among the private research institutes, there are former sectoral research organisations that have been privatised during the transformation process. Some of them still seem to be closely linked to formerly state-owned enterprises. They seem to be well integrated into the new research landscape. Manufacturing enterprises have 2.5 research organisations as partners on average.

R&D Services: Technical universities, public universities, the ASCR and other public research institutes (VVI) are the most frequent partners of firms involved in R&D services. Their range of partners is very broad and, on average, they work with 3.5 research organisations.

This trend should be continued in the future in general. Some enterprises indicated that they foresee an increase in cooperation with technical universities, but also with research organisations abroad.

Table 18: Share of enterprises with research cooperation according to sector

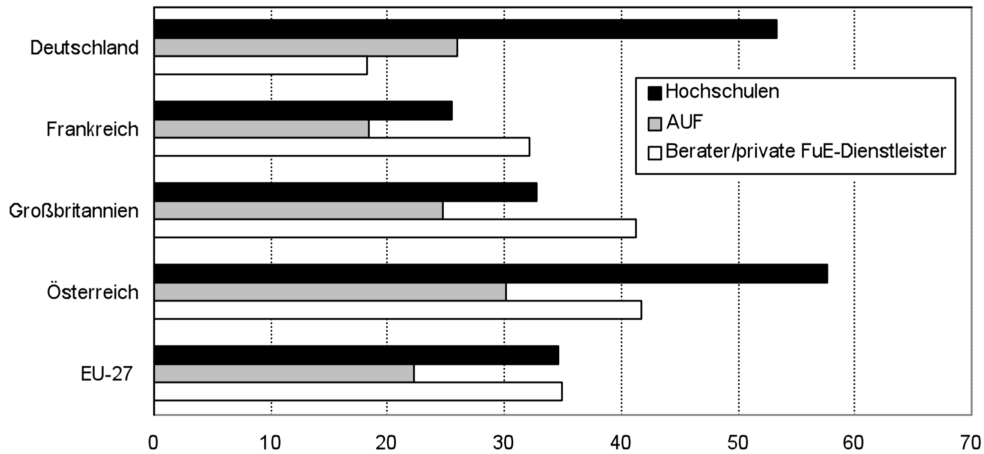
	Manufac turing	**R&D services**	**Other**	**Total**
In the CR (national level)				
Public universities or other public higher education institutes (except technical universities)	28%	61%	63%	48%
Technical universities	72%	78%	68%	73%
University hospitals	12%	6%	5%	8%
Private universities or other private higher education institutes	0%	17%	11%	8%
Public research institutes of the Academy of Sciences (VVI)	28%	50%	16%	31%
Other public research institutes (VVI)	16%	39%	21%	24%
Private non-profit research organisations	4%	22%	21%	15%
Other private research organisations	40%	22%	16%	27%
Internationally				
Higher education institutes	28%	22%	16%	23%
Other research organisations	20%	33%	32%	27%
Cases	*25*	*18*	*19*	*62*
Responses per firm	*2.5*	*3.5*	*2.7*	*2.8*

Source: Data based on own survey conducted in International Audit CR [2010]

NOTE: WHAT WORKS ELSEWHERE

International Comparison: A study on "Science, interaction and governance for technological capacity building in Germany" (Polt et al. 2009) revealed the major research partners of enterprises in Europe. In Germany, the most important partners for enterprises are universities (~50%), followed by public research organisations and private research organisations (Figure). This picture is similar to that in the CR.

Figure 40: Innovation cooperation with research organisations in a European comparison (in % of cooperating enterprises)



Source: Polt et al. 2009

5.3.4 Summary: cooperation pattern

48% of **researchers** indicated having industry cooperation, while researchers at technical universities perform best (75%), ASCR researchers hit the average (50%) and university research perform the lowest (1/3). Accordingly, there are considerable differences between disciplines. Researchers in engineering and informatics reported the highest share of SIL, researchers in natural and agricultural science indicated medium shares and researchers in social science and humanities have only a few SILs. SIL exists to a great extent at technical universities with their corresponding fields, but universities are somewhat limited by nature with their classical range of research fields. A specialisation of SIL according to research organisations and disciplines takes place in the CR.

There are regional differences in the performance of SIL. While Prague hits the average, Liberec, Hradec Králové and Pardubice, as well as South and Central Bohemia, outperformed the other regions.

Whereas cooperation with other research organisations is applied by almost all research groups, relations to industry have a clear size effect. The larger the group is, (critical mass) the more SIL occurs. Furthermore, the survey showed that larger groups work more frequently with larger enterprises, but smaller groups work with smaller enterprises. A matching of the size of enterprises and groups seems to improve success.

Linkages to SMEs in the CR are very frequent in all working groups, while linkages to large enterprises are only addressed by few researchers. About 1/5 of researchers have cross-border SIL. Knowledge transfer to enterprises in the CR is of higher importance than abroad for all research organisations. Technical universities perform best in SIL (nationally and internationally). Data show that the ASCR is seen as being relatively more active in knowledge transfer abroad than to enterprises in the CR. Again, specialisation in knowledge production and transfer – also from a geographical dimension – could be revealed.

44% of all surveyed **enterprises** reported having R&D cooperation with research organisations. The share is high due to a selection of innovative enterprises in the sample. Whereas R&D services have, by nature, the highest share (54%), manufacturing enterprises (40%) and ICT and construction (~30%) have only set up SIL to a limited extent.

The regional distribution of enterprises involved in SIL differs, but the low number of observations does not allow for a generalisation.

Technical universities are the most desirable cooperation partners for enterprises, followed by other research organisations. Scientific partners of enterprises are mainly located within the CR, but not in the region itself. Research organisations abroad or even outside Europe are hardly addressed by enterprises in the CR. International integration is only realised to a minimal extent.

5.4 Modes of interaction

This section focuses on the various channels to transfer knowledge from science to industry and the other way around. Channels for industry-science knowledge transfer range from joint publications and projects, personal contacts, staff and facility exchange, contract research, training programmes and professional experience in research or industry respectively. Enterprises and researchers were asked to indicate what kind of channels they have used in the last three years. Moreover, they assessed to what extent these activities have been valuable for the advancement of their research.

5.4.1 Diversity of knowledge transfer channels

The most common knowledge transfer channels used by *researchers* in the CR are (1) personal (informal) contacts with staff in enterprises (62%), (2) participation/talks at conferences and workshops which industry members attend (57%) and (3) joint R&D projects with companies in national programmes (42%) (Table 19). The share refers to all researchers involved in SIL. But only 48% of all researchers are involved in SIL. All other channels are only used by about 1/3 of all researchers. Although the variety of potential channels is high, the true channels used by researchers are very limited. The full range of possible paths of knowledge transfer is still to be exploited. TTOs are hardly used (8%). Personal mobility in terms of SIL (temporary staff exchange with industry, staff holding positions in both a research organisation and industry, hiring employees from industry) could hardly be identified. Training of industry staff at research organisations is rarely used.

Researchers had to assess their activities on a Likert Scale (1=not at all valuable to 5= valuable to a very large extent). Personal contacts, joint R&D projects with companies in national programmes and personal working experience with industry were evaluated as most successful. Whereas personal contacts and joint projects are also very popular channels, working experience in industry is less often used, but very efficient. Making greater use of personal mobility between industry and research seems to contribute to more and better SIL. While in general, the most frequently used channels are the same over all research organisations, some differences still occur:

- **University**: While universities are generally not very active in SIL, they revealed the advantages of using some channels more actively. Personal contacts and participation in conferences are most frequent, but the effectiveness of conferences on advancement of one's own research was deemed to be poor in comparison. Instead, positive experiences were had when working in joint projects, when consulting companies, when personal working experience with industry exists and when facilities (e.g. laboratories, equipment, and housing) had been shared.
- **Technical University**: Over 50% of researchers with SIL actively use the following channels: personal (informal) contacts with staff in enterprises,

participation/talks at conferences and workshops which industry members attend, joint R&D projects with companies in national programmes, publishing other industry-relevant publications (reports, magazines, newsletters), contract research for industry (incl. PhD projects) and personal working experience with industry. Technical university researchers use the greatest variety of channels and are most actively involved in SIL. According to their experience, personal contacts are very useful for keeping relationships running. Moreover, good experiences have been had with joint projects, working experience in industry and contract research. Human interactions seem to be the secret for understanding.

- **ASCR**: Researchers at the ASCR mainly use personal contacts with industry members as a channel for knowledge transfer. All other channels have only been used by a very limited number of researchers, which also refers to its nature as a research institute for basic research. Joint projects were assessed as being the most effective way to learn from each other. The limited number of links forms a contrast to the high share of GOVERD financed by industry. In Section 3.3.1, it was mentioned that income through licences (particularly generated by one institute of the ASCR) is responsible for this high share. An in-depth look provided by the survey clearly revealed that interaction with industry is limited for most of the researchers. But research and innovation is not a one way channel: feedback loops are foreseen that also touch and influence basic research. Certainly, the ASCR has more potential for SIL in general, but whether it is useful to ask actively to become involved in SILs depends on their task and orientation in the Czech innovation system.

Table 19: SIL Channels for researchers: frequency and assessment

Channels	Total (n=274)		University (n=57)		TU (n=54)		ASCR (n=118)		Others (n=45)	
	Share	Mean	Share	Mean	Share	Mean	Share	Mean	Share	Mean
Personal (informal) contacts with staff in enterprises	62%	3.6	56%	3.7	70%	3.9	55%	3.3	73%	3.5
Participation/talks at conferences and workshops which industry members attend	57%	3.1	54%	3.3	76%	3.2	46%	3.0	60%	3.3
Joint R&D projects in national programmes	42%	3.6	35%	3.6	50%	3.6	38%	3.5	49%	3.8
Publishing other industry-relevant publications (reports, magazines, newsletters)	35%	3.0	32%	2.9	52%	3.0	25%	2.9	40%	3.2
Consultancy for companies	35%	3.2	39%	3.6	43%	3.3	23%	2.7	51%	3.2
Contract research for industry (incl. PhD projects)	34%	3.2	30%	3.0	59%	3.5	28%	3.0	22%	3.4
Personal working experience with industry	33%	3.6	21%	4.0	50%	3.7	28%	3.3	36%	3.8
Shared scientific publications with industry members	32%	3.0	33%	2.8	41%	3.0	31%	3.1	27%	3.2
Sharing facilities (e.g. laboratories, equipment, housing) with companies	20%	3.3	25%	3.6	31%	3.1	17%	3.2	11%	3.4
Establishing of exchange and training programmes for students with industry	18%	3.1	28%	3.3	31%	3.4	11%	2.6	4%	2.0
Contract-based education and training for companies	18%	2.9	28%	3.3	31%	3.1	5%	1.5	18%	3.0
Joint R&D projects in EU Framework Programmes	17%	3.2	19%	3.3	15%	3.3	16%	3.2	16%	2.9
Hiring employees from industry	10%	2.0	9%	2.6	13%	2.3	11%	1.7	4%	2.0
Staff holding positions in both a research organisation and industry	10%	2.6	9%	2.6	13%	2.6	9%	2.4	9%	3.0
Using the Technology Transfer Office (TTO) services	8%	2.1	14%	2.1	13%	2.3	6%	1.7	2%	3.0
Temporary staff exchange with industry	6%	2.0	4%	1.0	7%	2.3	8%	2.2	2%	1.0

Note: Mean – Assessment on a Likert Scale (1=not at all valuable for advancement of research, 5=valuable to a very large extent)
Source: Data based on own survey conducted in International Audit CR [2010]

Other relevant relations between the channels of knowledge transfer and structural oriented issues are:

- **Size and origin of firm**: LEs and MNEs in the CR cooperate with researchers in terms of contract research, consultancy and joint projects. SMEs in the CR are mainly addressed when working in joint projects. Consultancy and contract research are probably too expensive for SMEs. This picture looks very similar for cross-border SIL.
- **Size of working groups**: Some channels are used by researchers independently of the size of working groups, for example joint research projects, hiring staff from industry, publishing other industry-relevant publications. The use of other channels has a size effect. Shared scientific publications with industry members are more easily realised when the working group is larger. Staff holding positions in both a research organisation and industry is more frequently used in large working groups. Contract research for industry (incl. PhD projects) is more common in larger groups. Contract-based education and training for companies is also only realisable in larger research groups. When expecting researchers to use the variety of channels, basic conditions might have to be changed in order to realise effects.
- **Regions:** Whereas the overall weight of channels used to address enterprises is the same for all regions, researchers use different channels across regions more or less frequently than the average. A comparison between regions with a high number of researchers who responded to our survey shows differences. These differences can be taken as learning experiences.
    - **South Moravian region (n=26):** This region performs better than average in the use of conferences and talking to people from industry. Moreover, publishing in industry-relevant journals, reports or newsletters is more often applied. The use of TTO is slightly more frequent than in other regions.
    - **Central Bohemian region (n=13):** In Central Bohemia, more researchers than average indicated having personal working experience in industry. This goes along with a higher integration of students in industry research via exchange and training programmes. Furthermore, TTOs are more often used than average. On the other hand, they perform below average in contract research.
    - **Moravian-Silesian region (n=13):** This region outperforms the rest in a variety of channels which they use more frequently than average. They indicated having joint scientific publications with industry members more often and they are more involved in publishing in industry-relevant journals, magazines or newsletters. Researchers in these regions more often attend conferences and talks with industry members and they more often have personal working experience in industry. They also perform best in joint projects in nationally funded programmes and contract research. On the other hand, they have a very low performance in joint projects on the EU level. Although this sounds very enthusiastic, the findings are based on a very low number of observations; therefore, it should be considered with caution.
    - **Prague (n=118):** Prague numbers are rarely exceptional. They mainly hit the average, but they also count for half of the researchers and therefore heavily shape the average. There is only one outstanding number. The share of researchers involved in contract research is below average in comparison to other regions.

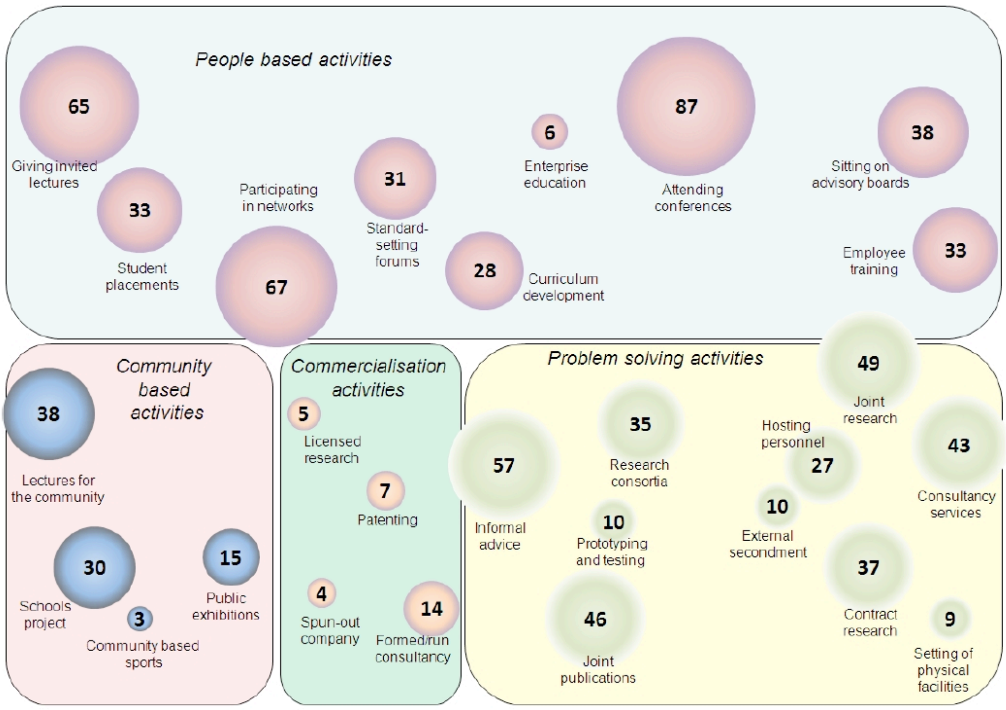
At the beginning of the researchers questionnaire, researchers were asked to indicate whether they are actively involved in technology transfer. 122 out of 689 researchers reported being involved (18%). In reality, 328 researchers are involved in SIL (48%).

Only 18% instead of 48% of researchers indicated participating in SIL at the beginning of the questionnaire. This number already gives a hint as to where a problem could be identified. Researchers' own perceptions of SIL produce distorted findings per se. Many more researchers are involved in SIL than actually perceive it in this way. Basic understanding of SIL needs improvement, awareness-increasing measures would be of great use. Moreover, standard indicators are not a good carrier of information in this perspective.

NOTE: WHAT WORKS ELSEWHERE

United Kingdom: In the UK in 2008-2009, a study was conducted on the interaction activities of researchers with industry. The study was based on about 22,000 responses from researchers in the UK. Figure 41 outlines how many researchers use specific modes of interaction. The share thereby refers to the total number of responses instead of the number of researchers involved in SIL. Attending conferences and participating in networks to establish and maintain contacts to people from industry are the most common interactions. What was even more emphasised was the training aspect: researchers give lectures to industry members and engage in employee training. The consultancy of enterprises (informally or formally) is also of higher frequency in the UK (Abreu M., Grinevich V., Hughes A., Kitson M. 2009).

Figure 41: Academic external interaction activities in the UK (% of responses)



Source: Abreu M., Grinevich V., Hughes A., Kitson M. (2009)

Enterprises were also asked to indicate what kind of linkages they have used with research organisations in the last three years. We have to keep in mind that the shares are related to all enterprises having SIL. In total, only 44% of all enterprises and 48% of all researchers in the survey are involved in SIL. A very similar picture to the researchers' image emerged (Table 20Table). Personal (informal) contacts with people in academia/research (75%), participation/talks at scientific conferences and workshops (64%), shared scientific publications with people from academia/research (55%) and joint R&D projects with research organisations in national programmes (52%) are the most frequent channels used over all enterprises. Three of the four most common knowledge transfer links of enterprises have been mentioned by researchers as well. Only little use is made of establishing training programmes with research organisations, contract-based education and training delivered by research organisations, using the TTO services at universities and temporary staff exchange with research organisations.

Enterprises were also requested to assess how useful the cooperation for the advancement of R&D&I in their enterprise has been. Personal contacts and joint projects were assessed most positively by far. Conferences are a frequently used means of meeting people from academia, but not very effective.

Although personal contacts are important for enterprises independently of the sectors, there are still some differences between manufacturing enterprises and R&D services. The number of cases was too small to make a separate distinction for informatics or construction.

- **Manufacturing**: Many enterprises use personal contacts and conferences to establish and maintain their relations. But manufacturing enterprises also have good experiences when working in other ways with research organisations. Joint projects funded by national or EU programmes, contract research (incl. PhD projects) and consultancy contracts were assessed as being an effective means of working with academia.
- **R&D Services**: By nature, R&D services are very actively involved in SIL. Apart from personal contacts and conferences, they work on joint scientific publications and joint projects funded by national or EU institutions. About 1/3 are involved in facility sharing, in contract research, used training programmes offered by research organisations or have staff holding positions in both a research organisation and industry. They also give good marks for the functioning of their networks. R&D services can be seen as frontrunners in establishing SIL. They can serve as learning experiments.

Table 20: SIL Channels for enterprises: frequency and assessment

Channels	**Total (n=64)**		**Manufacturing (n=25)**		**R&D Services (n=18)**		**Others (n=19)**	
	Share	Mean	Share	Mean	Share	Mean	Share	Mean
Personal (informal) contacts with people in academia/research	75%	3.7	76%	3.5	78%	4.2	74%	3.6
Participation/talks at scientific conferences and workshops	64%	3.2	52%	3.0	72%	3.6	74%	3.2
Shared scientific publications with people from academia/research	55%	3.3	40%	3.1	67%	3.9	63%	3.0
Joint R&D projects with research organisations in national programmes	52%	3.7	44%	4.1	61%	3.9	53%	3.1
Joint R&D projects with research organisations in EU Framework Programmes	36%	3.3	32%	3.8	50%	3.6	26%	2.6
Sharing facilities (e.g. laboratories, equipment, housing) with research organisations	33%	3.3	28%	3.4	33%	3.5	37%	3.4
Hiring employees from research organisations	25%	2.8	24%	3.0	22%	3.3	26%	2.6
Place research contracts to research organisations (incl. PhD projects)	25%	3.1	20%	3.6	33%	3.5	21%	2.3
Staff holding positions in both a research organisation and industry	23%	3.2	20%	3.4	33%	3.5	16%	3.0
Place consultancy contracts to research organisations	23%	3.2	24%	3.5	28%	3.8	16%	2.0
Establishing exchange and training programmes with research organisations	20%	2.6	12%	2.3	33%	3.0	16%	2.7
Contract-based education and training delivered by research organisations	20%	2.5	12%	2.7	22%	3.0	26%	2.4
Using the Technology Transfer Office (TTO) services at universities	16%	2.7	16%	2.5	17%	3.3	11%	3.0
Temporary staff exchange with research organisations	9%	1.5	4%	1.0	11%	2.5	11%	1.0

Note: Mean – Assessment on a Likert Scale (1=not at all valuable for advancement of research, 5=valuable to a very large extent)
Source: Data based on own survey conducted in International Audit CR [2010]

NOTE: WHAT WORKS ELSEWHERE

Germany: A study on "Science, interaction and governance for technological capacity building in Germany" (Polt et al. 2009) revealed the major channels used to transfer knowledge from industry to science and the other way around. A very similar pattern occurs. More than 70% of industry enterprises indicated that informal, personal contacts are the most important interactions. This is similar to findings in the CR. About 50% of German industry enterprises receive scientific consultancy from research organisations. This number is considerably lower in the CR. About 40% of German enterprises cooperate in terms of Master or PhD theses. 30% of German enterprises are involved in joint projects (this number is slightly higher in the CR). Contract research is also performed by about 30% of German enterprises (25% in the CR). 28% of German enterprises are involved in training courses at research organisations (20% in the CR) and 13% apply a temporary staff exchange (9% in the CR). The ranking of channels according to importance is similar in Germany and the CR, but personal mobility between research and industry in particular as well as training courses and consultancy contracts are more often used in Germany.

Netherlands: In 2006, a survey on SIL was conducted in the Netherlands. 575 valid responses from researchers were compared to 454 valid responses from enterprises (Bekkers R., Bodas Freitas I.M. 2008). The most important channels used by enterprises are joint publications, patents, personal contacts and employment of university graduates. Notable is the excellent assessment of PhD projects funded by industry and temporary staff exchange. The authors recommend reading the paper for detailed findings.

5.4.2 Summary: modes of interaction

Personal contacts, conferences and joint projects are most frequently used as channels of knowledge transfer between enterprises and researchers in the CR. Whereas personal contacts and conferences give a good platform for establishing and maintaining a network (passively), joint projects require the activation of networks and the actual exchange of ideas. Networks are good to have and need to be "ready to use" when there is an opportunity. Concrete projects push the transfer of knowledge, and are therefore evaluated as very good.

Although there is a long list of channels to use, the variety that actually comes into action is limited. This calls for better use of the variety of options. There is potential for better activities regarding *personal mobility* (e.g. staff exchange, holding double positions, recruitment policy) and *training opportunities* (e.g. research organisations train industry staff, industry funds PhD students). Although there are already several systematic activities regarding training opportunities, for example, the quality of such training varies and often needs tremendous improvement to not reduce the credibility of the whole SIL topic.

Technical universities most actively use the different knowledge transfer channels. They are involved in joint projects, employ people with industry background and conduct contract research. Universities, and especially researchers in the ASCR, rely more often on personal relations, which is a rather passive mode of exchange. But those researchers who have experience with other paths of exchange assess them very positively. Although there is an argument saying that basically oriented research institutes need limited SIL, the innovation process is not linear, but runs in cycles with feedback loops that are also important for basic research. All researchers have the potential to profit from SIL. Experiences show that even researchers at the ASCR consider exchange with industry members to be fruitful. There is more potential for excellent SIL, but the extent and direction must be given on the policy level.

The survey also revealed that the larger the firm and the larger the research group, the higher the variety of channels used. SMEs are profiting the most from joint projects. Large enterprises and large research groups cooperate in contract research.

The section also showed that standard measures do not deliver a realistic picture of ongoing activities in SIL. More complex measures are needed to create an unbiased image. The standard measures underestimate the linkages. Moreover, researchers need to broaden their understanding of SIL. Awareness measures would help to situate the aspects of SIL better – their broad spectrum and their profits – in researchers' perception.

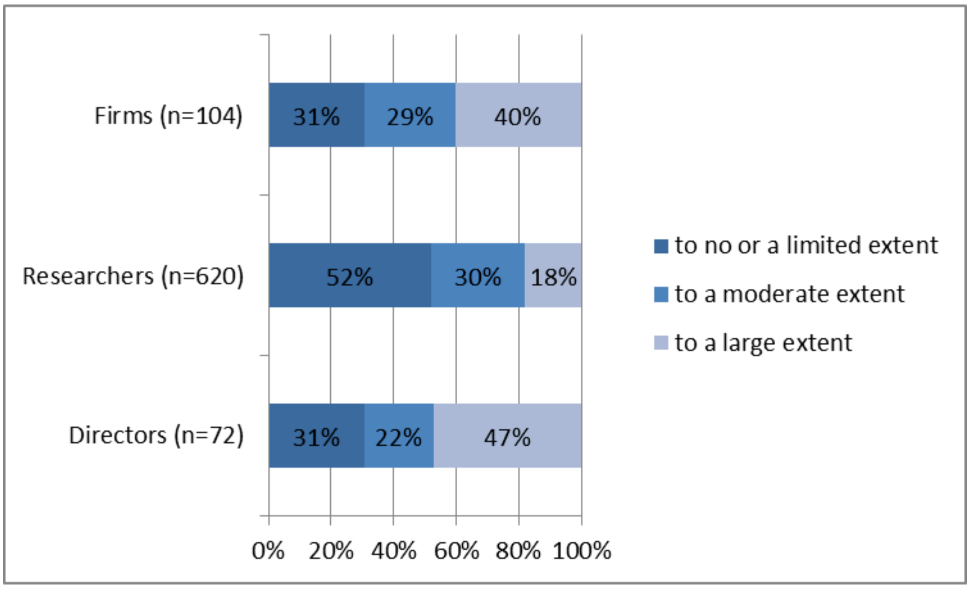
5.5 Satisfaction and barriers to SIL

Participants in the survey reported on their general satisfaction of SIL in the CR. SIL can deliver an important contribution to the Czech innovation system, but insufficient SIL can be a barrier for the R&D&I performance. Directors, researchers and enterprises were asked to indicate whether they perceive insufficient SIL as an obstacle for the Czech research and innovation system. Moreover, they delivered insights into the specific character of barriers.

5.5.1 General satisfaction of SIL: a stakeholders' perspective

40% of the enterprises consider insufficient SIL to reduce the performance of the R&D&I system in the CR (Figure 42Figure). 31% believe that existing SILs are satisfactory. Satisfaction responses are by no means all negative, but show a diversity of opinions.

Figure 42: Insufficient SIL as a barrier for the R&D&I performance of the CR

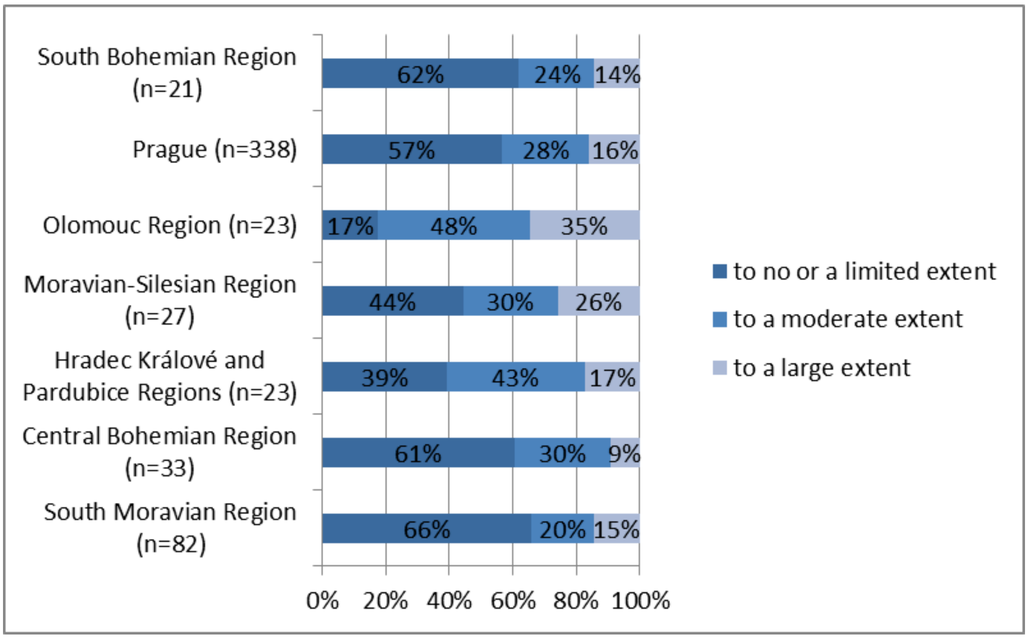


Source: Data based on own survey conducted in International Audit CR [2010]

47% of the directors of research organisations believe that insufficient SIL constitute to a large extent a barrier for the CR. Interestingly, only 18% of the researchers think so. 52% of the researchers suggest SILs do not cause any problems in the CR. There seems to be a big gap in the perception of researchers and directors. Reasons for this could be twofold. (1) Researchers apply cooperation with industry in various channels and therefore they do not see SIL as insufficiently addressed or as an obstacle. Directors might not know about researchers' actual activities, but perceive standard measurements of SIL as being deficient. (2) Directors believe in the importance of SIL for the Czech research and innovation system. It seems difficult to spread this idea to all researchers within the organisation. Researchers are lacking awareness for SIL, and it is therefore not weighted as being an important contribution to the overall Czech innovation system. In any case, there is a gap in perception and the importance of SIL between researchers and directors. With this gap in the mindsets, it is difficult to set priorities, make decisions and adapt the behaviour of a research organisation.

Figure 43Figure illustrates how satisfaction is distributed over the Czech regions. Whereas most regions hit the average in terms of satisfaction with SIL, researchers in the Olomouc Region most frequently consider insufficient SIL to be a problem for the CR. The highest shares of researchers suggesting that insufficient SILs are not an issue in the CR are located in the South Bohemian region, in the Central Bohemian region and in the South Moravian region.

Figure 43: Satisfaction of researchers with SIL in the different regions



Note: Only regions with more than 20 observations are taken into account

Source: Data based on own survey conducted in International Audit CR [2010]

From a *researchers'* perspective, some more observations could be made:

- Researchers in agriculture and economics (~35%) perceive SIL as a major problem, followed by researchers in medicine, industry research, earth science and informatics.
- Researchers and directors conducting mainly basic research indicated that SIL is a minor problem for the CR, while researchers doing mainly applied research perceived SIL as a larger problem.

A further investigation of *enterprises* showed that:

- Local enterprises reported insufficient SIL to be a larger problem for the CR than international enterprises. Due to the low number of cases, this cannot be generalised.
- No relation could be found between the assessment of importance of SIL and different sectors or firm sizes.
- Measures of policy makers taken to enhance science industry cooperation are not positively evaluated by enterprises. ~70% of enterprises are not satisfied or only to a limited extent. Only 2% of enterprises indicated feeling sufficiently supported. Although our empirical findings show that there are ongoing activities under the umbrella of SIL, the support measures by the government are considered to be of rather poor quality.
- The negative assessment of policy measures regarding SIL is true for all regions. South Moravia is the only region where enterprises assess SIL measures to be a little better. This also fits with the picture of overall satisfaction with SIL, where enterprises and researchers in South Moravia also assessed SIL most positively.

5.5.2 Barriers to SIL

For an in-depth view of the actual barriers of SIL, directors, researchers and enterprises indicated their main reasons why SILs are difficult to realise.

Barriers have been divided into:

1. those *specific to the national institutional system* (e.g. legal framework conditions or intellectual property rights (= IPR) rules that hinder effective knowledge transfer activities, tax incentives for internal R&D activities that reduce outsourcing of R&D),
2. those *specific to organisation* (e.g. research organisation provides few incentives to cooperate with industry, R&D investments are not of high importance in my firm, high costs of R&D activities are not affordable) and
3. those *specific to relations* (e.g. mismatch of knowledge and research needed, partners from industry/research are difficult to find, conflicts between the interests of academic and industrial researchers and different expectations and difficult project management).

Participants were asked to rank the barriers on a Likert Scale according to the extent to which they hinder SIL (1 = not at all, 5 = to a large extent). The mean is indicated separately for directors, researchers and enterprises (Figure 44). A distinction has thereby been made between participants with and without SIL to see whether barriers increase or decrease in perception when applying SIL.

In general, people from industry and research have a similar perception of barriers. The major barriers for SIL suggested by industry and research are:

- Finding appropriate partners
- Mismatch of knowledge and research needed
- Defining expectations and managing projects
- Conflicts of interests between academic and industrial researchers

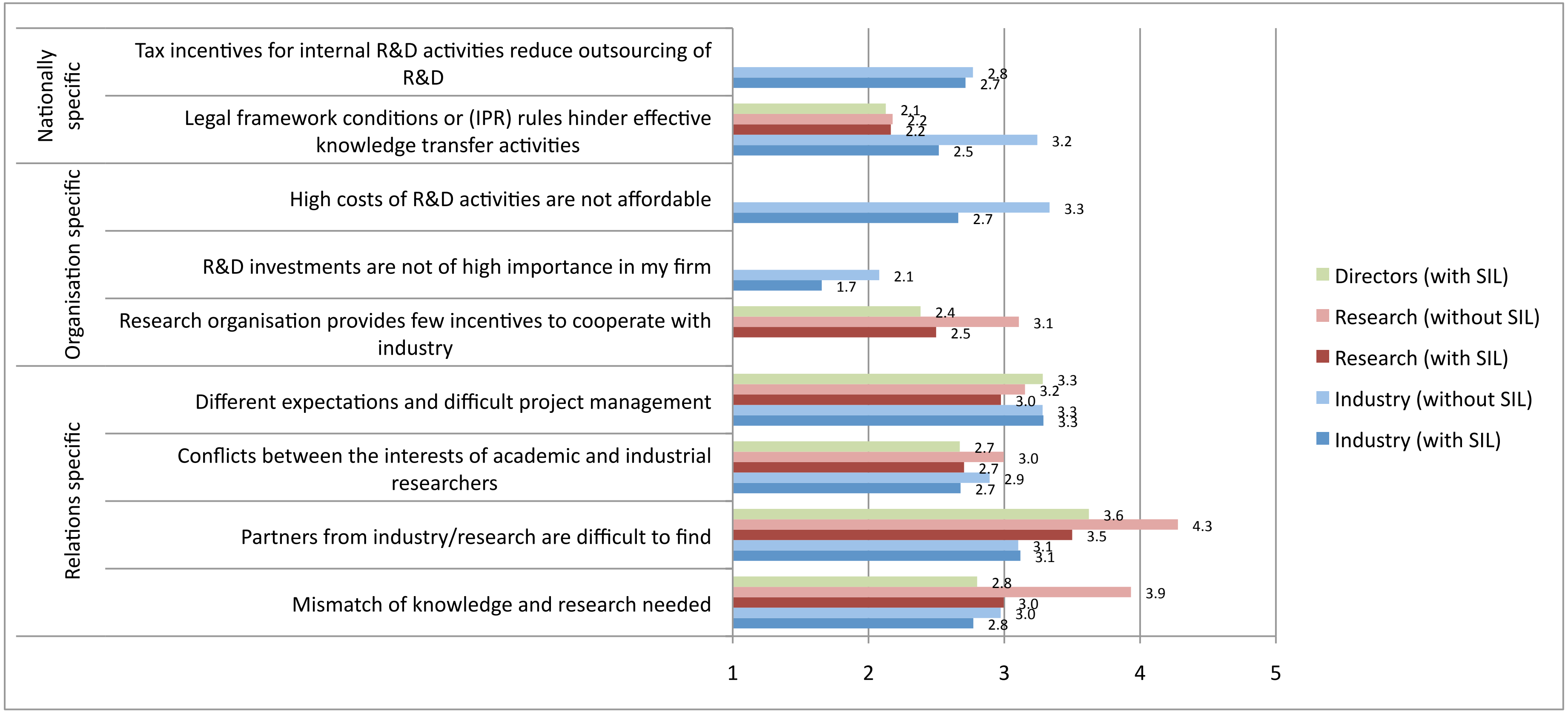
All four barriers are relation-specific. Although the CR is not a big country, finding partners is - for both research and industry – a major impeding factor for SIL. This statement refers to *not knowing* where to find partners. The mismatch of knowledge and research interests includes the *non-existence* of partners in the CR. Another major problem is the different expectations and interests on the one hand, but at the same time major difficulties managing the projects (time and cost issues are included here). If differences between researchers and industry are to be made, researchers emphasise the problem of finding appropriate enterprises slightly more (interested in their research results), whereas enterprises mention the problem of different expectations and management practises slightly more.

National institutional conditions such as the tax incentive for in-house R&D for enterprises or legal framework conditions are no hindrance to SIL. High R&D expenditure or no need for R&D is rarely a reason for enterprises to stay away from SIL. A poor incentive structure for SIL in research organisations is only a reason for researchers who have not yet worked with industry.

Another observation is that survey participants who do not have any SIL perceive all problems to be much larger than enterprises and researchers who are involved in SIL. Integrating more researchers and enterprises into SIL perhaps reduces the perception of problems.

Accordingly, researchers and enterprises could need support in finding each other to actually make cooperation possible. In a next step they might profit from support in formulating expectations and interests and project management support. Only this might lead to satisfaction and follow-up cooperation.

Figure 44: Barriers to SIL



Source: Data based on own survey conducted in International Audit CR [2010]

NOTE: WHAT WORKS ELSEWHERE

Germany: A study on "Science, interaction and governance for technological capacity building in Germany" (Polt et al. 2009) revealed the major obstacles for enterprises to cooperating with research organisations. The three most important barriers outlined are (1) no need for cooperation (corresponds to "R&D investments are not important in my firm"), (2) no relevant knowledge available (this corresponds to "mismatch of knowledge and research needed") and (3) a lack of information on research in research organisations (this corresponds to "difficulties to find partners"). A comparison with Germany shows that the major obstacle to actually identifying the right research partner is the same. Even though Germany is a more advanced country in terms of economic development, expenditure for R&D is not a large barrier for enterprises, neither in the CR nor in Germany.

Ireland: To counteract different expectations and difficult project management in SIL, a survey was conducted in Ireland to identify training requirements for researchers involved in SIL. Key priorities for training outlined are: Business Networking, Commercialisation Techniques, Finding/Engaging with Business, IP Protection and Management, Knowledge Transfer Management in Practice, Licensing, Spin-offs and Start-ups Creation, Technology/Knowledge Exploitation, Valuation of Technologies/Businesses/IP (Universities Ireland, Trade & Business Development Body, Irish Universities Association 2006).

5.5.3 Summary: satisfaction and barriers

SILs in the CR are not by any means perceived only negatively, but rather encounter a diverse field of opinions. 40% of enterprises believe insufficient SILs are a barrier for the Czech R&D&I system, but 31% of enterprises are satisfied. Local enterprises assess SIL as being a larger problem than international enterprises. Although our empirical findings show that there are ongoing activities under the umbrella of SIL, the support measures by the government are assessed as being of extremely poor quality. The highest satisfaction with SIL in the CR is reached in the South Moravian region from both perspectives – researchers and enterprises.

Researchers and directors of research organisations have large differences in opinions. 47% of directors suggest problems with SIL hinder the further development of the R&D&I system in the CR, but only 18% of researchers think so. This observation could be made in all research organisations, but the gap is largest in the ASCR. This reflects a fundamental problem in the perception and importance of SIL in the mindset of researchers on a lower level and directors in a leading position in research organisations.

The major barriers for both industry and research are (1) finding appropriate partners, (2) mismatch of knowledge and research needed, (3) defining expectations and managing projects and (4) conflicts of interests between academic and industrial researchers. In general, people from research and industry indicated the same problems. Interestingly, researchers and enterprises without SIL assess barriers as being higher than experienced people in SIL. Integrating more researchers and enterprises into SIL could perhaps reduce the perception of problems. Accordingly, researchers and enterprises could need support in finding each other, formulating expectations and setting managing practices.

5.6 Insights from interviews with enterprises and researchers

5.6.1 Background information on interviews

To gain insights from the academic and industrial point of view about their obstacles and success in current practices of cooperation, 27 interviews with companies, universities, research institutes and public organisations were conducted in November/December 2010 and April 2011 (Table 21Table). In cooperation with the Technology Centre, selection criteria were defined. It was thereby agreed to interview participants of successfully operated joint research projects, participants having R&D cooperation without a project framework and informed people from public organisations. The Technology Centre identified participants centring on different disciplines. Moreover, it suggested interviewing large, well known MNEs 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. Despite joint efforts in cooperation with the Technology Centre of the ASCR, we were not able to identify applicants of joint research projects which were eventually rejected.

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

- Structures of SIL
- Processes and experiences with SIL
- Role and assessment of public measures as support action

Table 21: Structure of interviewed partners

Type of interview partner	Number of Interviews		
Companies	10	*Large Companies*	*SMEs*
		7	*3*
Research Organisations	9	*Universities*	*Research Institutes*
		5	*4*
Public Organisations	8		
Total	27		

5.6.2 Experiences of cooperation from the industry perspective

Establishing contact

Enterprises' contacts to research organisations are mainly based on personal contacts set up during studies or PhD work. If no contacts exist, firms pro-actively search for university partners. Only sometimes are enterprises approached by research organisations. Enterprises identify and contact researchers at national conferences, by reading scientific articles, at meetings of professional associations, through direct visits, seminars and social events. As soon as more intensive cooperation has started, enterprises prefer to establish a contact point on each side – industry and research.

Training, teaching and educating each other

Training and teaching courses can run two ways. Firstly, enterprises are involved in the education of students and PhD candidates, and secondly, enterprises request training courses from university staff. The first point experienced more emphasis in the interviews than the second point.

Many of the interviewed enterprises provide extra teaching and training courses for students at university, sometimes even in their own facilities. Managers of enterprises are allowed to teach at university, as no formal qualification is needed. This is supported by the Operational Programme and European Social Funds. Managers' motivation to teach students is to enhance their employability. In their opinion, graduates often lack practical experience, advanced quality planning, social competencies in presenting, negotiating and solving conflicts. Therefore, enterprises also use the opportunity to provide part-time jobs to students to teach them special competencies. Many enterprises said that they would appreciate the introduction of a three-month mandatory internship for all students at university. Researchers also appreciated this idea. At some universities (e.g. TU Brno), study support programmes have already been introduced, making students earn credits for internships, but this could be applied nationwide. Some research institutes organise talks and exhibitions where students present their dissertations to enterprises in order to establish relationships.

Teaching activities often result in the involvement of diploma and PhD theses. Some enterprises reported having a formal procedure to develop a catalogue of topics for diploma and PhD theses. A very experienced firm reported developing three theses around a topic from different angles to reduce the risk of failure and disappointment on both sides. Enterprises take on the supervision of PhD and diploma theses, sometimes also sponsoring diploma theses. Good experience in teaching and supervision of students and PhD candidates sometimes leads to involvement when master and PhD programmes are developed at universities (strategic direction, provide courses, sponsoring etc.). The main motivation for enterprises to be involved intensively in training and education is the recruitment of the best students.

But there are many enterprises that do not follow a systematic pattern or strategy. There is evidence for an evolutionary development process of SIL in terms of teaching and training.

Knowledge also flows in the other direction. A few enterprises reported sending their employees to training activities at the universities. But enterprises complain that universities do not really appreciate this exchange. Time and quality of seminars is often lacking.

Conducting research together

Enterprises realise that there is a lot of know-how at research organisations, but there are only a few excellent and active people to bring knowledge from science to industry. All interviewed enterprises reported having contacts to universities, but only ¼ to the ASCR. For research purposes, enterprises reported being involved most frequently in contract research or joint research projects funded by national sources. Research findings are presented jointly at conferences. Large enterprises also organise and sponsor conferences together with universities. Some enterprises had staff employed part-time at university and part-time at their company. Most of the interviewed enterprises do not participate in any cluster or technology platform.

Many large enterprises indicated having a strategy of how to organise research projects with research organisations. In some cases, strategy and procedures were very clear, while in other cases, the strategy leaves a lot of leeway. One firm reported that they had developed a pattern (e.g. in the form of a manual) of what procedures need to be carried out to set up research projects in order to prepare for upcoming calls. Interesting ideas are collected, topics are defined and the overall structure of projects is prepared. Interestingly, research partners (also from universities) are contacted and involved in advance. This allows for an immediate response to programme calls. Additionally, the firm conducts a constant screening of research programmes. After a joint project was finished, another firm reported inviting the team of the university to discuss the research results and follow-up action. This method is a good starting point for cooperation and deserves to be more emphasised and institutionalised from both sides – university and industry.

Enterprises reported that cooperation with research organisations is mostly short-term oriented. Joint projects or contract research is not yet embedded in a long-term strategy. Short-term projects are usually accompanied by typical difficulties. Enterprises usually complained that time horizons of research organisations and enterprises are different. Research organisations (universities and the ASCR were named) do not provide staff when necessary. In general, their inflexibility was often mentioned. All the problems sometimes result in joint projects with strongly shared work in the sense of separate work packages. Real exchange is often missing. This mirrors the different priority setting of enterprises and research organisations. The attitude of research organisations towards industry funding changed slightly with the decrease of institutional funding. R&D-intensive enterprises have already realised more and better cooperation with universities.

Even though enterprises often complained about the inflexibility of research organisations, they realise that research organisations have the freedom to think the projects through and come up with new ideas, whereas enterprises are too often bound to time and costs. For cost and time-critical projects, private or public research organisations with a clear focus on applications are preferred. Large enterprises in particular have realised the problem and have started to seek long-term cooperation in the future. Enterprises are willing to invest in long-term-oriented research using the core competencies of the researchers at universities. They expect useful intermediate results. One firm introduced a system of how to organise research cooperation:

- Small scale projects (short-term, time and cost-sensitive) are either conducted internally (use tax reduction), with partners in other enterprises (suppliers, customers) or public and private research organisations with a high degree of application (they are able to work under cost and time pressure).
- Medium scale projects (medium-term, some time and cost issues) are often conducted under the umbrella of joint projects funded by national or international sources. People from university and the ASCR are involved. PhD students are involved.
- Large scale cooperation with universities or the ASCR is used for long-term research. Companies profit from intermediate results, PhD programmes are part of it. Time and costs are only a limited issue.

One firm sees working with universities as an evolutionary process. Firstly, they start to work mainly with students (internships, sponsoring and supervision of diploma theses, recruitment). Afterwards, they work together on 3-4 projects which are not too sensitive in terms of time and costs. This is a learning experience and a coaching session for universities (e.g. researchers have to learn about project set-up, project management, IPR, commercialisation of results - e.g. a researcher can publish a failure as a research result, but this is impossible for enterprises). The cooperating university started to see the cooperation not only as a cash cow for their research, but gained real advantages. Afterwards, the firm began large scale cooperation and education/training programmes.

SMEs and large companies have different interests and different capacities to work with research organisations. Only large enterprises and MNEs are capable of carrying out large-scale cooperation, as a critical financial power is needed. This should be considered from the university and policy side. SMEs need special support at least to enter the first stage of development. This is important, as otherwise small businesses never grow large.

If enterprises do not see the willingness of research organisations to cooperate or do not find the knowledge needed, they do not hesitate to work with universities abroad. MNEs in particular often perform cross-border SIL. As the knowledge base of MNEs is not necessarily located in the CR, universities in the CR immediately start to compete with those abroad. Although global knowledge sources are perceived as modern nowadays, many enterprises emphasised that spatial proximity still counts for research cooperation. Enterprises look for partners who are reachable within a day's return drive. This is a clear advantage for Czech research organisations.

Large enterprises also started to be represented in the scientific council of universities. Their aim is to increases awareness of SIL and its requirements.

5.6.3 Experiences of cooperation from the research perspective

Conducting research together

The motivation of researchers to cooperate with industry varies. Some researchers lose interest in playing the game of the ministries. Industrial funding gives them an independent “income”. Their main motivation for industrial funding is independence and freedom. A second reason is to give students and PhD candidates an insight into companies’ research. Personnel exchange with industry is perceived positively. Even if researchers stay in industry, they will be future partners. Research institutes do not hesitate to work with companies abroad if domestic companies do not require their research. Success factors in the opinion of research organisations are personal relations and mutual understanding. This allows for long-term cooperation even if joint projects are finished.

Other researchers are not very enthusiastic about strengthening SIL. Many researchers do not even have the correct understanding of SIL. Awareness-increasing measures could help them understand what kind of activities SIL includes, how to approach companies, how to conduct project management, how to deal with IPRs, etc. Training lessons for students covering awareness issues are now mandatory in some fields at universities, but the quality of lectures needs improvement. Many researchers also feel that demand from industry is relatively weak, which forces them to go for almost every cooperation. This leaves no room for strategy.

Research organisations reported that companies sometimes only want to use their name and reputation in order to apply for grants. Therefore, an incentive structure of research organisations to intensify SIL must be adjusted to the different disciplines, faculties and attitudes of researchers. There are no one-size-fits-all models.

Companies often want short-term solutions, but research organisations are oriented towards long-term research. Research organisations experienced that MNEs in particular are willing to fund blue-sky research in long-term contracts, but Czech companies hesitate to set up funding in this manner.

Research institutes at universities and the ASCR mainly conduct basic research, but this certainly also requires SIL as much as applied research does, although the time-horizon is different. One research institute said that they had had good experience in specialising in basic research while having a full information scheme on their research easily accessible for industry researchers in order to understand their research and find a starting point for cooperation.

University researchers reported suffering from the funding situation at universities. Universities get money for teaching per head. For university institutes, it is a difficult decision to go EITHER for more students with lower quality and having personally less time for research OR fewer students, excellent graduates and more time for research, which could lead to more funding from industry as a compensation for lower funding from teaching. Funding from MEYS is considered to be at least somehow stable, as funding from industry is a matter of economic development.

Research institutes would appreciate a tax incentive of companies for joint research, and not only for in-house research.

IPR issues and Technology Transfer Offices

According to the new evaluation methodology, researchers have started to write more patents, but they do not actually intend to apply for the patents. Some research institutes realised that they can sell patents or licenses to industry and use the funding for PhD students. More conflicts have occurred and will occur, since universities have incentives to file patents and licences. IPR will become a matter of tougher negotiation between industry and research. Enterprises are mainly used to pay for personnel and materials, but not for IPRs. But there are examples for common ownership of patents as a result of joint research. Even if research institutes and companies have arranged contracts in a harmonious way, problems occur if graduates are involved. Dissertations (including research results) need to be published, which is mainly disliked by companies. The TU Brno has found a solution of how to transfer research results in the annex of a dissertation to actually prevent it from being published, but still to let students cooperate with enterprises.

TTOs have been established at universities to help researchers and enterprises to interact with each other more intensively. TTOs are perceived as useful from the perspective of researchers and enterprises if advice on formal procedures is needed (e.g. patent filing). But TTOs have difficulties identifying potential cooperation partners for researchers. Finding “customers” for research findings requires a deep understanding of the specific research field. Such a job can only be undertaken by someone who has a substantial knowledge of basic research. These experts need training sessions on the applied side (e.g. patent law, licences etc.). Good experience is available at the TU Brno. Someone with a research background works partly for the TTO and partly for the department. Another problem is that many professors resist using TTOs, but prefer to design their own contracts. Trust in TTOs is missing.

Spin-offs

Universities as well as ASCR institutes have spin-off activities. They are often highly important cooperation partners. Unfortunately, there are no statistics on the number and exact activity of spin-offs. The setting up of spin-offs is perceived as very burdensome in the CR due to cumbersome administration. Funding from venture capital is also problematic in the CR. We had an example in which researchers decided to set up their firm in the US instead.

Professors are allowed to set up their own company in the CR. These are often not registered as spin-offs. There are no legal regulations on the foundation of companies by professors, as in other states. Although this was legalised after the fall of the iron curtain, it is no longer contributing to the innovation system. Professors directly commercialise research. They transfer knowledge for free from university to industry, which is not equal treatment from the perspective of other enterprises. Moreover, professors offer “products” for a below average price using their university equipment. This knowledge transfer is not visible in any statistics. This method of working prevents science-science collaboration as well as industry-science collaboration because professors are encouraged not to cooperate with anybody if they want to commercialise the product in their own company later.

An example of combining research efforts is the Czech Institute of Informatics and Cybernetics. This joint research institute hosts start-ups, TTOs, PhD education, research collaboration, joint-labs with industry, institutes from the ASCR and universities.

Structural change

There must be a rethinking of SIL on the management level of universities and the ASCR. Secondly, there must be a structural change in the research institutes at lower levels. Only a tailor-made structural change of every institute according to discipline and strategic orientation could move the ASCR and universities closer to industry. Structural adaptation includes the introduction of labour division (grant office, TTO, staff for administration of research projects, researchers having time for research, team leader payments etc.). Universities as well as the ASCR have partner organisations abroad which they can take as a learning opportunity.

5.6.4 Barriers for SIL in the National Innovation System

The interviews revealed three main barriers in the Czech national innovation system. *First* of all, **priority setting on the policy and organisational level** is insufficient. Enterprises and researchers see a lack of priority setting in the CR policy landscape. R&D expenditure is invested more or less evenly among all disciplines. Besides priority setting, clear strategic guidelines for orientation are lacking. Enterprises and researchers see a substantial risk in the performance of the R&D&I system if no clear and limited priorities are set (either in disciplines/sectors or in the form of excellence).

Moreover, enterprises often feel that research organisations do not follow a consistent vision. This is especially the case with the ASCR. Some enterprises suggest either transforming the ASCR into world-class research centres or into centres producing applicable research. In other words, the ASCR should either orientate itself towards excellence or towards the market/industry. Institutes of the ASCR without either of the two orientations should either transform or close. Either orientation could be useful for enterprises.

A *second* major barrier for the Czech R&D&I system is the **mismatch of knowledge needed and knowledge produced,** which leads to **little national embeddedness** of important research organisations and enterprises. MNEs often conduct their R&D globally due to a shortage of graduates in their field. It is difficult for enterprises to exist in a location where human capital is rare. They do not cooperate with domestic universities for strategic R&D. MNEs would have the financial power for long-term strategic R&D cooperation to make large scale knowledge transfer possible, whereas it is very difficult for large Czech enterprises to take over that role and bridge the gap. They suffer from a lack of funding.

On the other hand, some research institutes enjoy international lighthouse effects. They prefer to cooperate with international enterprises, but they suffer from local embeddedness. The example already shows that for some research fields, there is a good match of industry and science (e.g. chemistry, clinical medicine), but for some areas the match is insufficient (e.g. pharmacy).

Thirdly, **interaction of agents in terms of SIL is not supported by framework conditions**. PhD students are officially forbidden to carry out their work in companies and be funded by them, but there are examples of bilateral cooperation programmes between industry and academia fixing that problem. Universities often expect the government to pay for their PhD students, but they do not sufficiently consider the option of industry paying for it.

Moreover, informal networks among scientists in the CR work very well due to the small size of the country. On the one hand, this is positive due to quick accessibility and trust, but it also has a negative contour in terms of lock-in effects of networks (no integration of outsiders/internationals and therefore limitation of progress) and in terms of mutuality, which hinders the success of excellent research and ideas. International peer reviews to counteract lock-in effects are often not required for the evaluation of project proposals.

5.6.5 National and EU programmes on SIL

The MIT is naturally responsible for the care and funding of SIL. Many enterprises and researchers indicated that joint projects are the best way to start cooperation. Unfortunately, the MIT no longer funds joint projects directly in programmes, but there are programmes incentivising SIL. Even though the former programmes would have needed substantial improvement, it would still have been worth supporting SIL directly. Moreover, SIL programmes should have been extended. There are a couple of new programmes on the way and their performance remains to be seen, but they have potential to improve the situation. But topics such as the training of students and PhD candidates are still under-represented. Moreover, programmes should not be discriminating against international participants. Furthermore, individual-based research funding (very low in the CR) could be a means of supporting individual experts in building the bridge between industry and science. In general, SIL programmes should have a critical mass of funding and running time for research and innovation, as typical problems otherwise occur in time and cost issues and frustration on both sides sets in.

As large enterprises are excluded from application for public funding in research projects, enterprises formally outsource their research and set up their own research companies in order to have permission to apply for public funding. Programmes addressing SMEs (e.g. for joint research) should be complemented by programmes addressing large enterprises (e.g. support if they fund PhD projects, long-term strategic cooperation). The focus for SMEs and large enterprises must be clear and distinct.

Researchers and enterprises feel a heavy administrative burden in national and international programmes. Enterprises often (1) employ special staff or (2) contract a consultancy company to manage their national and international joint projects. For SMEs in particular, this is virtually impossible. One firm suggested it should be possible for SMEs to hire people from the ministry on a temporary basis for this kind of administration (given that they are highly qualified). Even worse is the fact that there are different interpretations of administrative procedures for the same national programme depending on the person responsible in the ministry. The different processes in the national programmes mean that some enterprises actually find them more burdensome than EU programmes. Support from the ministry to manage the administration is low. Although the EU programmes require more administration in general, support from the EU is much better. Apart from administration, the national support system appears confusing to enterprises because of too many funding bodies and the different framework conditions they apply in programmes. Moreover, some programmes' framework conditions limit the freedom to design contracts with research organisations the way companies would prefer to. A one-shop solution with clear and consistent framework conditions would ease access of enterprises and researchers to programmes.

A particular complaint from enterprises is that they are only funded up to 50% in national projects, whereas universities are funded 100%. There is still an incentive for enterprises to conduct the project efficiently. Problems occur if enterprises actually manage to save costs within their project part. They manage to reduce the 50% firm funding, but they also reduce the 50% public funding. As the reduction of public funding for enterprises has an influence on the overall budget of the project, the 100% public funding for the universities is also reduced. Universities never want to and are seldom able to return money. A decoupling of funds for research organisations and enterprises would be useful. In EU projects this problem does not occur, as a fixed amount of money is provided.

National programmes often take care of the personnel costs, but not the cost of investing in infrastructure. Consequently, companies need to find separate funding for both ingredients of R&D. For example, EU structural funds provide investments for infrastructure, buildings, equipment, but no manpower. It is difficult to have two programmes to support manpower and investments, because the time frame of the announcement of calls is often different. This is only one problem of little interaction between national and EU programmes. Czech programmes do not especially prepare EU programmes, complement them or follow them up. Follow-up projects could be an enabler for SIL, as they could focus on the transfer of findings to industry (see transfer projects of the German Science Foundation).

5.6.6 Summary

We interviewed 10 enterprises (mainly large enterprises) and 9 researchers, as well as 8 members of research agencies or ministries responsible for national programming. We identified a variety of forms of research and teaching cooperation between industry and science. There are two main findings:

1. Many large enterprises employ a systematic pattern of how to organise relations with research organisations. They learn from experiences and adjust their pattern to find solutions.
2. SIL follows an evolutionary process. Cooperation starts with small projects or teaching courses. According to learning experience and development of relations, cooperation continues on a medium (larger joint projects on the national or EU level, supervision of PhD theses) or large scale (long-term research cooperation, joint organisation in PhD programmes, enterprises represented in scientific councils of universities). This trajectory obviously

depends on discipline/sector, firm size and mission of the research organisation.

In the national system, framework conditions still exist that hamper SIL, for example no sufficient priority setting, mismatch of research fields in enterprises and research organisations, small size of the research community networks and risk of lock-ins, no permission of PhD funding for enterprises.

Moreover, there are no direct national support programmes on SIL. Support programmes on joint teaching and training and personal mobility are limited. Previous programmes did not sufficiently take into account the different needs and potential of SMEs, large enterprises and MNEs. They also had very little interrelation with other national programmes and EU programmes (e.g. preparation, follow-up). Moreover, the administrative burdens of managing programmes forces enterprises and researchers to employ extra staff.

5.7 Résumé – supportive, constricting, enabling and restraining factors

Structural characteristics

The sample of enterprises comprises innovative enterprises which have a higher probability of performing SIL. Manufacturing enterprises are very strong and present in the CR. Manufacturing is also the sector with the highest international orientation, whereas ICT or R&D services are more inwardly oriented. International orientation is often coupled with more intensive competition and pressure for upgrading. This is one driver for initiating SIL. On the other hand, manufacturing has the lowest adaptive capacity for scientific knowledge due to the limited share of highly qualified employees, whereas in R&D services and ICT, adaptive capacity for knowledge is much higher. The spatial distribution of enterprises and researchers is also striking. Whereas the lion's share of researchers is located in Prague, this is not the case for enterprises. SIL are very much focused on human interaction. This is often a matter of spatial proximity, which is difficult to realise if enterprises and researchers are unequally distributed over space.

Motives and incentives

Drivers and motives of researchers and enterprises to interact with each other in general correspond to each other but have differences in detail. Both are interested in the exchange of knowledge and the establishment of networks. The relevance of motive has a slightly different ranking for enterprises and researchers. Whereas enterprises rank the access to scientific knowledge highest, researchers' first priority is gaining industrial funding.

Incentives for SIL are very limited in all research organisations in comparison to incentives for other research results (e.g. publication, patents, etc.). Differences between research organisations become visible. Technical universities with higher motivation and more incentives for SIL and the ASCR with lower motivation and few incentives build two extremes in the spectrum. Despite the obvious differences, all research organisations agree upon the need for improvement.

Cooperation pattern

SIL exists to a large extent at technical universities with their corresponding fields of researchers, but universities are somewhat limited by nature with their classical range of research fields. Technical universities are the most wanted cooperation partners for enterprises, followed by other research organisations. Universities and the ASCR are the only attractive partners in special fields. A typical pattern of SIL according to research organisations and disciplines can be observed in the CR. There is potential for more SIL with universities and the ASCR.

Whereas nearly all research groups cooperate with other researchers, relations to industry have a clear size effect. The larger the research group (critical mass), the more SIL can be observed. Furthermore, the survey showed that larger groups work more frequently with larger enterprises, but smaller groups cooperate with smaller enterprises. There is also a clear size effect.

Linkages to SMEs in the CR are very frequent in all working groups, while linkages to large enterprises are only addressed by a few researchers. About 1/5 of researchers have cross-border SIL. Knowledge transfer to enterprises in the CR is of higher importance than to those abroad for all research organisations. Technical universities perform best in SIL (nationally and internationally). Data show that the ASCR is seen to be more active in knowledge transfer abroad than to enterprises in the CR. Again, specialisation in knowledge production and transfer – also from a geographical dimension – could be revealed.

About half of enterprises have R&D cooperation with research organisations. While R&D services have by nature the highest share, manufacturing enterprises and ICT and construction have only set up SIL to a limited extent.

A logit model to explain firms' involvement in SIL revealed that firm size and share of highly qualified employees have a significant influence on SIL. A critical mass of employees and a higher share of highly qualified employees make a firm more likely to be involved in SIL. The logit model explaining the involvement of researchers in SIL showed that being associated with technical universities or the ASCR, being a member of a large working group, having time to spend for management of projects and increasing working experience are the significant factors for researchers being involved in SIL. To increase the number of researchers involved in SIL would therefore mean giving them extra time to spend for managing projects with industry members, as they are more different to purely research projects. Research organisations must give priority, time and probably training courses on this. Moreover, organising larger research groups also contributes to more SIL. This probably requires the restructuring of research units. Furthermore, giving incentives to researchers with more working experience who are mature in their research career for transferring their knowledge to industry might also increase SIL.

Modes of Interaction

Personal contacts, conferences and joint projects are evaluated as being very effective for SIL from both sides – industry and research. Whereas personal contacts and conferences give a good platform for establishing and maintaining a network (passively), joint projects require the activation of networks and the actual exchange of ideas. Networks are good to have and need to be "ready to use" if there is an opportunity. Concrete projects push the transfer of knowledge. Therefore, they are evaluated as being very good.

Although there is a high degree of heterogeneity in the interaction channels of SIL, the variety of channels that actually come into action is limited in the CR. This calls for better use of the variety of options. There is potential for more and better activities regarding *personal mobility* (e.g. staff exchange, holding double positions, recruitment policy) and *training opportunities* (e.g. research organisations train industry staff, industry funds PhD students).

It is outdated to argue that basically oriented research institutes need limited SIL. The innovation process is not linear, but runs in cycles with feedback loops also important for basic research. All researchers have the potential to profit from SIL. Experiences show that even researchers at the ASCR assess exchange with industry members as being fruitful. There is more potential for excellent SIL, but the extent and direction must be given on the policy level.

A comparison between regions shows differences. The Moravian-Silesian region in particular performs very well in using the different channels. In particular regions, specific channels are more frequently used than in others. Regions can learn from each other's experiences in setting up and using specific channels.

Satisfaction and barriers

SIL in the CR are by no means perceived as purely negative, but encounter a diverse field of opinions. Enterprises are partly very satisfied, but partly very unsatisfied. Although our empirical findings show that there are ongoing activities under the umbrella of SIL, the support measures by the government are assessed as being of extremely poor quality or non-existent.

Researchers and directors of research organisations have great differences in opinions on satisfaction with SIL. This reflects a fundamental problem in the perception and importance of SIL in the mindset of researchers on a lower level and directors in a leading position in research organisations. With this gap in the mindsets, it is difficult to set priorities, make decisions and adapt the behaviour of a research organisation.

The major barriers for both industry and research are (1) finding appropriate partners, (2) mismatch of knowledge and research needed, (3) defining expectations and managing projects and (4) conflicts of interests between academic and industrial researchers. Interestingly, research and enterprises without SIL assess barriers as being higher than experienced people in SIL do. Integrating more researchers and enterprises into SIL could perhaps reduce the perception of problems. Accordingly, researchers and enterprises could need support in finding each other to actually make cooperation possible. In a next step, they might profit from support in formulating expectations and interests and from project management support. This alone might lead to satisfaction and follow-up cooperation.

The highest satisfaction with SIL in the CR is reached in the South Moravian region from both perspectives – that of researchers and of enterprises. This is a region to learn from.

6. Conclusions: SWOT analysis and Recommendations

6.1 SWOT

The evidence gathered and the analyses performed allow for the use of a SWOT analysis to create a picture of the CR's innovation system related to SIL. As a preliminary remark, it must be stated that the results contain some ambiguities, classifying as strengths features which may also be threats or similar.

Strengths

A few characteristics form relevant strengths in the knowledge production system, and hence will enforce potential for SIL.

<u>High-tech industries</u>

As shown in statistics, the CR's industry structures include reasonably large "high-tech" and "medium high-tech" sectors, which are based on a long-standing tradition and draw on a well-developed and experienced knowledge base, resulting in the current high competitiveness in international terms.

Furthermore, structural changes in industry are oriented towards the "ICT paradigm".

<u>Attractiveness for MNEs</u>

Data analysis clearly showed that the CR ranges amongst the countries with the highest shares of inward FDIs, expressing advantageous conditions for the companies concerned. This was especially the case for the largest industry in terms of business R&D – "motor vehicles" – and resulted in achievements which are resulting in international comparative advantages.

Similarly, other closely related industries to "motor vehicles" (such as rubber and plastics, electrical machinery) followed this path of reshaping and upgrading via usage of external knowledge applied by MNEs.

Consequently, this formed highly competitive industries in the CR.

Excellent research institutes

From bibliometric analysis, it appeared that the public research base consists of some extremely successful institutes (e.g. in terms of publications) – also at the international level. These include the institutes from the ASCR, Charles University in Prague, Czech Technical University Prague and Masaryk University.

As stated in interviews, this public research base – complemented by the increasing involvement of technical universities in SIL – provides fundamental features for "science frontier"-oriented SIL (as is the case for "high-tech" industries).

Furthermore, R&D in the public research sector consists of the largest shares in engineering and natural sciences – the usual candidates for SIL.

Public support of infrastructure

Studies documented the fact that the last decade was used to build up infrastructure for innovation activities based on structural funds. These include the implementations of science and technology parks, incubator centres, TTOs and initialised cluster building or technology platforms. Currently, regional R&D centres are selected and are in their start-up phase.

As a consequence, a lot of infrastructure has been installed and is ready to be used.

Overall, the quite successful catching-up development of the CR following the communist era was based on favourable locational attractiveness with low unit costs, a qualified labour force and a well-developed knowledge base in industries with a long-standing tradition. This basis attracted massive FDIs by MNEs – especially in "high-tech" and "medium high-tech" industries. Consequently, these industries have been reshaped and reorganised towards high efficiency and productivity – resulting in international competitiveness.

In the public research sector, evolution during the last decades has enforced the development of excellence institutes which now have high international visibility. This was based on the usage of competencies already present, but also by broadening the public research base through the introduction of research at universities – with technical universities in particular also intensifying SIL.

Furthermore, recent public measures have generated a broad variety of infrastructure – typically useful to support SIL.

Weaknesses

As the CR is just changing trajectory from an economy-driven to an innovation-driven system, SIL is still a major weakness. Several factors add to this status.

Low levels of SIL

The international comparison revealed quite low intensities of interaction between the science and the business sector. While other R&D indicators show a middle position of the CR between the transition economies on the one hand and the more advanced economies on the other hand, this is not the case for cooperation intensities in R&D. Here, the CR shows a lower or just equal level compared to transition economies. This might also be explained by the dependency on foreign capital. It is mainly MNEs which perform R&D, and they might use existing relations to research organisations in their home country. Taking into account the Czech Republic's GDP and the stage of development of the socio-economic system, these findings call for remedies leading to intensified SIL. This result is even more important from a prospective perspective: if the production system is to be upgraded towards more knowledge-intensive activities, SIL will play a key role.

Knowledge-intensive service sector

Statistics show a comparatively low share of the knowledge-intensive service sector in the existing industrial structure. Nevertheless, it should be mentioned that services such as "computer-related activities" (i.e. software production) start to increase in terms of R&D intensities and growth.

Human resources

Demographic figures express the most challenging weaknesses in human resources. Firstly, the existing structure with relatively high shares of engineers is suffering from nurturing rates and an ageing effect. Furthermore, the structure of enrolments in universities shows a shift towards non-engineering education, and hence produces questions concerning future demands.

According to statements from interviews, the competence level of staff responsible for SIL in public institutions is not yet characterised by high standards.

Furthermore, mobility of students and researchers between industry and science was assessed as being insufficient.

Interaction modes

From the survey conducted, it was evident that SIL players in science and industry mainly focus on the establishment and maintenance of SIL by informal processes, and less on highly interactive modes (e.g. joint projects, joint training, exchange of staff).

Size effect

The survey also showed that research groups in the CR are rather small. Evidence proved that small research groups have a lower capacity to perform SIL, whereas large groups have typically more SIL. Moreover, micro enterprises (<=10 employees) have a lower probability of being involved in SIL as well – and the CR has a considerable number of micro enterprises.

Public support of SIL

Published documents and information from interviews revealed rarely implemented policy measures to support SIL. Moreover, existing policy measures are assessed as being extremely poor by enterprises and research organisations in the survey.

Shortcomings in the public programme portfolio are evident when Operational Programmes support SIL only indirectly through the installation of infrastructure and limit the participation of Prague, although it has the highest concentration of the public research sector. Besides programmes supporting joint projects, there have been no programmes so far on joint training and personal mobility between industry and science.

Furthermore, national programmes include SIL in their selection criteria usually just as an additional element, but do not have it as a core element. As remarked in interviews, a few new initiatives (e.g. competence centres) are now focusing on SIL, including mandatory participation of members from industry and the public research sector.

The other problem with public programmes – also related to SIL – is that the policy measures are changing quite rapidly, which makes it difficult for applicants to form respective consortia.

Priority setting and roles of organisations

From documents, it is acknowledged that priorities and coherent treatment of public support in the Czech system is missing – which would have to be more functionally oriented, including an orientation towards SIL. Moreover, clear roles and missions of research organisations concerning SIL are not defined.

Awareness and incentive structures in public research institutes

Interviewees complained several times that awareness and understanding of SIL among researchers is low and differs between the management and operational levels in research organisations. This low awareness increases the risk of losing opportunities.

Analysis of the survey also revealed that the existing evaluation method for the distribution of institutional funding does not reflect SIL in any way. Researchers are mainly motivated by funding opportunities, but to a lesser extent also by the gaining of knowledge, which might not contribute to a fruitful collaboration. Overall, the academic environment is largely oriented towards career paths, which are not supportive for SIL activities.

No such study has been conducted to obtain an overview of SILs and their effects – which one may take as a lack of awareness on that topic.

Regional mismatch of public funding

Data revealed Prague to be the gravity centre of the public research sector, but public project funding does not reflect this concentration. The SF funds in particular are located outside Prague, building up new infrastructure, but not always related in the most promising way – as results from studies explain. On the other hand, institutes from Prague do not receive enough funding for maintaining/sustaining the local infrastructure.

Mismatches between industry and the public science sector

Mismatches have been mentioned in interviews and studies. MNEs are major players in the CR's business R&D system. But these companies often conduct their R&D according to a global strategy, and hence do not cooperate intensively with domestic universities for strategic R&D.

The lack of framework conditions, for example support for industry-financed PhDs, provides additional disincentives to MNEs.

On the other hand, internationally exceptional, well-known public research institutes are cooperating with international enterprises abroad.

Difficulty in finding partners due to a mismatch of knowledge needed and knowledge generated and conflicts of interests between the industry and science community are major barriers for the system in the CR.

Risk capital and start-ups/spin-offs

International comparison, but also statements in interviews, gave hints as to the problems in framework conditions for start-ups and spin-offs: entrepreneurial education and incentives to set up spin-off activities are low, which results in almost non-existent spin-off activities from research organisations. Moreover, there is a shortcoming in the supply of venture capital and other private risk capital to fund new (knowledge and technology-intensive) enterprises.

Overall, evidence gathered provides a list of weaknesses and bottlenecks, which may be summarised by three dimensions: firstly, human resources and their attitudes according SIL; secondly, structural issues – either an underdeveloped knowledge-intensive service sector, a mismatch between science and industry or on a regional level; and thirdly, insufficient public support.

Opportunities

The CR is converging towards the European average, leading the transition economies in terms of R&D. This implies opportunities for an intensified innovation-based development (i.e. increased SIL). Based on already accumulated investments and reorganisations, these opportunities appear in the following elements:

<u>Infrastructure and excellent institutes</u>

Bibliometric data and desk research highlighted excellent institutes in the public research sector. Furthermore, public measures implemented in the last decade have generated additional infrastructure for the innovation system. Both provide important pre-requisites for increasing SIL.

An opportunity arises through: (1) using these excellent institutes as attractors for international and national collaboration in R&D (which is already taking place, according to interviews) and (2) enhancing the institutes' roles concerning knowledge transfer into companies, using the installed infrastructure.

Therefore, sufficient human resources must be generated to provide a reasonable supply of researchers for the public research infrastructure and for the R&D departments in firms. Consequently, education should be seen as a core element in institutes. Here, PhD programmes as well as training in project management and soft skills for researchers should be added to the curricula.

<u>Highly concentrated R&D with agglomeration effects</u>

R&D&I activities in the CR are concentrated within two centres: Prague and the region of Brno. These agglomerations evolved from history and, in case of Brno, also from recent regional policy efforts (including the usage of SF means). Based on these highly concentrated structures, the agglomeration effects and spillovers could be used to develop the R&D&I system in the CR.

On the one hand, the attractiveness of these regions (regarding labour markets for scientists, but also regarding highly relevant services for industries) is to be supported by additional tailor-made interventions to sharpen regional profiles and increase the interactions between public research sector organisations and companies.

<u>Embed the MNEs</u>

According to statistics, MNEs are the main business R&D performers in the CR – and they decide upon their local R&D behaviour based on a global strategy. Here, the existence of top-league research institutes may be used to maintain the CR as an attractive R&D location for companies.

In order to embed MNEs in "local" SIL, public research institutes and MNE could bundle competencies in joint research centres.

<u>Establish a learning community</u>

Due to the small size of the country, experiences can be shared easily, which creates great learning opportunities. There is already a pool of SIL experience in enterprises as well as in research organisations which could be more actively accessed first before looking abroad.

Summing up, opportunities are appearing due to recently created infrastructure, such as research centres and internationally well-known excellent research institutes, which is fundamental for the creation of more intensified SIL. Furthermore, the existing concentration of R&D&I activities in Prague and the Brno region constitute the favourable background for increasing SIL through tailor-made interventions to sharpen regional profiles.

Threats

Successful developments often bear the seeds of future problems. Threats in the case of the CR's innovation system seem to be a result of successful catching-up and are responsible for ambiguities in the assessment of factors, as many of them have also been listed above as strengths or opportunities.

Sustainment of infrastructure

Data show that at the moment, a substantial share of the public R&D&I funding is received from SF programmes. But this funding depends on the income situation of the regions, and assuming that income growth continues along this path in the CR, the situation may change in the coming years and SF means will not be available to this extent.

Moreover, institutes in Prague (the largest part of public research sector) only receive limited funding from SF. Beyond the borders of the city of Prague, however, SF investments have led to new R&D infrastructures. There is thus a lack of funds for the maintenance of existing R&D infrastructure in Prague.

As a consequence, there is funding available for new infrastructure, while existing R&D structures are not sufficiently equipped. Furthermore, the shortcomings in the supply of young researchers, already present in some fields, may increase given the demographic developments. This may result in the existence of infrastructure which cannot be supplied with qualified personnel.

Negative impacts on SIL are the logical consequence – with impacts on further growth opportunities based on innovation.

Structural characteristics of high-tech industry

Although statistics for the CR report a reasonable number of high-tech enterprises, they are mainly responsible for production activities at the lower end of the value chain. The share of highly qualified staff is low. There is a risk that absorptive capacity in such enterprises is too low to initiate upgrading activities successfully that are considerably related to more intensive SIL.

Human resources

Mentioned frequently, human resources issues appear to be a top priority. Given the demographic pattern with ageing structures in the supply of engineers and the insufficient nurturing rate of engineers and natural scientists, the CR may become a less attractive R&D&I location.

The shortage becomes even worse once the relatively low cooperation between science and industry is taken into account – and as a consequence of human resources shortages, will even be reduced.

Moreover, an intensification of SIL would also be assisted by international scientists (including Czech scientists working abroad) moving to the CR. There are doubts as to whether the CR can strengthen “soft” location-related factors well enough to attract top scientists from abroad, especially considering the huge R&D infrastructures that will be established in the Operational Programmes.

Dependency on MNEs

Consequently, the research base in industry is largely related to foreign-owned companies, accounting for more than half of business R&D in the CR. Once they start to reduce their R&D&I activities (based on decisions anywhere), the innovation system would lose major parts.

Lock-in effects in scientific networks

The small size of the country carries the risk of lock-in effects within the research community due to mutual favours and reciprocity. Only international orientation in the evaluation of project proposals ensures that excellent research projects will be supported.

Overall, major threats result from the continued high risk of low absorptive capacity in industries as long as upgrading is not fully implemented and production remains at the lower end of the value chain, performed by less qualified staff. Furthermore, demographic patterns with ageing structures in the supply of engineers and insufficient nurturing rates may reduce the attractiveness of the CR as an R&D&I location.

Summing up, the SWOT of the CR's innovation system highlights the needs for policy actions. Intensification of SIL to support a development towards more R&D and knowledge-intensive activities and branches in the CR must make sure that structures already present (excellent research institutes and newly created research infrastructure) can be fully exploited. This requires a sufficient supply of qualified human resources. Furthermore, framework conditions (i.e. incentive structures) for the public research sector and programme portfolio must be reformed. Subsequently, attractiveness as an R&D&I location will be increased and will ease the integration into MNE's R&D&I value chains – which, as a consequence, produces the greatest impacts on the R&D and knowledge intensity of the CR's production system.

6.2 Recommendations

In recent years, the CR has made considerable efforts to improve research outputs in terms of publications, patents or project acceptance. But for economic and societal benefit, the impact of the research is of greatest relevance. Impact only occurs if knowledge is transferred to the economy and society. Substantial knowledge transfer already takes place in the Czech R&D&I system supported by public initiatives and programmes. However, the CR is a transforming country. It is developing along a trajectory curve towards higher value activities and knowledge-intensive products. A growing Czech economy requires more and better SIL in the future. The effectiveness of existing efforts to support SIL is constrained by a number of flaws in the current design and practice in the Czech R&D&I system. In preparation for a continuous development of the Czech R&D&I system, we **recommend** that policy makers in the CR take action in the following policy arenas that will be described in detail below:

1. Strengthen **human capital** for better interaction in knowledge transfer
2. Reinforce the **supply-demand pattern** of enterprises and research organisations
3. Support science-industry interaction on a **regional level**

Some of the recommendations build upon the recommendations of the Programme on Effective transfer (EFTRANs) on the commercialisation of university activities published in 2010.

1. Strengthen human capital for better interaction in knowledge transfer.

Current issues

The literature on SIL emphasises the importance of human capital for effective and efficient knowledge transfer between enterprises and PROs: "The best tech transfer is a pair of shoes" (Bramwell and Wolfe 2008, 1180; see also Garcia-Aracil and de Lucio 2008, Florida 1997). Human resources are, to a large extent, hampering SIL in the CR. Although industry-science linkages must offer a variety of interaction modes, the potential of many transfer channels remains unused or insufficiently explored due to limitations in the allocation and quality of human resources. Human capital issues occur in the following areas (Figure 45).

Figure 45: Human capital issues in knowledge transfer channels

Human Capital	Limited mutual training activities of (1) employees of enterprises in research organisations and (2) students/PhDs Candidates in enterprises
	Allocation of students over fields of study (shortage of graduates)
	Job mobility of people between industry and science
	Insufficient flow of students to enterprises (internships, supervision of diploma theses)
	Employability of students (skills in project management, solving conflicting situations, negotiation exercises, IPR awareness)
	Limited entrepreneurial spirit and education of students and researchers that reduce spin-off activities
	Awareness, understanding and practising of SIL by researchers is insufficient (project management skills, keeping deadlines)
	Competence level of staff responsible for SIL in public institutions is too low (ministries, TTO)
	Negative effects of informal networks of researchers due to small size

Recommendations

A. *Explore the variety of interaction modes that SIL has to offer*. So far, policy initiatives and programmes hardly consider the variety of SIL. We recommend using more the potential of SIL in horizontal mobility and training

- Personnel mobility – this includes policy initiatives on horizontal mobility enabling staff exchange, holding double positions, support to develop a recruitment policy to consider SIL in research organisations, provide incentives for returnees from abroad with experience in SIL
- Training opportunities – this includes policy initiatives supporting research organisations to train industry staff, industry to train and fund students/PhD candidates, create industrial internships in specific fields of study, improve the quality of courses at universities to ensure better employability of students (negotiation training, IPR issues, etc.)

B. *Increase priority and awareness measures of SIL on the individual level.* On the *researchers' level,* the quality of awareness-increasing measures should be heavily improved and should eventually reach a high-quality standard. This increases the understanding and application of science-industry linkages for researchers. It also responds to the fact that there is a declining awareness curve from people heavily involved in science-industry linkages to other researchers. Awareness measures could include:

- Lessons on the variety of activities that SILs actually include (from joint publication and projects to training exercises, double positions, mobility measures);
- Training in different ways to cooperate with industry (expectations, how to start working, project management) and how to make experience gained through "learning by doing" visible for others;
- Training in establishing a procedure to prepare joint projects in advance;
- Training in IPRs.

C. *Set-up of support programmes for SIL under consideration of human resource orientation* towards:

- Including education of PhD candidates and students as part of support programmes
- No discrimination of international participants (neither from researchers' nor from enterprises' perspectives)
- Individual support for experts supporting or applying SIL (e.g. double positions)
- Increasing qualification of support staff at responsible institutions (e.g. the MIT)

D. *Initiate and allow industry to participate in education programmes*. This includes:
   - Incentivising PhD funding from industry
   - Establishing PhD programmes for industry-oriented PhD studies as a complement to research-oriented PhD programmes
   - Incentivising chairs, funded by industry.

E. *Increase the quality of staff of TTOs and establish a clear division of labour*. TTOs need a clearer division of labour between general advisers and experts in the specific fields. This would increase performance and trust from both sides – industry and research. Positive experiences have been had in the double positioning of experts at the department level of research organisations (as researchers) and at TTOs (as knowledge transfer agents). Best practice examples of TTOs might serve as role models for the reform of existing, rather ineffective TTOs in the CR (e.g. Debackere and Veugelers 2005).

F. *Providing better framework conditions for spin-offs and entrepreneurial activities*. Spin-off activities are very limited in the CR. From the human resource perspective, students and researchers must be better equipped with entrepreneurial knowledge on how to develop a business plan, awareness of IPRs, design and negotiation of contracts etc. Moreover, simulation courses for students and high-quality support courses for researchers (e.g. training by specialised lawyers, training by excellent managers, experiences of entrepreneurs) could be provided.

G. *Counteract lock-in effects of small informal networks*. Researchers (and sometimes enterprises) are limited in their activities due to integration in national networks. Internationalising peer review processes, letting international enterprises participate in SIL programmes, awareness measures about lock-in effects etc. could help to create an atmosphere for free choice of partners (also for SIL) considering excellence.

2. Reinforce the supply-demand pattern of enterprises and research organisations

Current issues

The interaction of enterprises and researchers encounter limitations due to structural issues on the national level, missing strategies and orientation in enterprises and research organisations, and insufficient support programmes. Friedman and Silbermann (2003) as well as Caldera and Debande (2010) stress the importance of clear university missions and established policies and procedures as driving forces for enhanced performance of SIL. Policy support should range from political priority setting on SIL to establishing adequate framework conditions and finally providing appropriate financial support. Researchers and directors of research organisations were found to have considerable differences in opinions on satisfaction with SIL. This reflects a fundamental problem in the perception and importance of SIL in the mindset of researchers on a lower level as well as directors in a leading position in research organisations.

Recommendations

H. Increase priority and awareness measures of SIL at all levels of the R&D&I system in the CR.

- On a *strategic level,* research priorities in the CR should be defined. There are different possibilities to set priorities. (1) Areas of priority can be determined by selecting disciplines. (2) Priorities can also be defined in support of research excellence. (3) Priority setting can also take place by defining "functional areas" (e.g. strengthening linkages between science and industry or internationalising the R&D&I system). We recommend focusing on the third possibility - "functional areas" - and defining SIL in the national priorities of the CR to ensure not only the output, but also the impact of research. This also includes a strategy and a roadmap on action to be taken on the national level, for example: defining the general role of the ASCR and universities in the national innovation system, reconsidering the role of SIL in the evaluation methodology according to disciplines and mission of research organisations, easing regulations on the sponsoring and supervision of PhDs by firms and the ASCR. Make the system more accessible and transparent.
- fostering awareness and coordination of SIL at the *ministry level*. Compile a coherent programme portfolio to support SIL coordinating different ministries and agencies or considering a one-shop solution. Define responsibilities at the ministry level and fill the "in-between" gaps between the MIT and MEYS. Consider leaving room for bottom-up initiatives to coordinate SIL and transfer responsibility. Key responsibilities must be addressed: overview and involvement in the set-up of programmes and policy initiative, developing instruments of awareness (for enterprises and research organisations), monitoring of SIL to control effects and impacts (e.g. commercialisation surveys, evaluation, audits), initiation of expert advisory (boards).
- On the *level of research organisations,* SIL should find access to the mission and strategy of research organisations. All research organisations have a variety of tasks at the same time in the national R&D&I system, only the priority setting is different. Knowledge transfer to industry should be among the goals of all research organisations. The importance was emphasised by the European Commission (2008) when publishing the "Code of Practice" containing operational guidance for research organisations, aiming to enhance the way they manage IP, thereby promoting knowledge transfer between the public and private sectors. SILs have a high heterogeneity which enables research organisations to create their own way of taking responsibility for knowledge transfer. It is outdated to argue that basically oriented research institutes need limited SIL. The innovation process is not linear, but runs in cycles with feedback loops that are also important for basic research. All researchers have the potential to profit from SIL. Experiences show that researchers at the ASCR assess exchange with industry members as being fruitful. A rethinking of the mission towards SIL is recommended for all research organisations. This would result in the following action points:
  - Research organisations need a clear incentive structure for SIL (on different levels), but there is no 'one size fits all model' (e.g. some universities in the CR have already introduced a system in which funding from industry provides research institutes with additional funding of their home research organisations)
  - Research organisations need to implement a "code of contract"
    - On how to set up spin-off activities and make code mandatory,
    - On how to approach potential customers pro-actively for research findings and

    - On how to prepare, conduct and follow up joint research activities with industry (e.g. for projects: collecting ideas, defining contours of the project, etc.)
  - Research organisations need a strategy and roadmap of how to support horizontal mobility of researchers pro-actively
  - Universities need a strategy and roadmap of how to integrate enterprises into their teaching activities
  - Research organisations should provide researchers with the necessary conditions to conduct joint projects, which includes training courses on working with industrial partners (project management, negotiation, IPRs, etc.), extra time for project management with industrial partners, building larger research units to leave time and room for research with industry members, giving incentives to researchers with more working experience who are mature in their research career for transferring their knowledge to industry etc.
  - Internal evaluation procedures of SIL (on different levels) must be established
  - Universities should especially consider using the potential of an ALUMNI network as a bottom-up approach to (1) connect former graduates and future graduates and (2) actively exchange research frontiers from the industry and science perspectives. This has been a widely introduced instrument in the US and the UK.

  Furthermore, it is essential that the management level of research organisations increases their openness towards research impacts on economy and society.

- On the *level of firms,* policy makers can give support through:
  - The establishment of industrial PhD programmes or access to PhD eduction at universities;
  - Creating industrial internships for students mandatory in specific fields of study;
  - Introducing tax incentives for enterprises on R&D cooperation with research organisations (universities, academy and ALSO private research institutes), e.g. tax incentives for joint projects, PhD funding, employees with joint positions etc. (discussion has already started);
  - Improve start-up funding (pre-seed and seed-funding already in preparation)
  - Incentivising large strategic coupling between firms and research organisations

I. *Introducing direct and adequate public support programmes on SIL.* The support measures implemented by the government need to be strengthened substantially. The following issues should be considered when developing a programme portfolio:

  - For research cooperation, SMEs and large enterprises/MNEs need distinct support measures, as they take different roles in knowledge transfer. SMEs need support in training, teaching and joint projects on small and medium scales. MNEs need to be pushed towards large-scale projects, but they should have the opportunity to start from a lower stage. Furthermore, they have to follow a development process towards more diverse SIL.
  - If expectations are met, it is a continuous development. Cooperation starts on a small scale (e.g. short-term joint projects, teaching, sponsoring of bachelor/master theses, internships), develops to a medium scale (e.g. larger

joint research projects, supervision of PhDs, funding of PhDs, staff of enterprises takes training course at university, temporary staff exchange) and to a large scale (e.g. long-term strategic research projects with MNEs, enterprises become partners in designing PhD programmes, double positions).

- Companies should be supported in developing their own strategy of how to get involved in training and teaching at university. The size of firms and their former experience thereby provides information on where they are located on the trajectory curve of SIL and what direction they could head in, as SIL is a process, not a single event.
- The major barriers for both industry and research are (1) finding appropriate partners, (2) mismatch of knowledge and research needed, (3) defining expectations and managing projects and (4) conflicts of interests between academic and industrial researchers. Accordingly, researchers and enterprises could need support in identifying each other to actually make cooperation possible. In a next step they might profit from support in formulating expectations and interests and from project management support. Only this could lead to satisfaction and follow-up cooperation.
- National SIL programmes should be integrated strategically with EU programmes (complement, follow-up, preparation).

Adequate support programmes need appropriate framework conditions, which should include

- one stop shop for SIL programmes (only handled by one institution) with clear and consistent framework conditions
- support for applicants from the responsible institution should be ensured
- programmes should contain sufficient funding and running time to establish SIL and provide learning opportunities for both sides
- giving a fixed amount of funding instead of a relative amount to allow enterprises and universities an independent funding (to fix problems, mentioned in Section 5.6.5 National and EU Programmes on SIL)
- application and evaluation procedure must incorporate international review processes (also to overcome lock-in effects of national networks)

J. *Support the availability of venture capital for innovative start-ups.* Following the theory of asymmetric information of firm financing, innovative start-ups are faced with rationing on credit markets that results in a "finance gap" in the early stages of firm development. This market failure must be addressed by public policy due to support programmes for venture capital. As was shown in the international comparison, the amount of invested venture capital is far below the level observed in the countries selected for comparison. While these might also be interpreted as a lack of demand for venture capital, for example as of a lack of entrepreneurial education or as other institutional barriers for the formation of new enterprises, the supply side can be addressed in order to exclude this possibility of market failure. However, designing policy programmes to support venture capital availability faces – according to Josh Lerner (2009) – the risk of "broken dreams". Therefore, several crucial factors for the design of well-functioning programmes should be taken into account in order to avoid replacing market failures with policy failures.

K. *Attract and embed MNEs more intensively in the regional and national innovation system.* (1) Attract MNEs via quality measures such as competencies of human resources, bundling of competencies in research centres (e.g. Czech Institute of Informatics and Cybernetics), strategic partners of universities, tax incentives for traineeships or integration in the set-up of industrially oriented PhD programmes, and (2) embed MNEs into the regional and national innovation system. MNEs should also take responsibility for increasing the attractiveness of the Czech research and innovation system once they are there.

3. Support science-industry interaction at the regional level

Current issues

A comparison between regions reveals differences: while Prague is the scientific centre of the CR, enterprises are better than researchers distributed around the country. Although Prague has highest potential for lively SIL, the Moravia region around Brno outperforms Prague. Players in the Moravia region use the variety of interaction modes between industry and science more successfully. Specific interaction channels are more frequently used according to implemented framework conditions (e.g. TTOs).

Recommendations

L. *Rely on existing R&D infrastructure in the region and its continuous development*. Consider a sustainable and long-term approach for the development of a regional innovation system. Continuity in the implementation of policy initiatives and building on existing infrastructure (e.g. regional R&D centres) is more effective for a systemic development of regions than constant changes and introduction of new measures at the regional level. For example, Prague as the core of research in the CR has some excellent research institutes which could act as a gravitation point for building additional research infrastructure, but so far the development of infrastructure in Prague has only been supported to a limited extent by EU SF. The CR needs to guarantee R&D infrastructural development in Prague from other sources.

M. *Provide supporting instruments for SIL individualised for each region for different steps on the trajectory curve*. Regions have different problems (non-embeddedness of MNEs, mismatch of disciplines, etc.). There should be room for each region to create the right instruments for its needs (no ‘one size fits all model’) on different stages and scales of SIL.

N. *Share experiences of SIL generated in other regions in the CR*. Regions can learn from each other’s experiences in setting up and using specific channels. The TU Brno set up some specific programmes on SIL using the TTO most successfully, for example. In addition to the view abroad, experiences gathered in the CR should also be shared.

Appendix A : References

Abreu M., Grinevich V., Hughes A., Kitson M. (2009): Knowledge exchange between academics and the role of business, public and third sector.

Aiginger, K. et al. (2009); Evaluation of government funding in RTDI from a systems perspective in Austria. Vienna.

ASCR (Academy of Sciences of CR) (2009) Annual Report 2009.

Bekkers R., Bodas Freitas I.M. (2008): Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? In: Research Policy 37 (2008) 1837–1853

Bekkers, R. (2009). An evaluation of incentives and policies that affect research institutions' knowledge transfer activities, at researcher and management level.

Bergman E (2010): Knowledge links between European universities and enterprises: A review. In: Papers in Regional Science, 2/89, 311-333.

Berman Group (2009) Evaluation of the Absorption Capacity of Operational Programme Enterprise and Innovation 2007-2013 in Relation to Target Groups.

Berman Group (2010) Field research of public R&D teams in the South Moravian Region (2010).

Blažek, J., Uhliř, D. (2007) Innovations and innovation policies in the CR: The case of Bohemian regional innovation strategy. European Planning Studies, Vol. 15, No. 7, pp. 871-888.

Blažek, J., Žížalová, P. (2010) The biotechnology industry in the Prague metropolitan region: a cluster within a fragmented innovation system? Environment and Planning C: Government and Policy. Vol. 28, pp. 887-904.

BMWF, BMVIT, BMWFJ (2010) Austrian Research and Technology Report.

Bozeman, Barry (2000) Technology transfer and public policy: a review of research and theory. Research Policy, Vol. 29, pp. 627-655.

Bramwell A, Wolfe DA (2008): Universities and regional economic development: the entrepreneurial university of Waterloo. In: Research Policy, 37, 1175-1187.

Caldera A, Debande O (2010): Performance of Spanish universities in technology transfer: An empirical analysis. In: Research Policy, 39, 1160-1173.

Czech Invest (2009a) Automotive Industry in the CR.

Czech Invest (2009b) The Czech EE/Electronics Industry.

Czech Invest (2010a) 2010 City Invest Czech.

Czech Invest (2010b) Science-Innovation-Business.

CZSO (Czech Statistical Office) (2010) Annual Yearbook 2010.

Debackere K, Veugelers R (2005): The role of technology transfer organisations in improving industry science links. In: Research Policy, 34, 321-342.

D' Este P, Iammarino S (2010): The spatial profile of university-business research partnerships. In: Papers in Regional Science, 89, S.335-350.

European Commission (2009): INNO-Policy TrendChart – Innovation Policy Progress Report: CR 2009.

European Commission (2008): COMMISSION RECOMMENDATION on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations , COM(2008) 1329, Brussels

Florida R (1999): The role of the university: Leveraging talent, not technology. In: Issues in Scienec and Technology, 15. Online under: http://www.issues.org/15.4/florida.htm [11.5.2011].

Foray, D. (2006) The Economics of knowledge. MIT press.

Friedman J, Silberman J (2003): University technology transfer: Do incentives, management, and location matter? In: Journal of Technology Transfer, 28, 17-30.

Garcia-Aracil A, de Lucio IF (2008): Industry-University Interactions in a peripheral European region: An empirical study of valencian enterprises. In: Regional Studies, 2/42, 215-227.

Grupp, H. (1997) Messung und Erklärung des technischen Wandels. Berlin.

Gulbrandsen M et al. (2011): Introduction to the special issue: Heterogeneity and university-industry relations. In: Research Policy, 40, 1-5.

Hofer, F et al. (2004): Technology and knowledge transfer in the Graz region. In: Industry and Higher Education, 18, 177-186.

Jaffe A (1989): Real effects of academic research. In: American Economic Review, 79, 957-970.

Jensen, M.G., Johnson, B., Lorenz, E., Lundvall, ,B.A. (2007) Forms of knowledge and modes of innovation. Research Policy, Vol. 36, pp. 680-693.

Klusáček, K. (Project Manager), Kučera, K., Pazour, M. (2008) White Paper on research, development and innovation in the CR.

Landesmann, M. (2010): Which growth model for Central ans Eastern Europe after the crisis? FIW Policy Brief No. 4.

Larsen MT (2011): The implications of academic enterprise for public science: An overview of the empirical evidence. In: Research Policy, 40, 6-19.

Lerner J (2009): Boulevard of broken dreams: Why public efforts to boast entrepreneurship and venture capital have failed - and what to do about it, Princeton.

Matějů, P. (head of the team), Ježek, F., Münich, D., Slovák, J., Straková, J., Václavík, D., Weidnerová, S., Zrzavý, J. (2009) White Paper on Tertiary Education.

Mowery D, Sampat B (2005): Universities in national innovation systems. In: Fagerberg J et al. (eds.): The Oxford Handbook of Innovation, Oxford, 209-239.

Mustar P et al. (2008): University soin-off enterprises: Lessons from ten years of experience in Europe. In: Science and Public Policy, 2/32, 67-80.

2009 Expert Group on Knowledge Transfer, Final Report (pp. 82-111). Brussels: European Commission.

OECD (2010): Education at a glance 2010. Paris.

OECD (2010) Tax Policy Study No. 20 - Tax Policy Reform and Economic Growth. Paris.

OECD (2011): Attractiveness for Innovation. Paris.

Pavitt, K. (1984) Sectoral patterns of technological change: Towards a taxonomy and theory. Research Policy, Vol. 13, pp. 343-373.

Pavlinek, P., Ženka, J., Žížalová, P. (2011) Functional upgrading through research and development in the Czech automotive industry. Unpublished paper.

Polt, Wolfgang, Rammer, Christian, Gassler, Helmut, Schibany, Andreas, Schartinger, Doris (2001) Benmarking industry-science relations: the role of framework conditions. Science and Public Policy, Vol. 28, No. 4, pp. 247-258.

Polt, W., M. Berger, P. Boekholt, K. Cremers, J. Egeln, H. Gassler, R. Hofer, C. Rammer. Unter Mitarbeit von J. Deuten, B. Good, K. Warta (2009): Das deutsche Forschungs- und Innovationssystem; Ein internationaler Systemvergleich zur Rolle von Wissenschaft, Interaktionen und Governance für die technologische Leistungsfähigkeit. Studien zum deutschen Innovationssystem Nr. 11-2010.

Reinstaller, A., Hölzl, W., Janger, J., Unterlass, F., Stadler, I., Daimer, S., Stehnken, T. (2010) Barriers to Internationalisation and Growth of EU's Innovative Companies. PRO INNO Europe: INNO-GRIPS II Studie, European Commission, Brüssel.

Universities Ireland, Trade & Business Development Body, Irish Universities Association (2006): University Collaboration on Technology Transfer: An All-Island Feasibility Study.

Vavrečková, J. (2008) Riziko odlivu vědeckých, výzkumných a vývojových pracovníků z České republiky do zahraničí v kontextu významu vědy a výzkumu v současné společnosti [Risk of outflow of scientific, research and development workers from the CR abroad in the context of the meaning of science and research in contemporary society]. Prague.

Yrrkö, J.A., Rouvinen, P., Seppälä, T., Ylä-Anttila, P. (2011) Who captures value in global supply chains? Case Nokia N95 Smartphone. ETLA Discussion Papers No. 1240.

Yusuf S (2008): Intermediating knowledge exchange between universities and business. In: Research Policy, 37, 1167-1174.

Žížalová, P. (2010) Geography of Knowledge-based Collaboration in a Post-communist Country: Specific Experience or Generalized Pattern? European Planning Studies, Vol. 18, No. 5, pp. 791-814.

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