

Final Report

Synthesis Report

Technopolis Group

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INVESTMENTS IN EDUCATION DEVELOPMENT

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

This report synthesises the following individual module reports:

Final Report 1: Assessment of Public R&D Expenditures in the Czech Republic

Michael Dinges - Joanneum Research Forschungsgesellschaft mbH Policies, Centre for Economic and Innovation Research

Final Report 2: R&D Governance in the Czech Republic

Erik Arnold, Bea Mahieu, Andrej Horvath – Technopolis Group

Final Report 3: The Quality of Research, Institutional Funding & Research Evaluation in the Czech Republic and abroad

Erik Arnold, Barbara Good, Fritz Ohler, Brigitte Tiefenthaler, Niki Vermeulen – Technopolis Group

Final Report 4: Review of the IPR System

Alfred Radauer - Technopolis Group; Juraj Poledna - Peritus

Final Report 5: Science-Industry Linkages

Reinhold Hofer, Susanne Meyer, Martin Berger, Christian Reiner - Joanneum Research Forschungsgesellschaft mbH Policies, Centre for Economic and Innovation Research

Final Report 6: International Co-operation in R&D

Jakob Edler, Kieron Flanagan, Abdullah Gok, Philip Shapira - Manchester Institute of Innovation Research, MBS, University of Manchester; Patries Boekholt - Technopolis Group

Final Report 7: Human Resources in R&D

Liudvika Leisyte, Paul Benneworth, John File, Andrea Kottmann, Egbert de Weert - Center for Higher Education Policy Studies, University of Twente

Final Report 8: Bibliometric Analysis of the Czech Republic Research Output in an International Context 1993-2009

Theo van Leeuwen, Rodrigo Costas Comesana – Centre for Science and Technology Studies CWTS, Leiden University

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Summary

This is the final report of an Audit of the Czech research system carried out for the Ministry of Education, Youth and Sport (MEYS) by an international team during 2010/11, with support from the Technology Centre of the Academy of Sciences of the Czech Republic. It is one of the most comprehensive studies of its kind ever undertaken and involves analysis of

- Public funding of Research and Development (R&D) in the Czech Republic
- Governance of the R&D system
- The quality of research and research management
- The evaluation of programmes and the Evaluation Methodology used in allocating institutional funding to research performing organisations
- The system of Intellectual Property Rights (IPR)
- Science-industry links
- International cooperation in R&D
- Human resources in R&D

These dimensions are summarised in this report and discussed in detail in individual module reports, published separately.

Many stakeholders believe that political instability since 2006 has had a negative impact on higher education and research. Research & development have become politicised and discussions have often been dominated by interest groups rather than by a strategic vision. Combined with frequent changes of government and even more frequent changes of ministers, this makes the Czech Republic a very difficult place in which to make and implement a consistent Research and Development and Innovation (R&D&I) policy. Many of the persistent disputes in research and innovation policymaking in the Czech Republic are symptoms of lack of trust, especially lack of trust in government. This is exacerbated by the failure of the Czech Republic to implement the civil service reforms to which it committed itself upon entering the EU. A number of recent reforms are flawed attempts to cope with instability and the perception that neither the government nor the civil service can be trusted. In the end, Research and Development and Innovation (R&D&I) policy – like other parts of government and the state – will only work well when there is a degree of political stability and people feel they can trust the government.

The structure of the National Research and Innovation System (NRIS)

The Czech Republic spends a little over 1.5% of Gross Domestic Product (GDP) on R&D, compared with 2% in the EU-27 overall. The business sector accounted for 60% of this before the financial crisis, but its share has since fallen back to about one half.

The main specificities of the structure of the Czech National Research and Innovation System (NRIS) stem from the communist period and the subsequent transition. The research and higher education system is still characterised by a split between Academy (ASCR – Academy of Sciences of the Czech Republic) and university systems, though these increasingly collaborate. There are currently 26 public higher education institutions. Before the transition, the universities focused on education but during the last two decades they have taken over PhD training from the ASCR, rapidly built research activities and currently have a total of some 19,000 FTE researchers. The ASCR was more or less the sole producer of basic research in communist times. It currently has nearly 7,000 staff and consists of 53 research institutes. There are currently 19 government laboratories and an applied industrial research institute (in international terminology Research and Technology Organisations or RTO) sector comprising around 60 such institutes – about a half as many as there were before

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1990. These RTOs are formally private companies but perform public functions and are under certain conditions eligible to receive basic funding from the state. The role of such organisations in innovation in other countries is very important but their role in the Czech NRIS is under-studied. More broadly, the respective roles of the different classes of institution in the NRIS have not been studied; for example, there is a *de facto* policy to grow the university research system and maintain the Academy rather than an explicit policy, which would require consideration of the costs and benefits of uniting the Academy and university system (as was done quickly in Estonia and slowly in France) or integration with the government laboratories, in the Danish manner.

Since the transition, business R&D has to a fair degree recovered in the Czech Republic's areas of traditional strength, notably vehicles and transport, but is led by Foreign Direct Investment (FDI). This has given the Czech Republic an apparently strong position in medium and high technology branches, but in practice the production involved tends to be in the low-value parts of these industries and most of the R&D done by industry is Development rather than Research.

At present, in the Czech Republic growth is mainly driven by diffusion and absorption of technologies that are new to the firm or new to the country but not new to the world. Domestic knowledge generation in business through R&D or non-R&D technical activities as well as accumulation of knowledge in public R&D system is not yet the major driver of growth. Achieving an appropriate mix of different types of research and development activities across the economy is necessary in order to enable knowledge-based development. This should include embedding Multinational Companies (MNCs) in national supply chains and upgrading the activities they perform nationally. The agenda should therefore include supporting and learning from this activity and successively moving the effort in the Czech Republic into higher-value activities, as well as looking for new areas of knowledge-intensive growth. Currently, the work of industry and the research and higher education system appear too polarised adequately to support catch-up innovation and growth.

Governance of the Research and Innovation System

We can identify three distinct periods in R&D funding during the post-communist era. The first, from 1990-98, involved institutional readjustment and was complicated by the split with Slovakia. Government was strongly averse to central planning so budget responsibility for R&D system was decentralised to the ministries and the Academy. The second period, from 1998-2003, was one of preparation for joining the EU. The government started to move away from the old system of unconditional funding and to base institutional funding of research performers on plans called 'Research Intentions'. A first national R&D policy was launched, aiming to remedy systemic failures and support the development of a healthy R&D system under the leadership of the Ministry of Education, Youth and Sport (MEYS). The third period, 2004 onwards, involved reorientating the NRIS towards innovation and applied research and included the ambition to increase the use of evaluation to help develop the research and innovation system and to guide aspects of resource distribution. Of especial importance in this period is the 2008 reform of R&D&I, which sought to simplify and modernise the system and improve its governance, support research excellence and the application of research, improve research-industry cooperation, make public research organisations more flexible, improve the supply of human resources and increase international collaboration in research. Additionally, at present European Structural Funds provide a major opportunity to invest in research infrastructure and innovation support measures such as technology platforms outside Prague, while generating an obligation to find national money to use the infrastructure in the future.

Some of the structures through which the Czech state's role in research and innovation is governed are internationally unusual and problematic. To a fair degree, the Academy still has the same status as a Ministry, in the sense of having a line in the

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state budget and authority to decide how to spend its money. The more typical Western model is for the basic research-funding organisation to be an agency of the Education Ministry and the innovation agency to be an agency of the Industry Ministry. Now, research policy is being set at the level of the R&D&I Council and handed to the ASCR, Technology Agency, Science Foundation and the Ministries to be implemented. The Science Foundation and Technology Agency lack Ministries acting as their principal, so the R&D&I Council – which effectively sets the entire national research budget – is de facto becoming a science ministry while formally being an advisor to (and not part of) the government.

The National R&D&I Policy 2009-2015 introduced important changes in governance, reducing the role of the Ministries in defining priorities and setting up a new priority-setting system based on committees of experts (primarily researchers) reporting to the R&D&I Council. The current approach of making institutional funding formula-based and concentrating control of targeted funding in the R&D&I Council reinforces the Council's role as quasi Science Ministry. In an international context, the R&D&I Council plays an unusual role in the management of Research and Development in the country, not only assuming the role of principal to the ASCR, Technology Agency and Science Foundation but also covering long-term strategy development, monitoring, evaluation and decision-making on budget allocations. Internationally, similar councils tackle some of these tasks in a broad-brush way. The R&D&I Council centralise all these activities, taking responsibility for *micro-management*. It thereby increasingly assumes the role of an executive body. This imposes a heavy burden on the members of the Council and its advisory committees, both in terms of time and of expertise – and most of all on the small Secretariat.

The Czech Republic has shifted its governance of the NRIS from one traditionally rather focused on science to become much more inclusive of innovation. But the governance has also become more centralised, increasing the distance between decisions about research and innovation funding and the stakeholders affected by them. As the young Technology Agency evolves, there are opportunities to strengthen these stakeholder links but this depends crucially on the willingness of the R&D&I Council to do less micro-management. More broadly, there is a need to empower the various state actors in the NRIS, encourage the creation and use of distributed strategic intelligence and refocus the Council as an arena for discussing and setting broad-brush policy, as opposed to being a negotiation table where institutional representatives fight it out for their share of the budget.

Part of the audit task was to examine the way R&D is programmed. In the Ministries we examined this is mostly well done with strong ambitions to implement good processes and is supported by competent staff. The Science Foundation is effective and efficient and maintains a very traditional approach to its work. The Technology Agency is of course young and will require further development but shows promise. A major concern throughout the system, however, is the declining role of stakeholders in programming as power shifts towards the R&D&I Council and the loss of 'strategic intelligence' about needs and opportunities that is caused by centralisation.

Funding

Like most countries, the Czech Republic funds research through two channels. Internationally, 'institutional' funding is used to provide a stable institutional base and opportunities to invest in new capacity and activities. Project-based funding that has to be won in competitions organised by research councils like the Science Foundation, innovation agencies like the Technology Agency and other funders complements this. By and large, the research councils look after the health of the basic research system while the innovation agencies programme at least some of their resources so that they can tackle areas of national need or priority. The project-based competition is intended partly to quality-assure the work funded by the institutional funding because

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poor quality institutions cannot win competitions. In few countries do universities and scientific research institutes obtain as much as half their research income competitively. However, the Czech Republic **aims** to achieve a 60:40 ratio between competitive (“targeted”) and institutional funding by 2015; if we count only the part of institutional funding that flows to research performers¹ that ratio has already been achieved.

Like a growing number of countries, the Czech Republic has chosen additionally to quality-assure the **institutional** funding flow, using a Performance Based Research Funding system (PBRF): the so-called Evaluation Methodology (EM). Most PBRFs have long (multi-year) time constants and reallocate only small proportions of institutional funding from poorly performing groups to the better performers, allowing the laggards to improve. The EM involves (re)allocating the entire flow of institutional funding annually, based on outputs generated in the preceding five years. This means that all of state research income is contestable and is inherently unstable, altering from year to year.

Funding is delivered to Czech research performers via increasingly centralised channels. Institutional funding is delivered primarily via MEYS and the Academy of Sciences (ASCR). MEYS, the Ministry of trade and Industry, the Technology Agency and the Science Foundation dominate targeted funding. More widely, responsibility for competitively funded basic research has been transferred to the Science Foundation – and the policy intention is to increase its share of targeted funding from its current 20%, which is low by international standards.

The role of evaluation in policymaking and governance

The evaluation system for evaluating R&D&I in the Czech Republic works badly. While in 2004, the National Policy for R&D adopted internationally accepted principles for evaluation, the interpretation and use of evaluation in R&D&I in the Czech Republic have become increasingly narrow. In particular, it focuses on measuring the wrong thing by looking at the immediate outputs of the research system rather than whether it produces the intended societal effects.

The Evaluation Methodology for institutional funding is not fit for purpose. Its reliance on quantitative indicators is driven by a desire to de-politicise and de-personalise the funding process. By relying only on (proven) past achievements, it aims to act against nepotism, corruption and lobbying. It sends out a clear signal: no outputs, no institutional funding. As such, it addresses the issue of low productivity in some research organisations. At the same time, it is intended to improve the quality of research outputs. These are good ambitions.

However it suffers important weaknesses including reductionism, failure to address differences in inputs and outputs or to take account of policy requirements such as the national thematic priorities treating all institutions in the same way, regardless of their missions by using output indicators that are in practice arbitrary. Informed peer review would in many cases lead to different and more nuanced assessments of research group performance than is possible using the EM. The EM leads to opportunistic behaviour (‘gaming the system’) by researchers and makes institutional funding unpredictable. It leads in some cases to large swings in funding and encourages short-term focus by punishing investment in the development of new fields and capacities that have few short-term outputs. It has been refined annually, but in the absence of a change that introduces prospective elements and judgement it will continue to perform badly, fragmenting research efforts, discouraging

¹ Budget lines for institutional funding contain other cost items relating to the operation of ministries, which are not normally treated as institutional funding outside the Czech Republic

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collaboration, distorting research performers' innovation-orientated activities and impeding the development of research strategy and investment and the creation of science-industry links.

The general logic of state intervention is that the state identifies problems in society and intervenes to remedy them. These 'problems' may be permanent (people get ill and need to go to hospital; society will benefit from research but companies do not have adequate incentives to invest in it) or temporary. In either case, the aim is to remove or reduce the problem. Thus, health policy aims to maximise the proportion of the population that is well. To achieve this, the health system produces lots of outputs such as injections, operations, dietary advice and hospital bed-nights. It is useful to count these things – they cost money, they show that the system is doing something and we are interested in the efficiency with which they are produced. But ultimately, evaluation needs to measure the health of the population – that, not the amount of output, is what tells us whether health policy is succeeding. It is perfectly possible for the number of outputs to go up while the health of the population declines – for example, if the hospitals are making outputs that do not meet patients' needs.

In most systems, evaluation helps us understand whether interventions are effective. They become part of the **policy cycle** and provide some of the strategic intelligence that keeps policy relevant. In R&D policy in the Czech Republic, programme evaluation focuses on R&D outputs. Especially in a context where stakeholders' role in policymaking is declining, this detaches R&D&I policy from needs. In parallel, the EM allocates institutional resources to strong research performers based solely on outputs and irrespective of whether their research is useful. This is probably a good thing to do in basic science, but not in the 80% or so of the effort that is intended by policy to be applied and innovation-relevant. The equivalent in health policy would be to reward hospitals for the amount of treatment they do, as opposed to their effects on health. Clearly, a radical change is needed in the nature of R&D evaluation.

Performance of the R&D&I System

The performance of Czech research as measured by the number and quality of publications has been steadily improving, though it remains below world average levels. The Czech Republic has traditionally had a strong focus on the natural sciences and mathematics but the country's publications profile is now slowly changing so that (bio)medicine and health sciences play a somewhat larger role but are growing from a comparatively low level of performance in international comparison. Increasing collaboration inside and outside the country and the gradual build-up of capacity mean that performance is likely to carry on getting better, provided the pattern of increasing funding of R&D can be maintained or is at least stable. Since internationally collaborative papers tend to be of distinctly higher quality than national ones, it is doubly important to improve the Czech Republic's rather indifferent performance in the EU Framework Programme and to expand its participation in other international cooperations.

The drivers for internationalisation of the Czech NRIS are to improve the quality, scope and critical mass in science and research by linking national (financial and human) resources and knowledge with resources and knowledge in other countries. Four-fifths of the Czech Republic's international collaboration papers are with European countries although the USA is also a major partner. The ASCR and Charles University dominate international co-publication patterns, suggesting that there is scope to increase the collaboration performance of the other organisations. At senior level, Czech researchers are internationally well connected and a small majority has worked abroad. However, less than 10% of researchers appear to be foreign, and half of those are Slovaks. Teaching language requirements and cumbersome immigration requirements inhibit growth in this proportion. The Czech Republic gets a poor return from the Framework Programme – in part because national researchers find it easier

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to get money at home; partly because there are no career or funding incentives that reward FP income more highly than other forms². It has few project coordinators and is especially weak in the parts of the FP that cooperate outside Europe. Given the weak bottom-up incentives and the lack of an overall internationalisation strategy for the Czech Republic there seems considerable scope to make better use of research internationalisation not only to support strengthening of the research community but also in pursuit of FDI and improved linkages between Czech industry and the rest of the world.

Research management, in the broadest sense, is problematic. With the help of scientific peers, we reviewed the performance of 15 research groups, which were selected in cooperation with our steering committee to give a good spread of disciplines and geography while also being among the strongest national research groups in their respective fields. Groups were often small, and dependent upon a single director, sometimes as a result of comparatively fragmented university organisation with highly autonomous professors. Small size limited interdisciplinarity and tended to lock groups into existing research trajectories.

Groups had little awareness of human resource issues. Many were not tackling succession, despite the age of their leaders; many were in-bred; international mobility was low and – while there was clearly a rising trend – opportunities for Academy Institutes and universities to work together were under-exploited. Larger group sizes, better human resource planning and more explicit strategies will help reduce the current fragmentation and boost output. A key ingredient would be reduction in funding uncertainties, to allow institutions to set and deploy longer-term strategies. This would imply reforming the EM.

More broadly, the approach to human resource development in the Czech NRIS remains rather unsystematic. One reason for this is the old-fashioned style of institutional governance and organisation that promotes fragmentation of research. Public research organisations need to take stronger central responsibility for human resource management (and other aspects of research management), enabling career pathways to become more flexible, reducing the degree of in-breeding (currently groups plan to fill 85% of posts with their own PhD graduates) and reducing fragmentation through devices such as local and international graduate schools.

Lack of skilled personnel is one of the factors seen as hampering innovation in general. Czech researchers seem broadly dissatisfied with their pay and conditions but while average salaries are below the EU-25 in exchange rate terms they are about the same as the average in terms of purchasing power parities. Salaries have a significant performance-driven component, which in many cases is driven directly by previous outputs counted in the EM.

Career progression is cumbersome and rigid. More than 50% of senior scientists are over 50 while the proportion of women is half the EU-27 average. These proportions seem rather stable, so deliberate measures will be needed in order to correct these imbalances. There is both a lack of qualified academic personnel and of training opportunities. Human resource management in the research system is quite undeveloped, making little use of career development plans. Reforms are in hand to make career progression and competition for posts more transparent. More flexibility is needed in careers to make it easier, for example, to hold joint appointments and more diverse criteria, better attuned to career and institutional objectives are needed in HR management. Multi-annual research budget allocations will make that easier to achieve. There are a number of challenges in investing in HR for R&D&I through a coherent national and regional approach that makes good use of the large ongoing

² Many national systems view receipt of Framework Programme funding as an 'esteem indicator' – a sign of recognised quality, and it should probably be used as such in the successor to the EM

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investments in European Structural Funds. In order to support industrial development, there is a clear need to strengthen areas outside the main core region, Prague, Central Bohemia and the South West, without undermining Prague's strength and attractiveness as a service core for central Eastern Europe.

Science-Industry Links (SIL) are of variable strength. There appears to be a lot of **informal** but little formal linkage. The low-value activities of many of the MNCs mean they do not easily become embedded in the Czech NRIS. Thus, many of the existing links are with medium-sized firms. Both the operation of the Evaluation Methodology and the lack of public RTOs militate against links with such firms. Measures are needed better to embed the multinationals in the Czech research system and to provide the appropriate level of coordinated support to less capable firms at national and regional levels.

In any country, the strength of Science-Industry Links depends upon the respective needs and capabilities of industry and science. With MNC plant in the Czech Republic largely doing low-value work within high-technology industries, they tend to relate closely to headquarters R&D and little to research in the Czech landscape. If we look at the rest of industry, we see the same pattern as in other countries: the bigger the company, the more it interacts with the universities and institutes. This size effect has two causes. First, the larger the firm the more it tends to make multiple products and the wider its knowledge needs become. Second, as firm size increases so does its tendency to employ technicians, engineers and scientists and to do R&D. Hence, its absorptive capacity³ – the ability to look outside the firm, identify, internalise and exploit useful knowledge – increases with size and that in turn drives up its demand for knowledge. To the extent that much of Czech industry is still behind the technology frontier, its external knowledge support needs will tend to focus on choosing, understanding and unbundling existing technologies rather than science. Of course, in some branches like Chemicals where Czech industry has traditionally been strong, SIL are likely to be much more prevalent than in others. Both researchers and companies surveyed were dissatisfied with support measures for SIL.

Formal IPR instruments, notably patents, are little used in the Czech Republic. This is consistent with the importance of technology adoption and use rather than the generation of new-to-the-world innovations in industrial development but also reflects traditions and habits from communist times and the fact that the developing European Patent Office and system has largely been irrelevant to Czech industry. While the Czech Republic has state of the art IPR legislation and there is a small community of experts in the area, outside this group there is little understanding of IPR. This applies both to patenting and to the much broader set of instruments such as trademarks, registered designs etc that form modern IPR management. While there are important exceptions – not least the Institute of Organic Chemistry and Biochemistry of the ASCR (which generates significant licensing income for the Academy) – management in both industry and the research sector tends to lack knowledge and experience of IPR management. Several types of institutions, which should provide at least basic referral and information services, do not have such offerings, the most prominent being the majority of chambers of commerce and business associations.

Moves to establish Technology Transfer Offices in the universities and institutes are in their infancy and many organisations have not yet built up much experience in how to trade off formal technology transfer (through patents and licenses) with the broader knowledge transfer functions of public sector research. In many situations, an open

³ W Cohen and D Levinthal, 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, No 35, 1990, pp 128 - 152

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innovation approach or strategic partnerships can be more effective ways to obtain social returns on government investment in research than formal mechanisms.

Conclusions

We can summarise our major conclusions by considering how effective the implementation of the main lines of the reform of the national R&D&I policy of 2008 have been.

How Well Has the 2008 Reform Worked So Far?

Aims of the Reform	Effects visible to Date
1. To <i>simplify the support of R&D</i> , supporting institutions according to the results achieved and teams according to the projects undertaken. This implies an improvement of the evaluation system for public financed R&D	The EM has indeed simplified the support system, at the cost of inhibiting many aspects of system performance. It is not fit for purpose and no amount of incremental adjustment is likely to make it so. It evaluates only one dimension of public support and neglects many of the reasons for which the state funds research. Combined with other reforms, its likely effects will be to disconnect research from development, innovation and societal need. There is no improvement of the evaluation system for the targeted funding of R&D visible so far.
2. To <i>simplify the R&D&I support system and the administrative procedures</i> . The number of budgetary chapters (22) under which the Czech R&D is supported is significantly reduced and the paperwork requirements simplified. The latter will be achieved also through establishment of a single agency responsible for support to industrial research projects (the Technology Agency)	The number of budget chapters has been reduced, at the cost of increased distance between those who understand needs and those responsible for research policy and the imposition of an impossible load on the R&D&I Council. The Technology Agency is a very promising development but its funding and governance need to include the Ministries and other stakeholders to link it to societal needs and national priorities.
3. To encourage and support <i>excellence in research</i> and facilitate the <i>application of R&D results</i> in innovation. This will be achieved through improved R&D evaluation as well as more emphasis on excellence in basic research and applicable results in applied research	The EM may in a narrow sense increase research excellence (especially in the 'hard' sciences though probably not in the social sciences) but not relevance, so its likely effects are the opposite of the overall policy intention to integrate innovation more closely into the research system.
4. To strengthen <i>research-industry cooperation</i> . To condition programme support of R&D upon the cooperation of public research with users of R&D results, based on co-financing from public and private resources. A proposal is made to extend the indirect support of R&D (tax reliefs) to R&D results purchased by enterprises from (Czech) public research institutes and universities	This is primarily being pursued by the Ministry of Trade and Industry. The poverty of programme evaluation means there is little evidence as to its effectiveness. In principle, it is the right thing to do and extending the tax reliefs to R&D results may also be beneficial – though this measure must be carefully implemented to avoid crowding our more active Science-Industry Links that will be more effective in developing companies' technological capabilities.
5. To introduce <i>more flexible organisational structures</i> of public research organisations in order to promote research-industry collaboration and create the conditions for their commercialisation of research results	Not yet addressed, but clearly necessary as part of a wider modernisation of institutions, especially the universities.
6. To provide <i>qualified human resources</i> for R&D&I, including a simplification of conditions for hiring researchers from abroad	Some limited progress. Much more to do.
7. To increase international collaboration in research, development and innovation, especially within the European Research Area.	Some limited progress. Much more to do.

Recommendations

The following recommendations flow from our overall analysis. These are discussed in more detail in the body of the report. Yet more detailed discussions and recommendations are contained in the individual module reports.

1. Building trust in government and among members of the R&D&I community is a precondition for successful performance in the NRIS. Such trust is based on fair principles transparently and impartially implemented combined with conspicuous punishment for those at any level who break the rules. **The promised civil service reforms should urgently be carried out. The state's organisations that aim to manage the NRIS – from the R&D&I Council, the Ministries, the Science Foundation and the Technology Agency – should be required to make details of decisions and reasons for making them public. Oversight processes, including the use of international peers, should be in place so that there are credible guarantors who can test and vouch for the independence and objectivity of decisions.**
2. The size and quality of the Czech R&D&I system have been increasing for a number of years but remain below international levels. **The state should continue to increase its investment in R&D, in line with the policy of spending 1% of GDP on R&D by 2020. Measures need to be in place to encourage industry to spend a further 2% of GDP on R&D by that time, in line with the expectations of the former Barcelona Goal and the new Horizon 2020 policy of the EU.**
3. There are signs that the division of labour and institutional boundaries among the universities, ASCR and RTOs are not optimal and that opportunities for more closely working together are being missed. Outdated forms of organisation and management appear in some cases to impede effectiveness. **The R&D&I Council should launch an inquiry into the organisation, performance and division of labour among the universities, ASCR and RTOs with a view to proposing measures to modernise and potentially reallocate roles among these organisations. Updating human resource and research management practices should be key elements of the resulting reforms. Measures should urgently be introduced to combat the shockingly low level of female participation in research, which represents a massively inefficient waste of talent.**
4. Recent reforms have tried to combat lack of trust in government, perceived improprieties in decision-making and perceived lack of capabilities in the Ministries by centralising responsibility for R&D&I budgets and policy in the R&D&I Council. This overburdens the Council with a level of responsibility with which it cannot realistically cope and makes it hard for it to take good and informed decisions. It makes it into a quasi-Science Ministry without linking it properly into the government or the democratic process and distances it from the system-wide knowledge and strategic intelligence required to link policy to needs. **Alongside the civil service reforms, Ministry capacities should be strengthened and the Ministries re-empowered to act in R&D&I by having their own budget lines. The R&D&I Council should refocus on setting broad strategic directions rather than budget allocation and micro-management. The Science Foundation and Technology Agency should be given principals in the form of Ministries. As with the Research Council of Norway and Austria's FFG, multiple Ministries should be able to use them as funding agencies for their R&D&I activities. The relationship between the principals of the funding agencies and the agencies**

themselves should have the character of performance contracts. The agencies should be managed by objectives; their actions and activities should not be micro-managed by the R&D&I Council or others. The character of steering should therefore shift towards soft steering with the involvement of relevant stakeholders.

5. Good international practice in R&D programming is to involve stakeholders, so as to ensure a fit with needs and opportunities. This is of course subject to checks and balances and the planning and implementation processes must be transparent. **Czech R&D programming practice should respect the international tradition of stakeholder involvement combined with scrutiny to ensure objectivity and independence.**
6. The proportion of research funding in the Czech Republic that is delivered under competitive conditions is too high, exceeding levels that many countries regard as dangerous. **Institutional funding should comprise at least 50% of research funding. It should be quality-assured but on a slow (5+ year) cycle that creates stability and opportunities to plan rather than on an annual basis.**
7. The Evaluation Methodology is not fit for purpose. It introduces structural and behavioural distortions and impedes many aspects of the NRIS' development. **The Evaluation Methodology should be replaced by a system of performance contracts that have both prospective and retrospective components, supported by a combination of objective indicators and international peer judgement.**
8. The system of R&D evaluation in the Czech Republic more broadly focuses on counting outputs at the expense of understanding policy interventions and their impacts. It therefore provides information that is at best of limited relevance. **Evaluation practice should be the subject of root and branch reform, refocusing on outcomes and impacts in addition to outputs and contributing to policy and programme development and planning. Inter alia, this will involve implementing the 'waterfall principle' that involves levels in the steering hierarchy using independent expertise to evaluate levels hierarchically below themselves but not in effect being able to do self-evaluation.**
9. The Czech NRIS lacks an Internationalisation strategy. This inhibits its development. **The R&D&I Council should launch a consultation and study to generate a Czech R&D&I internationalisation strategy.**
10. Intellectual Property Rights (IPR) are poorly understood in the Czech Republic. Few understand the breadth and usefulness of a proper IPR strategy. **The employers' organisations or chambers of commerce should launch a campaign of IPR education for industry. At the same time, the universities and institutes need to develop clearer IPR strategies. This does not mean that there should be further pressure to patent the irrelevant – rather, understanding IPR properly allows rational decisions to be made about what not to patent and how best to share knowledge with industry and other organisations outside the research and higher education sector.**

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1. Introduction

This is the final report of an Audit of the Czech research system carried out for the Ministry of Education, Youth and Sport (MEYS) by an international team during 2010/11, with support from the Technology Centre of the Academy of Sciences of the Czech Republic. It is one of the most comprehensive studies of its kind ever undertaken and involves analysis of

- Public funding of R&D In the Czech Republic
- Governance of the R&D system
- The quality of research and research management
- The evaluation of programmes and the Evaluation Methodology used in allocating institutional funding to research performing organisations
- The system of Intellectual Property Rights (IPR)
- Science-industry links
- International cooperation in R&D
- Human resources in R&D

These dimensions are summarised in this report and discussed in detail in individual module reports, published separately.

The Czech Republic is among the more advanced countries in the world, even if it has yet fully to complete the transition from communism to meet the income and performance standards common in Western Europe. The World Economic Forum's Global Competitiveness Report⁴ gives a stylised but helpful view of important aspects of the way the country works based largely on national surveys of business executives' opinions. Out of 139 countries, it ranks the Czech Republic 21st for the quality of its scientific research institutions, 29th for industry-university collaboration in R&D and 24th in its capacity for innovation. The Czech Republic comes 32nd in terms of the tertiary education enrolment rate and 34th for the overall quality of the education system. But it ranks very poorly on institutional dimensions: 121st for public trust of politicians; 102nd for diversion of public funds; 118th for the burden of government regulation; 102nd for the transparency of government decision making; 90th for the ethical behaviour of firms and 89th for protection of minority shareholder' interests. In other words, aspects of the research and innovation system seem reasonably good (even if not among the very best in the world) but levels of trust – especially of government – are low.

There is a shared view that the political situation in the Czech Republic over the last few years has been an important factor influencing the research & development field in general. According to many stakeholders, political instability since 2006 has had a major impact on the overall atmosphere in higher education and research. According to many stakeholders, research & development has become a highly political topic, and the discussions have often been dominated by particular interests and pressure groups rather than by a strategic vision of what is needed in the Czech Republic in the long term. Combined with frequent changes of government and even more frequent changes of ministers, this makes the Czech Republic a very difficult place in which to make and implement a consistent innovation and research policy. Many of the disputes that impede research and innovation policymaking in the Czech Republic are symptoms of lack of trust. This is a fact that must guide both the reading of this report and any implementation of our recommendations.

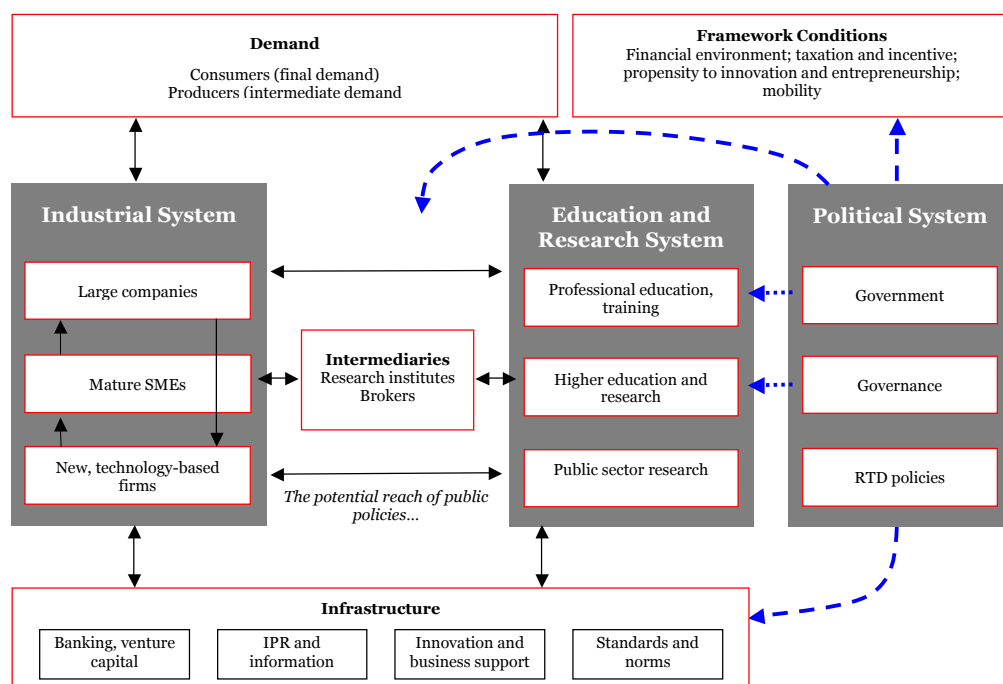
⁴ Klaus Schwab, *The Global Competitiveness Report, 2010-11*, Geneva: World Economic Forum. Rankings are based on opinion-surveys except where indicated by an asterisk*

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The team conducting this audit brings a common set of knowledge and experience about how research and innovation systems work and how they can best be managed. This is based on a combination of things that have been learnt in the field of ‘research on research’ over the past 40-50 years and our experience of international practices in the governance and management of the state’s role in the National System of Research and Innovation (NRIS). There are large differences between different national contexts, so it would be foolish to offer a unique example as ‘best practice’. What works in one place may not work in another. Nonetheless, there are some ideas that we believe are transportable.

The most important is probably the idea of a national innovation system – which we prefer to refer to as a National System of Research and Innovation. We define this as a system of interconnected organisations or core actors **and** wider framework conditions within which societies create, store and transfer the knowledge, skills and artefacts that contribute to innovation (Figure 1). From this perspective, the innovative performance of an economy depends not only on how the individual organisations perform in isolation, but also on how they interact with each other and on their interplay with social institutions (such as values, norms and legal frameworks⁵). This is now very much the mainstream view in the field of research and innovation policy.

Figure 1: A National Innovation System Heuristic



Source: Erik Arnold and Stefan Kuhlman, *RCN in the Norwegian Research and Innovation System*, Background Report No 12 in the Evaluation of the Research Council of Norway, Oslo: Royal Norwegian Ministry for Education, Research and Church Affairs, 2001

The current perspective on innovation and research is that these are vital components of socio-economic performance within complex national, international and regional systems. Individual components of these systems – such as companies, universities, institutions, institutes, governance, education, tax laws and other ‘framework conditions’ and so on – all need to work well if the system as a whole is to generate

⁵ Keith Smith and Jonathan West, *Australia’s Innovation Challenges: The Key Policy Issues*, submission to the House of representatives Standing Committee on Science and Innovation, Inquiry into Pathways to Technological Innovation, Hobart: University of Tasmania, April 28, 2005

economic welfare. Not only the components of the system but the way they are interconnected need to be efficient and of high quality. Correspondingly, the balance among different system components and the policies that relate to them needs to be appropriate and the policies need to be mutually consistent.

Traditionally, the state is regarded as intervening in research because there is a 'market failure'⁶ in capitalism that means the private sector under-invests in fundamental research because it cannot readily monopolise the results. Rather, these results tend to 'spill over' to the rest of society. So research is a bad investment for companies but a good one for the state, because society gets the spillovers. It is efficient for companies to do R&D on things that are 'closer to market' where they can appropriate more of the benefits. The innovation systems perspective stresses that, because the system comprises fallible organisations with imperfect knowledge but the ability to learn, there are various kinds of 'systems failures' such as lock-in and failures in institutions or framework conditions that also justify intervention. The need for modernisation of university organisation and governance would be an example of such a failure.

Because systems failures and performance are highly dependent upon the interplay of characteristics in individual systems, there can be no simple rule-based policy as is possible in relation to the static idea of market failure.⁷ Rather, a key role for state policy making is 'bottleneck analysis' – continuously identifying and rectifying structural imperfections.⁸

While it would be foolhardy to try to state a set of iron rules for managing an NRIS, a number of principles do emerge from this discussion that help provide criteria for auditing the Czech system

- Since innovation, applied and basic research are interdependent, all three need to be healthy and interlinkages among them and the institutions that perform and fund them must be strong
- Scientific performance must converge towards global levels and preferably over time exceed this in selected areas of national or industrial importance
- Since a lot of important innovation involves adapting and using knowledge that is not new to the world, there must be strong capabilities for accessing global knowledge, including through FDI, connecting multinationals' demands to domestic supply chains, reverse engineering and 'unbundling'
- It is important to have broad capabilities in basic research in order to keep university teaching up to date, ensure there is scientific capability available in most fields to meet policy and societal knowledge needs and to provide a point of growth when it turns out that increased capacity is needed
- However, a significant proportion of basic and applied research should be directed towards areas of national and industrial priority – not only to supply knowledge but – crucially – to supply relevantly educated and trained people. Therefore, both quality and relevance criteria are important at relevant points in the system
- Links between industry and the research and higher education system (including the applied research institutes) are important both for 'advanced' and less advanced companies, though the type of link and the right counterpart will depend upon the absorptive capacities of the individual firms

⁶ Ken Arrow, 'Economic Welfare and the Allocation of Resources for Invention,' in Richard Nelson (Ed.) *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962; see also Richard Nelson, 'The simple economics of basic scientific research,' *Journal of Political Economy*, 1959, vol 67, pp 297-306

⁷ Johan Hauknes and Lennart Norgren, *Economic Rationales of Government Intervention in Innovation and the Supply of Innovation-Related services*, STEP Report 08 1999, Oslo: STEP Group, downloadable from www.nifu.no

⁸ Erik Arnold, Stefan Kuhlmann and Barend van der Meulen, *A Singular Council: Evaluation of the Research Council of Norway*, Oslo: Ministry of Education, Research and Church Affairs, 2001

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- NRIS governance needs to include a transparent ‘arena’ in which stakeholders and decision-makers can debate and establish broad R&D&I priorities, leaving the budget to the government and the details of implementation to others. Members of the arena should act as experts and not as representatives, and should not be incentivised by the process to represent their own or other organisations
- The strategic intelligence needed should be created and analysed in a distributed way across the institutions of the NRIS
- Evaluation is a key component of strategic intelligence and requires the same ‘intervention logic’ at its heart as programme design. The overriding purpose of evaluation is to understand the degree to which interventions tackle and solve societal problems. Evaluation of outputs alone has limited value
- R&D&I policy should be implemented according to the principle of subsidiarity: namely, that decisions should be made as low down as possible in the hierarchy of organisations involved
- The organisations involved, not least those responsible for funding R&D&I, need appropriately skilled and experienced people and should use transparent, efficient and rational programming practices that take account both of national priorities and the needs of stakeholders
- Mechanisms are needed to articulate demand for technology and research, not only supply. The knowledge and experience of stakeholders is needed in order to do this effectively
- The state’s role in governing the parts of the NRIS under its control must include the ability to act as a ‘change agent’ – overcoming lock-ins where these have a negative effect on the NRIS. It needs to be able to tackle systemic failures as well as the traditional market failures involved in funding research
- More broadly, the state must have the capacity to do ‘bottleneck analysis’ in the NRIS, generating strategic intelligence about performance, problems and opportunities for change
- The NRIS must be internationally open, both in industry and in the research and higher education system, linking the Czech communities to global sources of knowledge and to the quality demands of the global science and technology systems

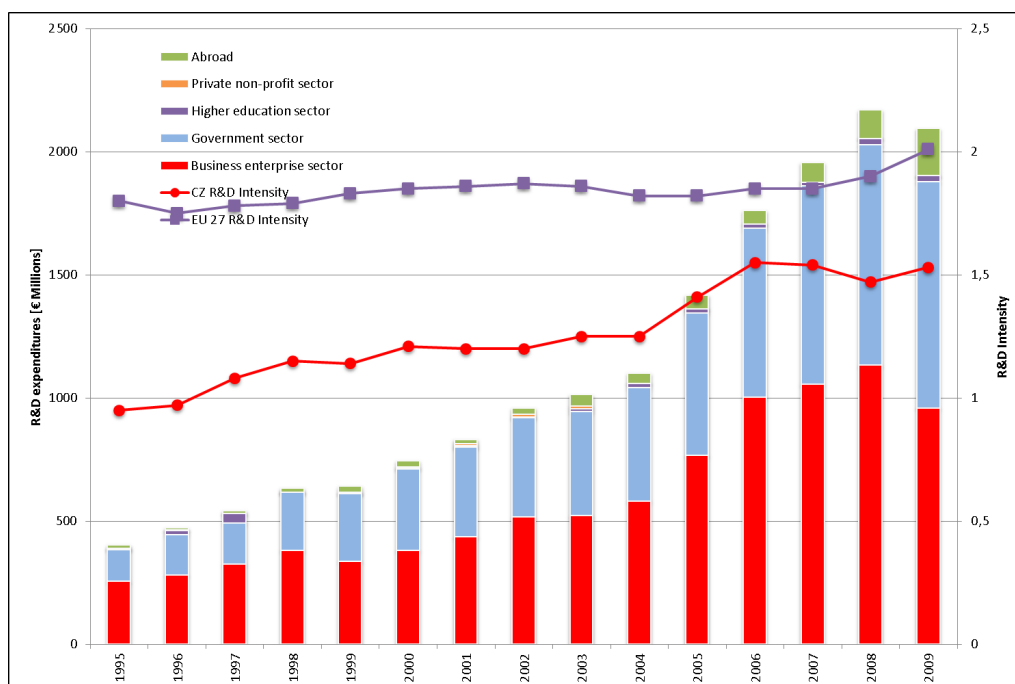
2. Structure of the Czech NRIS

The main specificities of the structure of the Czech NRIS stem from the communist period and the subsequent transition. The research and higher education system is still characterised by a split between Academy and university systems, though these increasingly collaborate. In the rush to privatise after the end of the communist period, quite a number of research institutes that would elsewhere be regarded as Research and Technology Organisations (RTOs) and therefore deserving of some public subsidy in order to generate spillovers moved into the private sector.

Business R&D has to a fair degree recovered in the Czech Republic's areas of traditional strength, notably vehicles and transport, but is led by Foreign Direct Investment (FDI). The agenda is therefore to learn from this activity and successively to move the effort in the Czech Republic into higher-value activities, as well as looking for new areas of knowledge-intensive growth. Achieving an appropriate mix of different types of research and development activities across the economy is necessary in order to enable knowledge-based development. At present, the work of industry and the research and higher education system seem too polarised adequately to support catch-up innovation and growth.

Overall, the pattern of R&D expenditure in the Czech Republic has been strong in recent years. While the proportion of GDP the Czech Republic devotes to R&D (1.53% in 2009) remains below that of the EU-27 (2%), it has been catching up very quickly since 1995 and much more quickly than in other CEE countries. Total expenditure has quadrupled in this time. R&D investment in the enterprise sector abruptly lost momentum with the onset of the crisis in 2008 but the narrowing gap in R&D intensity between the Czech Republic and the EU-27 would not have been possible without a considerable increase of business as well as public R&D investments (Figure 2).

Figure 2: R&D in the Czech Republic by Sources of Funding



Source: Eurostat (2010), calculations JOANNEUM RESEARCH

2.1 The Research and Higher Education System

The research and higher education system in the Czech Republic comprises a mix of public and private universities, the Academy of Science of the Czech Republic (ASCR) and a number of public and private institutes focusing on applied research for the state and for industry.

There are currently 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* produce 69,647 graduates (2009).

- Traditional universities (e.g. Charles University in Prague or Masaryk University in Brno with traditional faculties like 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
- Specialised universities in selected fields (e.g. Czech University of Agriculture in Prague or University of Economics in Prague)

Before the transition, the universities focused on education but during the last two decades they have rapidly built research activities and currently have a total of some 19,000 FTE researchers.

There are currently 19 government labs – 14 in Prague; 3 in Brno; 1 in Teplice; and 1 in Vyškov – directly serving the needs of their parent ministries.⁹

The other large research organisation is the ASCR related to the government sector, which was more or less the sole producer of basic research in communist times. It currently has nearly 7,000 staff and consists of 53 research institutes divided into three scientific domains

- Mathematics, Physics, and Earth Sciences
- Chemical and Life Sciences
- Humanities and Social Sciences

Radošević and Lepori argue that in several CEE countries the path dependency inherent in keeping or reforming the former Academy systems together with the real political power of the incumbents has limited the rate at which new incentives can induce reform¹⁰.

Finally, there is an RTO sector, largely comprising privatised state institutes. Most are members of the Association of Research Organisations. The loss of state funding meant that many of these organisations reduced or gave up their research activities and turned to small-scale manufacturing, provision of services, sales activities, or in some cases simply managed by renting out equipment and real estate acquired via the privatisation process. There are currently around 60 such institutes – about a half as many as there were before 1990 (AVO¹¹).

In some cases spin-offs from large enterprises were set up as private R&D organisations during the privatisation process of the 1990s (e.g. former research

⁹ ERAWATCH country profile Czech Republic:
<http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=4&countryCode=CZ>

¹⁰ Slavo Radošević and Benedetto Lepori, 'Public research systems in central and Eastern Europe: between excellence and relevance,' *Science and Public Policy*, 36 (9), 2009

¹¹ AVO – Association of Research organisations: http://www.avo.cz/index_e.htm

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department of Škoda Plzen called Škoda výzkum (engineering) or the former R&D department of Vítkovice Steel called 'Materialovy a metalurgický výzkum s.r.o.' in Ostrava¹².

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). These organisations work for the business sector but some also participate actively in public research programmes. Because they are private organisations, their activities are classified to the 'Business' sector in official statistics. However, some of them are eligible for institutional funding. In 2009, they accounted for 14% of BERD and received 29% of government funding for R&D in the Business Enterprise sector.

Overall, the public research sector has about 27,000 researchers¹³ and about 10,000 technicians. There has been a slight shift from the government sector (mainly but not exclusively the ASCR) to higher education resulting from a decrease of R&D personnel in government sector.¹⁴ This public research base is highly concentrated around Prague (54% of R&D personnel¹⁵) and Brno (18% of R&D personnel) while R&D capacity in business sector is less spatially concentrated.

Countries differ significantly in the degree to which state-funded research is done in the Higher Education sector or elsewhere, typically in institutes. Like other CEE countries that have retained an Academy of Sciences, the Czech Republic continues to fund a lot of research in Academy institutes. After an initial reduction in the size of the Academy that stripped it back to performing more or less basic research, it has remained rather constant in size for the past decade. The growth in the system has been in the former teaching universities, which now also do a lot of basic and applied research and have overtaken the Academy in terms of the volume of research and publications.

With both the Universities and the Academy aiming to focus on basic research, the OECD statistics suggest there is very little experimental development done in the research and higher education sector. This is partly an artefact of the privatisation of industrially applied institutes during the 1990s, which means that the Research and Technology Organisation function performed in other countries by organisations such as TNO or the Fraunhofer Society are done by private companies in the R&D services sector. But it also implies that the ability of the research and higher education system to support the areas of engineering strength in Czech industry is limited.

If we look at the overall pattern of government spending on R&D compared with the EU-27, the Czech Republic is slightly specialised in agriculture and (increasingly over time) in industrial production and technology. The Universities are more specialised in performing research in agriculture and engineering while the Academy focuses more on natural sciences. Taken as a whole, the public research system is comparatively specialised in Agriculture and Engineering. Medical and Health Sciences, Social Sciences and the Humanities are under-represented compared with the EU as a whole.

¹² ERAWATCH 2010

¹³ By occupation in government sector and higher education sector in 2009

¹⁴ More detailed information regarding the funding, performance and steering of all public research organisations is given in respective work packages

¹⁵ Full time equivalents 2009

2.2 Business

About one quarter of Czech value added comes from manufacturing industry, but this accounts for two-thirds of Business Expenditure on R&D (BERD) and its overall R&D-intensity has risen from about 2% to some 2.2% of sales between 2002 and 2007¹⁶. The Czech Republic has attracted significant inward investment in its traditional areas of strength: Mechanical engineering especially vehicles and chemicals. While the foreign multinationals increasingly do perform R&D in the Czech Republic, this tends to relate to the late stages of value chains, so the locally performed R&D tends more towards experimental development than research. There is therefore an opportunity to 'tune' some of the R&D performed in the public sector to support this kind of activity and to develop alongside the private work as the balance of private activity moves more towards research over time. This means that industrial stakeholders need to be involved in identifying needs and in R&D programme design.

The Czech Republic has the highest share of the labour force in medium- and high-technology manufacturing industry of any country in the EU. But it is clear that it occupies the low-value end of these industries (many of which are dominated by foreign multinationals) and does little R&D. Some 55% of business R&D expenditure is by companies with more than 500 employees. This is typical of smaller or less developed countries. In heavily industrial countries (Finland, Sweden, UK, France, Germany) the proportion is 70-84% and the proportion should become similar in the Czech Republic over time if the country is to perform healthy and productive industrial R&D.

Compared to the 10 EU benchmark countries for which disaggregated R&D data are available, business sector R&D expenditure is specialised in the fields of agriculture, textiles, metals, other non-metallic mineral products, motor vehicles, construction, telecommunications, financial intermediation and computers and related activities. FDI has given the Czech Republic an apparently strong position in medium and high technology industries, but in practice the production activities involved tend to be in the low-value parts of these industries. Much remains to be done in terms of embedding the MNCs in national supply chains, upgrading the activities they perform nationally and linking them to the Czech public research base.

The most R&D-intensive parts of manufacturing are the vehicles and transport equipment sectors. The Czech Republic's revealed comparative advantage has grown rapidly in these sectors (and in the low-R&D-intensity rubber and plastics sector) since the mid-1990s. Skoda accounts for about 75% of vehicles R&D, but there is a growing cluster of foreign-owned first tier component suppliers now also starting to do R&D. Despite rising R&D intensity, the Chemicals sector has lost comparative advantage in recent years. Machinery and equipment and electrical/optical equipment show modest increases in R&D-intensity. Computer and related activities and radio, television and communication have significantly increased their R&D-intensity so they could be interesting growth points in the future but the Czech Republic activity in these sectors is very small.

According to the OECD (2010)¹⁷, subsidiaries of multinational enterprises¹⁸ account for 50% of production and 46% of value added in manufacturing in 2007 in the Czech Republic. In respect to R&D, MNCs are responsible for 55% of expenditure and 43% of researchers (2007). The most important sector is - the manufacture of motor vehicles, which accounts for 38% of total R&D expenditures in manufacturing in 2007 (OECD

¹⁶ See Module report 5

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

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

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ANBERD 2009). The share of MNCs 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 MNCs is 47%, in chemicals (9%) it is 69%. These findings are supported by detailed firm level R&D investment (Figure 3) according to the EU Industrial R&D Investment Scoreboard (several years). This table shows that the major companies R&D investors in the Czech Republic are foreign owned companies (marked with 2 stars).

Hence, MNCs play a strong role in the Czech Republic's system. The largest individual private R&D spender is Skoda (which accounted for about 12 % of BERD in 2008). 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 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).

Figure 3: The largest R&D spenders in the Czech Republic 2005-2009

Company	Euro million				
	2009	2008	2007	2006	2005
Skoda Auto AS **	...	203.4	205.3	170.8	186.4
Komerční 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 hutní výrobu)	...	0.7	0.7	1.0	0.8
Paramo As **	...	0.3	0.3	...	...
Ceske drahy	...	...	0.0	...	...
Telefonica O2 Czech Republic **	...	...	...	0.6	...
Deza	...	...	...	0.4	...
Vitkovice Steel **	...	...	...	0.3	...
Oskar Cesky Mobile **	...	...	...	...	0.3
Cesky Telecom **	...	...	...	...	0.2
NKT Cables **	...	...	...	...	0.1

Note 1: This table includes also foreign subsidiaries (marked with two stars "**"). All the rules for inclusion in the Scoreboard are applied (i.e. availability of accounts and disclosure of R&D); ... = no information

Note 2: Cesky Telecom is now merged with Telefonica O2

Source: EU Industrial R&D Investment Scoreboard 2006-2010.

An international comparison of the type of R&D expenditures in the Business Enterprise sector shows that the Czech Republic has a distinct focus on experimental development (71%), whereas the level of applied research and basic research is comparatively low, although the structure in this respect resembles that of the US and Japan, which of course have much higher rates of R&D investments in the Business Enterprise Sector.

The high level of experimental development supports the thesis stated in ERAWATCH (2010), that the innovation process of Czech companies is still mainly characterized by purchasing foreign machines and equipment, which they adapt to their own

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production process or completely replace this process with the new technologies. Innovation is thus based in particular on adapting knowledge developed abroad, rather than being based on utilisation of in-house developed R&D results or R&D results developed by domestic research institutes in the Czech Republic. Research policy should involve creating public-sector capabilities that can complement and enhance these efforts, gradually helping Czech industry to move towards the technology frontier.

The Czech Republic is in a process of economic catch-up that is related to the acquisition of foreign technology. Hence, its technology upgrading cannot be reduced to the Innovation Union Scoreboard framework, which ignores knowledge embodied in intermediate inputs and capital goods that is important for countries behind technology frontier. Innovation activities in countries catching up through the acquisition of foreign equipment revolve around adaptation of machinery, equipment and software. Thus, shares of expenditure on machinery, equipment and software in the CEE countries range from 55 per cent (Czech Republic) to 91 per cent (Bulgaria)¹⁹. The share of expenditure on R&D and other intangibles is significantly higher in the more developed EU countries.

Experience of earlier 'catching up' highlights the importance of international openness and encouraging companies to do their own R&D as a way to learn. The approach taken in the SE Asian 'Tiger' economies in the 1960s and 1970s was to combine massive capital investment with deliberate 'reverse engineering' and experimentation in selected branches of industry.²⁰ Nelson and Pack have argued that the success of the 'Tiger' economies²¹ was the outcome of several inter-related features, including

- Their openness to foreign knowledge and their ability and willingness to tap international markets
- The pressures brought to bear on firms to increase their productivity to continue to increase exports rather than to use the knowledge obtained to extract rents from the domestic economy, thus creating a demand for foreign technology
- The high productivity of foreign technology as its dissemination and successful use were enhanced by an educated domestic labour force²²

The Mercosur countries provide a stark contrast. While they also made significant investments in foreign technology during the same period as the 'Tigers,' a similar investment in using R&D for learning was not made, and the contribution made by foreign technology to development was correspondingly lower.²³

The more that innovation in enterprises is focused around equipment, the less will be the focus of these firms on protecting knowledge, which will be in the form of know-how rather than intellectual property. Know-how is related largely to the efficient operation and adaptation of the newly introduced equipment rather than to R&D-based innovation, which results in less importance assigned to patent protection, registered trademarks and industrial design copyrights.

The country's ability effectively to absorb new technologies in embodied and disembodied form is key to its productivity and growth. Indigenous innovative activity

¹⁹ Slavo Radosovic and Anna Kaderobkova, *Challenges for European Innovation Policy: Cohesion and Excellence from a European Perspective*, London: Edward Elgar, 2011

²⁰ Linsu Kim and Richard R Nelson (eds), *Technology, Learning and Innovation: Experiences of Newly Industrialising Countries*, Cambridge University Press, 2000

²¹ Hong Kong, Korea, Singapore and Taiwan

²² Richard R Nelson and Howard Pack, 'The Asian growth miracle and modern growth theory,' *The Economic Journal*, Vol 109, 1999, pp 46 - 436

²³ José Eduardo Cassiolato and Helene Maria Martins Lastres, 'Local systems of innovation in Mercosur countries,' *Industry and Innovation*, Vol 7 No 1, 2000, pp 33 - 53

becomes increasingly important as it progresses closer to the technology frontier. The challenge is how to couple its national R&D and innovative activity with absorption and adaptation of foreign knowledge. This requires a twin track in publicly funded R&D: on the one hand, deepening understanding of the areas where foreign technology is being absorbed and unbundled; on the other hand building autonomous research and innovation capacity, especially in areas likely to generate economic restructuring and growth. It is difficult to see how such a twin track is articulated in current Czech R&D&I policy. Doing so would require greater involvement of companies in the gathering of strategic intelligence, foresight and the governance of key organisations.

The proportion of a country's Gross Expenditure on R&D (GERD) performed or funded by business normally correlates well with the share of GERD in GDP and is generally taken as an indicator of development. In 2009, the Business Enterprise Sector accounted for a total of 60% of R&D performance in the Czech Republic, the Government Sector for 21.4%, the Higher Education Sector for 18.1% and the Private Non-Profit Sector for 0.5%.

Leaving aside the last couple of years, where the underlying trend appears to have been disturbed by the financial crisis, the 2007 data show the proportion of R&D financed by national industry at the same level as in the EU-27. Since then, the share of the national Business Enterprises Sector has fallen back to 45.8% in 2009. Funding from abroad accounts for an additional 9.2% of R&D investments, of which the majority (70%) comes from foreign parent companies and the rest from the EU.

3. Reforms and Governance in R&D&I

We can identify three distinct periods in R&D funding during the post-communist era. The first, from 1990-98, involved institutional readjustment and was complicated by the split with Slovakia. The second, from 1998-2003, was one of preparation for joining the EU. The third, 2004-8, involved reorientating the NRIS towards innovation and applied research. Of especial importance in this period is the 2008 reform of R&D&I, which sought to modernise the system and improve its governance. Together these have involved some significant shifts in the allocation of budget amongst different organisations and activities.

State funding of R&D&I has grown rapidly in recent years, to a considerable extent through increased institutional funding of university research and significant growth in 'targeted' or competitive, project-based funding both in the research and higher education sector and in industry. Taken together with the use of the Evaluation Methodology as a basis for allocating all institutional funding for research, this means that probably too high a proportion of funding is competitively allocated, making it hard to develop strategy and invest in the research sector. A better balance is needed among funding forces that promote quality, stability and restructuring.

The Czech Republic has shifted its governance of the NRIS from one traditionally rather focused on science to become much more inclusive of innovation. But the governance has also become more centralised, increasing the distance between decisions about research and innovation funding and the stakeholders affected by them. As the young Technology Agency evolves, there are opportunities to strengthen these stakeholder links but this depends crucially on the willingness of the R&D&I Council to do less micro-management. More broadly, there is a need to empower the various state actors in the NRIS, encourage the creation and use of distributed strategic intelligence and refocus the Council as an arena for discussing and setting broad-brush policy, as opposed to a negotiation table where institutional representatives fight it out for their share of the budget.

R&D programming in the state is mostly well done with strong ambitions to implement good processes and is supported by competent staff. The Technology Agency is of course young and will require further development. A risk is that lack of trust of officials leads to under-use of their 'soft' skills in making programmes work.

The evaluation dimension of strategic intelligence works badly. The Evaluation Methodology for institutional funding is not fit for purpose. It distorts behaviour, reduces the stability of the research system and hampers its performance. Evaluation more generally is over-focused on outputs and provides little information about whether programmes meet their goals. Radical changes are needed in the practice and use of evaluation in order to make it useful in accountability, policymaking and policy improvement.

3.1 Reforms

3.1.1 *The period 1990 - 1998*

In the decade following the end of the communist era, government was strongly averse to any sort of central intervention in the economy, and overall in society there was a profound mistrust of governmental planning and quantitative goal setting.

In the R&D&I system there were some 250 research institutes performing industrial R&D in 1990. Many were privatised and by the end of the decade only 5% of them remained as institutes. The first steps towards competitive funding were made by creating a Grant Agency in the Academy of Sciences (1990), which was quickly

replaced by the Science Foundation of the Czech Republic (1992). The Academy of Sciences of the Czech Republic was set up in 1992 in response to the split with Slovakia and given about half the resources of its predecessor. A competitive 'targeted' research funding system was set up in 1994/5 through public tenders and attempts were made in 1994 and 1997 to change the basis for allocating 'institutional' funding to research performers. However, the structural distinction between "research" (the Academy of Sciences) and "teaching" (the Universities) was maintained.

In the 1990s, the R&D system was fully decentralised.

- Ministries and state agencies such as the State Office for Nuclear Safety or the Czech Office for Surveying, Mapping and Cadastre, as well as the Academy of Sciences all had an R&D budget and directly funded "departmental" research organisations that fell under their competence. Overall, there were 20 'funding bodies'
- It is said that lack of co-ordination led to a fragmentation of R&D support through competitive funding, with Ministries launching multiple (small budget) programmes that had unclear – and often overlapping – objectives. Between 1995 and the turn of the century, over 65 R&D programmes were launched
- The R&D Council was created as a purely advisory body, whose members were scientists

Budget allocations – both at national and 'funding body' level - were still very much determined by the index method used in communist times, i.e. funding based on the level of expenditures in previous years. The main exception to this rule was the Academy of Sciences, which in 1995 attempted an internal reform based on peer reviews of research quality. The economic situation prompted cuts in R&D budgets (especially in relation to research institutes) caused a brain drain from research to industry and to a generation gap in research.

3.1.2 The pre-accession period: 1998 - 2003

During this period, the government(s) started implementing measures to allow the country join the European Union (in 2004). In 1998, the 'Research Intentions' system had been introduced in order to connect institutional support for research to specific objectives. Subsequently, the Ministry of Education, Youth and Sport started funding the Research Intentions of the institutions in 2001. They funded a little less than 60 Research Intentions. In 2004 a new set of Research Intentions was funded across all ministries and the Academy of Sciences. These new intentions were implemented in 2005. New legal arrangements allowed funding not only of the traditional research performers (universities and institutes of the Academy of Sciences) but also the funding of non-profit private research institutes and companies. It is estimated that about 18 research intentions from private companies were funded. Since 2005, a further tranche of research intentions was funded (98% at the universities), and in 2007 a further 30.

The Research Intentions system of institutional funding opened the door for the re-integration into the institutional funding system of the industrial R&D research institutes that had survived the privatisation wave of 1990 by recognising them legally as private (non-profit) research organisations.

The **first "National R&D Policy of the Czech Republic"**²⁴, identified systemic failures in the conditions for attracting young people into research careers, poor cooperation within and among research institutions and the low level of international

²⁴ National Research and Development Policy of the Czech Republic, Attachment to the Governmental Resolution from January 5, 2000 No. 16

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cooperation and mobility among researchers. It identified a long list of management problems and sought

- To increase the efficiency and the outcomes of R&D, focusing on R&D results and the possibilities of their utilisation in all areas of society
- To create better links between R&D policy and other policies
- To concentrate state support on a smaller number of efficiently co-ordinated programmes and projects
- To improve the legislation of the state R&D support
- To increase the demands on R&D, including a more significant differentiation of the quality of the research outcomes
- To increase the objectivity and the transparency of the distribution of funding

The first National R&D Policy started the process for an improved coordination of the research activities, based upon the identification and selection of research priorities that were intended to guide both the R&D programmes and the institutional research plans, and the development of national research programmes. It stressed the importance of evaluation of R&D results and set this as the basic criterion for the distribution of the available funds. It also established ways for increasing the quality and efficiency of the state administration in R&D and posed the issue of a restructuring of the state R&D administration. It formulated the main requirements for the new R&D Support Act²⁵, approved in 2002, which gave the Ministry of Youth, Education and Sport (MEYS) the lead role in R&D policy. The R&D Support Act specified that National Research Programmes and (departmental) R&D strategies and programmes would reflect the long-term R&D trends and medium-term research priorities as well as respond to the systemic and thematic priorities set in the National R&D Policy. Departmental R&D Programmes were to be submitted to the MEYS and the Research Council for opinion and subsequently adopted by the Government. Apart from operational details such as duration and costs, proposed departmental programmes needed to specify the goals of the programme and sub-programmes together with their rationale, an analysis of the present state in the Czech Republic and abroad, and an indication of the expected benefits.

The 2002 R&D Support Act also defined the schemes for public R&D support, methods and rules for providing grants, the classification of the state budget R&D expenditures, ownership of R&D results and the procedures funding R&D bodies should use in administration. These included public tender management, the evaluation of research plans ("research intentions") for institutional funding and the provision of information on R&D through the national R&D Information System.

In 2003, the government approved the First National Research Programme²⁶ (NPV I) for 2004-2009, based upon the research priorities defined in 2002.

3.1.3 The period 2004 – 2008

This period was marked by a fundamental shift in R&D policy focus towards innovation and applied research, stressing the role and importance of research for economic development and innovation. The R&D Council was therefore changed in 2004 from an expert body for science into a representative body grouping all stakeholders (and including politicians). In the same year, the government approved the First National Development Plan 2004 – 2006 (NRP I) that coordinated support from the European Structural Funds with national R&D policy. The competent body for the coordination and overall administration of these funds was the Ministry of

²⁵ ACT of 14 March 2002 on support of research and development from public funds and on amendment to some related acts (R&D support act), Act 130/2002 Coll.

²⁶ Národní program výzkumu 2004 - 2009

Regional Development. A major Operational Programme related to R&D was the OP Industry and Enterprise, administered by the Ministry of Industry and Trade (MIT). It supported (amongst other things) setting up Business Support Services Centres, R&D Clusters and Technology Centres as well as specific programmes to foster research-industry collaboration, business innovation and innovation infrastructures. In total, 16 EU-funded programmes were implemented in the Czech Republic, for a total of about 80 billion CZK.

In 2005, the Government adopted a National Innovation Policy for 2005-2009²⁷, which was drafted by the R&D Council and the ministries of education and industry after consultation with the major stakeholders. It addressed the main problems related to the innovation system in the Czech Republic and set as objectives: to strengthen R&D as a source of innovation; to establish public-private partnerships; to secure sufficient human resources for innovation; and to make public administration in R&D&I more effective. In the same year, the Government adopted the second National Research Programme 2006-2011²⁸ (NPV II), which was focused on applied research to be co-financed by industry. It involved more centralised administration. Only the education and industry ministries funded research projects through the programme. The programme produced significant funding increases, especially through the Ministry of Industry and Trade, but made less progress in the desired administrative simplification. At the end of the programme, there were still 22 'budget chapters' for research across various ministries and agencies. In many other countries, having a large number of budget lines for research is perfectly normal but in the Czech Republic this was and is still seen by some as a problem in itself. The international perspective is that the relevant issue is not the number of budget chapters but whether policy can be coordinated across them.

3.1.4 The 2008 Reform

Analyses of the Czech NRIS in 2006/7 pointed to a large number of weaknesses in the production and use of knowledge, the planning, administration and evaluation of funding policy. These have in the main been confirmed by the present study.

- Lack of research capacity
- Lagging quality in certain disciplines, including natural and technical sciences of economic importance
- Little demand for innovation
- Inadequate exploitation of research results
- Insufficient public and private investment in R&D&I
- Little protection of intellectual property rights
- Insufficient coordination of publicly funded research
- Lack of R&D&I management skills
- Apparent failure of policy measures: neither the research planning process for institutional funding ('research intentions') nor the evaluation process for 'targeted' (competitive, project-based) funding was seen as successful
- Barriers to cooperation in research among organisations in the research and higher education sector and within industry
- Barriers to science-industry cooperation
- Barriers to R&D cooperation within industry
- Lack of innovation culture more broadly

The National R&D&I policy 2009 – 2015²⁹ aimed to implement a series of reforms to tackle these issues. It aimed to simplify and increase the efficiency of the R&D support

²⁷ National Innovation Policy of the Czech Republic for 2005 – 2009, Prague, June 29, 2005

²⁸ Národní program výzkumu II (2006-2011)

²⁹ Národní politika výzkumu, vývoje a inovací České republiky na léta 2009 – 2015, 2009

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system so that public funds invested into applied research, development and innovation would lead to concrete economic or other social benefits. It set seven main objectives.

1. To *simplify the support of R&D*, supporting institutions according to the results achieved and teams according to the projects undertaken. This implies an improvement of the evaluation system for public financed R&D
2. To *simplify the R&D&I support system and the administrative procedures*. The number of budgetary chapters (22) under which the Czech R&D is supported is significantly reduced and the paperwork requirements simplified. The latter will be achieved also through establishment of a single agency responsible for support to industrial research projects (the Technology Agency)
3. To encourage and support *excellence in research* and facilitate the *application of R&D results* in innovation. This will be achieved through improved R&D evaluation as well as more emphasis on excellence in basic research and applicable results in applied research
4. To strengthen *research-industry cooperation*. To condition programme support of R&D upon the cooperation of public research with users of R&D results, based on co-financing from public and private resources. A proposal is made to extend the indirect support of R&D (tax reliefs) to R&D results purchased by enterprises from (Czech) public research institutes and universities
5. To introduce *more flexible organisational structures* of public research organisations in order to promote research-industry collaboration and create the conditions for their commercialisation of research results
6. To provide *qualified human resources* for R&D&I, including a simplification of conditions for hiring researchers from abroad
7. To increase international collaboration in research, development and innovation, especially within the European Research Area.

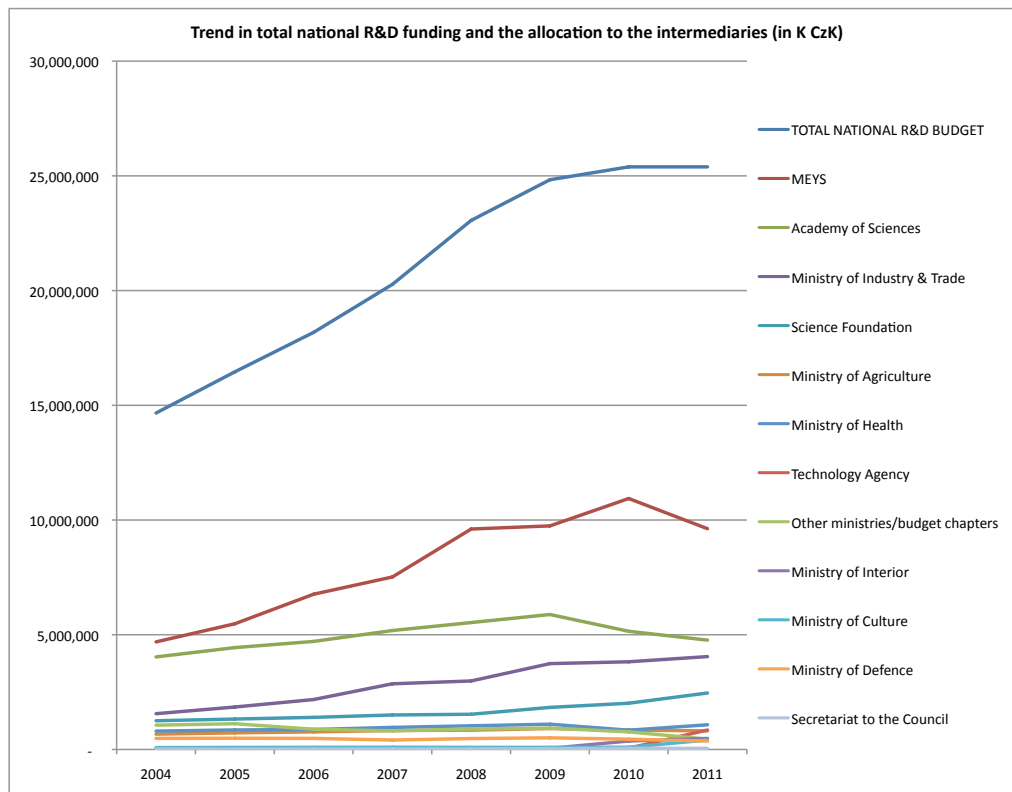
Implementing the reforms involved making the R&D&I Council the sole coordinating body in the field, creating the Technology Agency to fund applied research in parallel with the work of the Science Foundation, reducing the number of research budget chapters from 22 to 11 and budgeting for research and innovation as a single sphere with a single budget. The R&D&I Council became the focal point for the production of strategic intelligence in the system, setting the budget and evaluating results. The function of evaluation was narrowed, abandoning the previous attempts to instil 'evaluation culture' and embed learning in the system and replacing them with the idea of evaluation as a component in a performance-based resource allocation system. The National Policy for R&D&I 2009-15 also planned to

- Establish policies to stimulate research-industry and industry-industry collaboration in R&D, including the allocation of large amounts of Structural Funds to R&D infrastructure and regional capacity
- Support innovation by establishing intellectual property management in research performing organisations, reforming the governance of universities and research institutes by adding non-academic members to boards, supporting the development and exploitation of intellectual property in SMEs, assessing opportunities to provide venture capital and setting up consulting services for SMEs
- Supporting international R&D collaboration
- Building research capacity by creating post-doctoral positions and research fellowships
- Stimulate innovation through awareness promotion and publicity about Czech innovation abroad

3.2 Funding

National public R&D funding grew considerably during the last decade, but flattened during the last three years (Figure 4). By and large, the big increases have occurred at MEYS, building up the university research system, and in increasing the funding for targeted programmes.

Figure 4: Trend in total national R&D funding by budget-holder, 2004 - 2011



Sources: data for 2004 – 2006 are based on the approved budgets published on the R&D&I Council website; data for 2007 and 2008 are those reported in the approved budget for 2009; data for 2009 are those reported in the approved budget for 2010; data for 2010 and 2011 are those reported in the approved budget for 2011

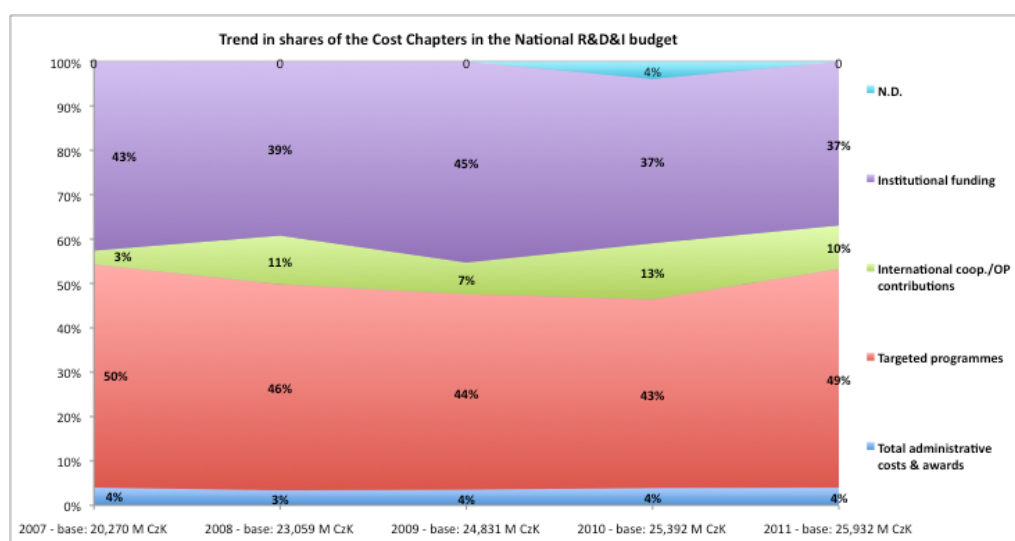
In the Czech R&D&I system, national funding is divided between two major groups of instruments: institutional funding and “targeted” funding.

The term ‘Targeted Funding’ – in international terminology ‘competitive’ or ‘project’ funding – comprises three funding modes: response-mode funding of basic research by the Science Foundation; competitive funding for research programmes of applied research; and public tenders for projects that have the public administration as sole future user.

Figure 5, shows that while in 2009 much of the overall increase in the national public R&D&I budget was spent via institutional funding, in 2011 the budget for competitive (‘targeted’) funding was increased and the budget for institutional funding returned to its 2008 levels in absolute terms. In the 2011 budget, ‘institutional funding’ that flows through directly to the research-performing institutions accounts for 37% of the total national R&D&I budget, 49% is allocated to ‘targeted’ funding, and 10% covers national costs of international cooperation and Operational Programmes. The target set in the National R&D&I Policy 2009-2015 for the year 2015 of a 60:40 ratio of targeted to institutional funding has therefore effectively been reached.

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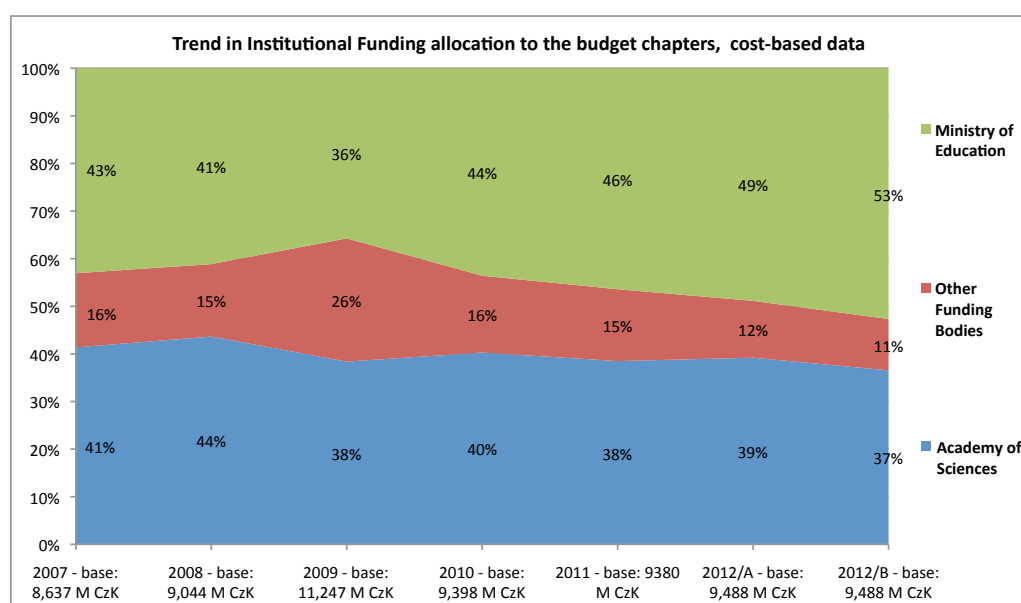
Figure 5: Trend in shares of the cost chapters in the national R&D&I budget



Sources: data for 2007 and 2008 are those reported in the approved budget for 2009; data for 2009 are those reported in the approved budget for 2010; data for 2010 and 2011 are those reported in the approved budget for 2011

There has been a shift from an equal distribution of institutional funding between Higher Education Institutions and institutes of the Academy in 2004 (both approximately 40% of the total) to a situation in 2012 where the institutes of the Academy will get roughly 38% compared with about 50% for the Higher Education Institutions. In the light of the need to strengthen the university sector, this is probably a sensible outcome – but it is one that does not seem to be part of official policy. Over the longer term, this needs to become an explicit discussion, as part of a wider debate about the respective roles of the Academy and the universities.

Figure 6: Trend in national institutional funding distribution among the intermediaries, cost-based data, 2007 - 2011



Sources: data for 2007 and 2008 are those reported in the approved budget for 2009; data for 2009 are those reported in the approved budget for 2010; data for 2010 and 2011 are those reported in the approved budget for 2011

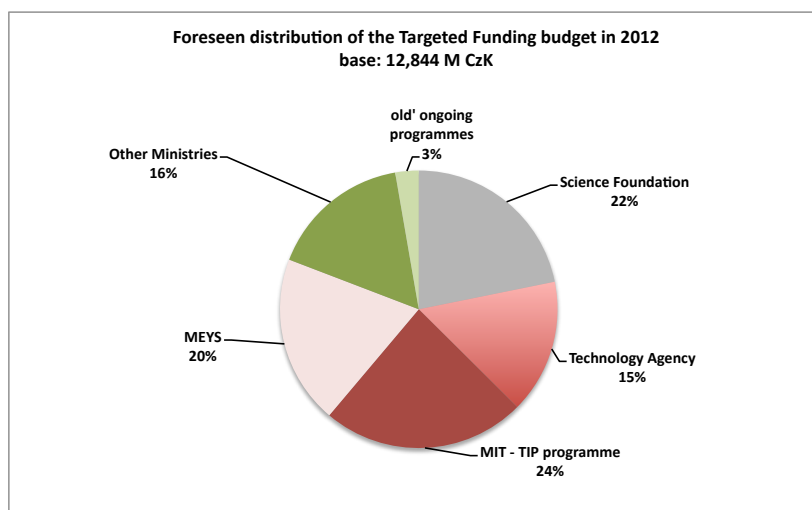
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budget for 2011; data for 2012 (variations A and B) are those based on the budget proposal for 2012 dd. July 2011

Note: The last two blocks are alternative scenarios for 2012. 'Institutional funding' here is the funding that flows directly to the research-performing institutions, not the larger sums specified in the state budgets

A decade ago, targeted funding was spread widely across Ministries. By 2008, it had been focused much more on the Ministries of Education and Trade and Industry. Now, the two agencies have taken a substantial share (Figure 7).³⁰ These data reflect the concentration of basic research funding in the hands of the Science Foundation as a result of the 2008 reform. In 2011, there is an approximately 20:80 ratio of response-mode to programme funding, which in the current system implies also a similar ratio in national 'targeted' public funding for basic versus applied research. The National R&D&I Policy 2009-2015 documents recognised that funding for basic research is considerably lower than in other countries and declared an intention to increase it – predominantly via targeted funding.³¹

Figure 7: Planned distribution of the Targeted Funding budget in 2012



Source: Draft national R&D&I budget for 2012 – proposal of 28 January 2011

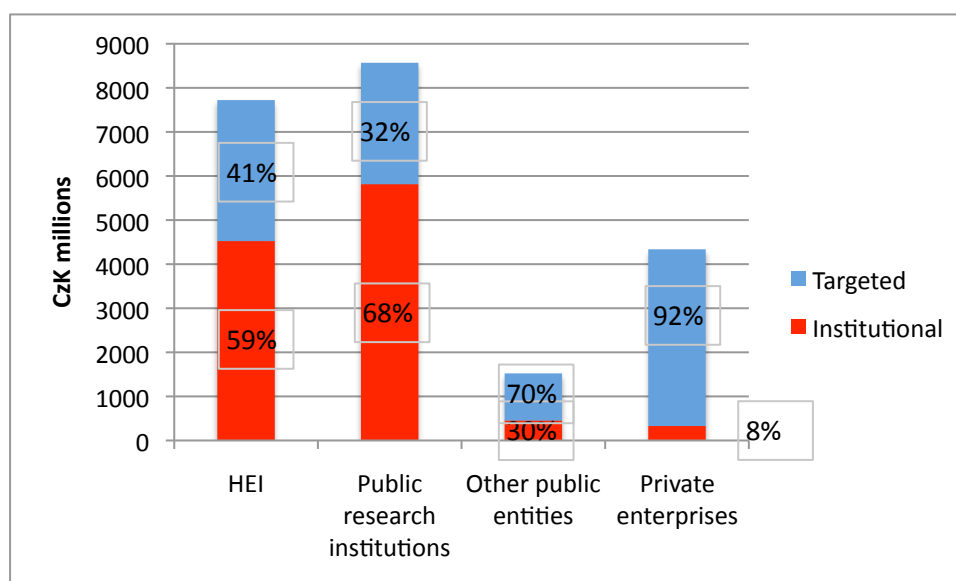
Figure 8 shows how the proportions of targeted and institutional funding vary among the different research-performing sectors. An international comparison of these figures is hard, because few countries collect relevant data. The proportion of targeted funding of the Czech universities appears to be at the upper end of the range we can see internationally. However, there is one outlier: the UK, where universities' aggregate research council income is higher than their institutional research funding.

³⁰ The 'Final report, 1 – R&D Expenditure' covers further in detail the different competitive programmes and responsibilities of Ministries.

³¹ See Goal A 3-2 of the National R&D&I Policy 2009-2015

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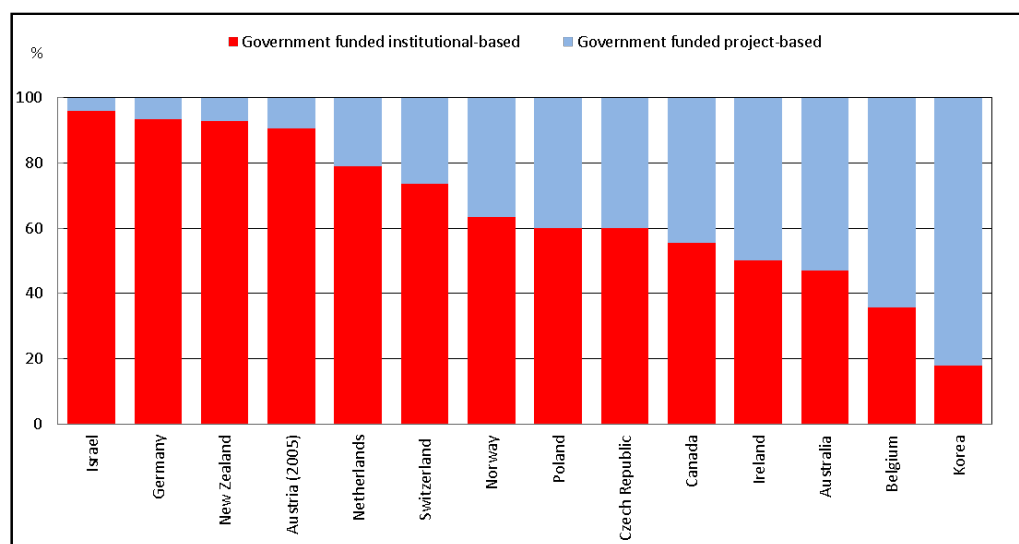
Figure 8: Proportion of Institutional vs Targeted Funding of Research Performers (GBAORD)



Source: Czech Statistical Office

OECD R&D statistics tend to confirm this picture for the university sector. The proportion of competitive project funding to Czech universities is towards the upper end of the range, internationally (Figure 9). There appears to be an emerging and highly competitive ‘Anglo-Saxon’ funding model that distinguishes itself from the more institutional-funding-based continental one.

Figure 9: Government Funding of HERD: Institutional Funding vs. Project Funding (2008)



Source: OECD (2010)

Different countries choose different balances between institutional and project-based funding of research. In principle, the project-based component involves competition and therefore induces quality as well as providing a way to reallocate resources towards excellent research. The institutional component provides stability; it makes it

possible to take decisions about things like the number and size of research-performing entities (for example, it may not be desirable for all research in a field to be done in one place), supports the provision of infrastructure and enables exploration and capacity-building by providing resources that are sheltered from competition.

A growing number of countries are using Performance-Based Research Funding (PBRF) systems that allocate some or (rarely) all of the institutional resources in the medium term, based on performance so that institutional funding also becomes competitive. Historically, the trend has been for countries to move from 100% institutional funding to a mix of institutional and project funding and then finally to making part of the institutional funding performance-based. In the 1990s, higher education funding was split in many countries between 20-30% project funding and the balance of institutional funding, but the share of project funding has risen since then³². There appears to be no 'ideal' mix; rather, the objective is to maintain a balance between competition, stability and restructuring that ensures quality while keeping the research system up to date and relevant. Project funding is itself normally a mix of researcher-initiated ('bottom-up') funding and programmed ('top down') funding.

When we take into account the intention to make the Czech PBRF – the so-called Evaluation Methodology - allocate 100% of institutional funding, we can see that the balance among forces promoting quality, stability and restructuring has been lost, in turn undermining the ability of the system to respond to industrial and other societal signals.

3.3 Governance and the R&D&I Council

3.3.1 Governance structures

Governance refers to the effective implementation of state supported actions and the management of research and innovation by organisations that have been allocated responsibilities from the state. In the public management literature, it “... is a perspective within which the conventional boundaries between politics and administration are perhaps less significant, and which enables large social questions to be approached more directly than from within the narrower perspective of traditional public administration”. Governance is a systemic activity, where “the boundaries between individual institutions become less significant than the question of how the whole ensemble dances (or fails to dance) together.”³³ Thus in research and innovation governance we do not look only at policy but also at the interplay between the various actors that together determine the priorities, strategies, activities and outcomes in research and innovation. The focus is on the **processes** of policy formulation and implementation, rather than on the contents.

Governance has vertical and horizontal dimensions. The vertical dimension involves steering, where an organisation at one level tells another at a lower level what to do and receives an upward flow of information in return. In practice, governance mechanisms also need a horizontal dimension to combine the ability to plan strategically with a role in mediating among stakeholders to produce alignment among objectives. “Successful policymaking normally means compromising through a ‘reframing’ of stakeholders’ perspectives and joint production of consensus.”³⁴ So

³² Barend van der Meulen, *The Austrian Science Fund: Governance and Processes*, Enschede: Universiteit Twente, 2001

³³ Pollitt, C., Bouckaert, G., *Public Management Reform, A Comparative Analysis*, Oxford University Press, 2000.

³⁴ Stefan Kuhlmann, ‘Future governance of innovation policy in Europe – three scenarios,’ *Research Policy*, 30 (2001), 953-976

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governance is not just about 'steering' but about creating arenas, to decide the right direction in which to steer, and generate consensus-based commitment to steering in that direction.

Policymakers and other stakeholders continuously need strategic intelligence about the innovation system and to develop open systems able both to reflect on performance and to consider future opportunities in developing policy. Some of this comes through the normal activities of actors such as innovation agencies, which collect information and experience as they work. Other intelligence comes from dedicated studies and special exercises such as foresight and planning. Evaluation provides a significant feedback loop from present and past actions. These elements taken together provide the information basis for policy learning, while the ability of the system and its component actors to make use of the information and to adapt and improve policies over time depends not only on the availability of information but, crucially, on having institutions and governance arrangements in place that can effectively connect knowledge to policy practice.

There appear to be strong arguments for some balance in strategic intelligence capabilities between the ministry and agency levels

- It connects the implementation of research and innovation policy with the political sphere
- It generates tension between the levels of policy and programmes, so that policies and interventions are mutually questioned
- It ensures that ministries have 'buyer competence' when setting up performance contracts with their agents
- By delegating aspects of policy implementation to agencies, it reduces the need for ministries to be all knowing. Thus, it generates a source of operational intelligence that is close to the eventual beneficiaries of research and innovation policy and that can provide kinds of knowledge not readily available at ministry level

The National R&D&I Policy 2009-2015 centralised the implementation of the R&D&I policies in a set of 7 ministries and 2 agencies (the Science Foundation and the Technology Agency, in the belief that the previous system with 22 research-related budget lines across as many organisations led to fragmentation and that many of the organisations involved lacked the capability to manage their targeted research budget well. The agencies and most of the Ministries provide support to R&D&I through the development of competitive research programmes. An exception is the Ministry of Industry that is officially no longer responsible for targeted funding, though it continues to run a major programme that will last until 2017. Most Ministries continue to distribute institutional funding to the research institutes under their responsibility.

The emerging funding structure in the Czech Republic based on the Grant and Technology Agencies plus a range of other more specialised funding sources corresponds to the 'two pillar' structure used in Finland and the Nordic area. It follows practice in many countries by having a research council (the Science Foundation), where funding decisions are effectively put into the hands of the beneficiary research community and an innovation agency (the Technology Agency) that is under wider societal control. Such structures are becoming increasingly influential elsewhere in the world, at a time when it is however becoming increasingly clear that the distinctions on which it is based – basic versus applied research, response-mode versus programme funding - are declining in validity. Internationally, many research funders are trying to cope with the limitations of a 'two pillar' approach and move beyond these rigidities, taking a mixed response-mode and programmed approach to funding and conducting a mixture of more fundamental, applied and innovation-related research.

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In the past 20 years or so, an increasing number of countries have established advisory committees or councils similar to the Czech R&D&I Council. The Finnish Research and Innovation Council has served as an inspiration for many. The growth appears partly to be due to the increasing degree to which research and innovation policy issues affect several sectors of society and partly to the spread of the 'innovation systems' perspective, which recognises the systemic nature of innovation and therefore the need for a coordinated approach from government.

There is no wider literature about such councils, so we have had to rely on our own earlier work looking at nine councils internationally³⁵. The councils almost always involve both industry and academia as advisors. Curiously, only the Finnish council involves the research institute sector, despite its inherent closeness to innovation processes. The councils considered tend not to suffer policy capture. They engage with a sufficiently wide set of stakeholders and provide a neutral forum for discussion, so that attempts by special interests to pursue their own objectives quickly become visible.

From the government perspective, the councils reviewed provide three possible choices

- A **joint planning model** (Japan), where the government uses the council as a virtual 'horizontal ministry of innovation', much as engineering companies build project teams by bringing together people across different disciplines
- A **coordination model** (Finland, Netherlands Innovation Platform, Austria), where the intention is that the council should communicate horizontally across ministry responsibilities so as to align policies in support of innovation, without this alignment always being binding. The Czech council is in this category
- An **advice model** (Canada, Ireland, Netherlands AWT, Switzerland, UK), where the government is happy to be advised on research and innovation policy but does not want to be restricted by that advice

The planning and coordination models require significant commitments of ministers' time as well as willingness across political parties to see research and innovation as permanently central aspects of government policy. The councils examined all inhabit systems where there is considerable distributed strategic intelligence within the state's part of the innovation system. This means that a great deal of instrument and even policy design takes place in ministries, agencies and at other levels 'below' that of the advisory council. It has the advantage of exploiting the superior knowledge of needs and implementation found at lower levels of the system and demands good communication between the council and organisations working at 'lower' levels. Making good use of the intelligence distributed across the system appears to depend to a fair extent on developing what might be called 'social networking capital'.

Desiderata that emerge from the survey of councils include

- An innovation policy council should serve as a publicly open arena in which stakeholders and decision-makers debate and influence the directions of long-term research and innovation policy. This arena role should be complemented by actively consulting stakeholders
- Its composition and status should be such that it is socially and politically legitimate and therefore largely robust against changes in government. It should include scientific and technological expertise
- The council may sometimes need to act as referee and take decisions with which not everyone agrees, but an important goal is to create consensus about policy, so that it is natural for stakeholders to do things that are consistent with the policy

³⁵ Erik Arnold and Gernot Hutschenreiter, Chile's National Innovation Council for Competitiveness: Interim Assessment and Outlook, Paris: OECD, 2009

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- Part of the council's function is to create and collate the 'strategic intelligence' it needs in order to analyse deficiencies in the innovation system and propose improvements. This should be part of a wider pattern of distributed strategic intelligence, in which others also gather and analyse data and exploit them in support of policy analysis and deployment. The information produced and exchanged should be open so that it can be debated
- The council should produce a long-term strategy for the innovation system that does not only tackle systemic and market failures but sets thematic priorities, is holistic, suggests an appropriate policy mix and serves to reduce the 'dynamic inconsistency' between the long time constants of the research and innovation system and the shorter term perspectives of the world of politics
- A key role of the council is coordination: vertically, horizontally and over time. In many countries, coordination also needs to have a regional dimension. Coordination serves to reduce inconsistencies and goal conflicts among policies and actors, make the division of labour in the support system efficient and reduce fragmentation of effort while empowering the actors involved to do their jobs effectively
- The council needs to maintain a high profile with the public and at the level of opinion-formers, promoting the importance of research and innovation and demonstrating its own impact
- It should be sufficiently independent of the system that it can act as a change agent. This means it should have no agendas or operational functions other than its brief to promote R&D&I and it should not have an interest in acquiring or spending significant resources of its own
- The council should have a clear interface to government, at least at the level of ministers, so that someone is responsible for accepting (or rejecting) and implementing its advice. This often means that some ministers should be members of the council

In recent years, the Czech Republic built the foundations for a radical change in its R&D&I governance system, based on the Reform approved in 2008 and the subsequent National Research, Development and Innovation Policy document (2009) for the years 2009 – 2015.

The National R&D&I Policy 2009-2015 introduced important changes in governance.

- It *reduced the autonomy* of the Ministries in their definition of sub-priorities and explicitly included them among the funding bodies that are to implement directly the national priorities³⁶.
- It established *new guidelines* for both the focus of the priority areas and the approach that should be adopted for the priority setting process, hereby setting the framework for the preparatory activities to be implemented in these years for the discussions and decision-making of the new National R&D&I Policy for the time period after 2015. The Policy document established that the criteria for the definition of the R&D priority areas would be the needs of industry and support for sustainable development (economic, social & environmental) in fields where the country has research capacity. Independent experts, applying an open and transparent method and particularly involving the users of R&D results, would conduct foresight exercises and run the priority setting process. A comprehensive

³⁶ The Policy states, "The identified priority areas will be transformed into programmes for targeted applied research support that will be launched by the Technology Agency and other public fund providers. During their decision-making on support for applied research, the support providers have to base themselves on these priority areas. The focus of targeted programmes for applied R&D will consistently respond to the needs for the development of the knowledge society and the needs of the user spheres."

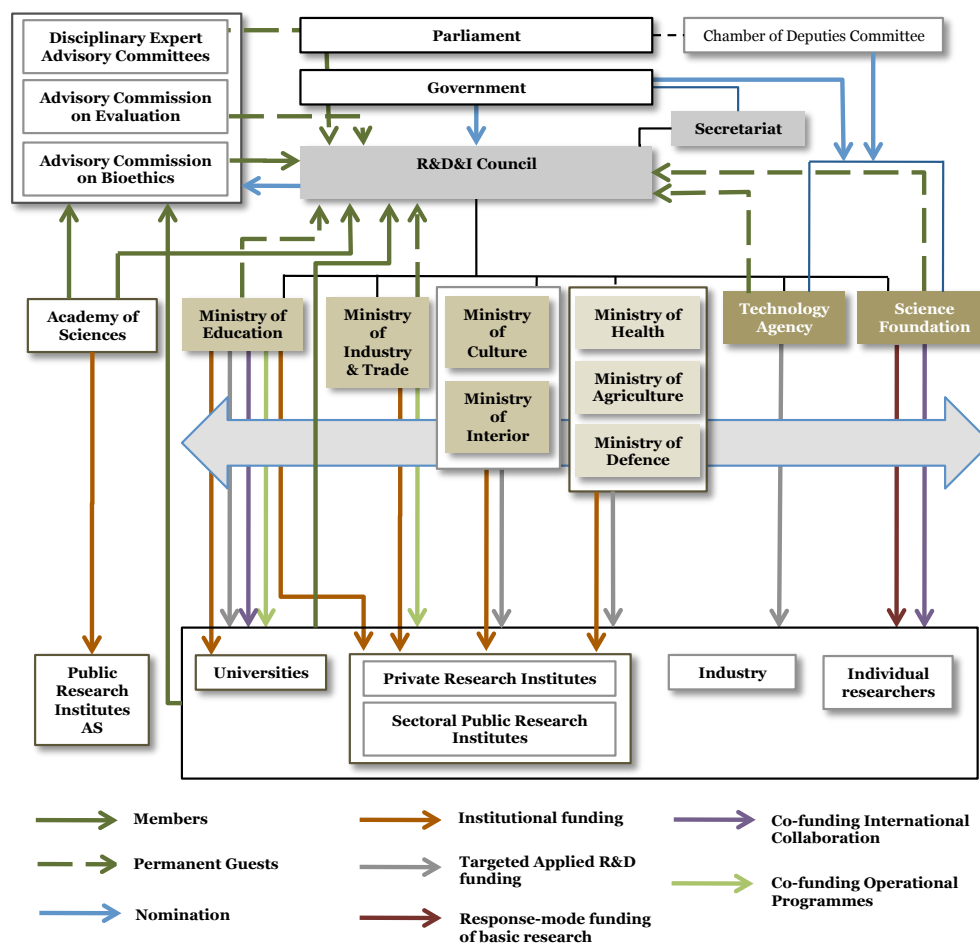
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analysis of the R&D and innovation potential of the Czech Republic should provide additional strategic intelligence³⁷

- It declared its intentions to *re-distribute the budgets* based upon the importance of the priority areas³⁸
- The aim is to define *problem-oriented* priority areas, covering both basic and applied research³⁹
- *Programme evaluation* is intended to acquire an important role in both the launch of new programmes and the guidance or modification of the running ones⁴⁰

The current R&D&I Governance Structure in the Czech Republic is shown in Figure 10.

Figure 10: The current structure for R&D Governance in the Czech Republic



³⁷ Most of these tasks are included in the recently launched study that was commissioned by the Secretariat of the R&D&I Council to the Technology Centre ASCR

³⁸ “During the identification of the priority areas, expert support will be delivered for the quantification of the share that public funding should dedicate for the identified priority areas.”

³⁹ The priority setting process should “define the link between basic research and the next phase of the innovation process, i.e. applied research, experimental development and its implementation in solutions for innovation, especially in the priority areas that reflect the needs of society and knowledge economy in the Czech Republic.”

⁴⁰ “New programmes of targeted support will be launched on the basis of the results of consistent evaluation of preceding programmes and they will be guided or modified based on their ongoing evaluation.”

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At the top level, setting overall directions and priorities across the National Research and Innovation System, is the R&D&I Council. Below this, a set of ministries and 2 agencies (the Science Foundation and the Technology Agency) are responsible for implementation of the R&D&I policy. The two agencies have an internationally unusual status since they do not answer to any Ministry. Government nominates their governing bodies based on proposals from the Council, while Parliament nominates their supervisory bodies.

Government and Parliament are deeply involved in the current R&D&I System. Government nominates – or removes - the members of the R&D&I Council and the Secretariat of the Council is part of the Cabinet Office. In the Czech Republic, the **R&D&I Council** is the high-level advisory body to the government on research, development and innovation, setting overall directions and priorities across the National Research and Innovation System. It currently has 17 members. A member of Government, normally the Prime Minister, acts as Chair of the Council, thus ensuring its legitimacy. Two expert Advisory Commissions and three S&T Expert Committees support the Council in its activities, as well as a Secretariat with a staff of 20 employees (in 2010).

At least from a structural point of view, we see serious limits to the capacity of the R&D&I Council to perform one of its key roles, i.e. coordination of all actors involved in R&D and Innovation: industry stakeholders are involved only to a limited extent and only some of the intermediaries (the two agencies, the Ministry of Education and Industry) have the possibility to attend the Council meetings as observers.

By international standards, the R&D&I Council plays an unusual role in the management of Research and Development in the country, operating almost as a virtual science ministry. Unlike equivalent councils abroad, the R&D&I Council also assumes the role of principal to the Technology Agency and the Science Foundation. Equally unusual by international standards is the breadth of its tasks, covering long-term strategy development, monitoring, evaluation and decision-making on budget allocations. Other councils tackle some of these tasks in a broad-brush way. The R&D&I Council centralise all these activities, taking responsibility for *micro-management*. It thereby increasingly assumes a role of an executive body. This imposes a heavy burden on the members of the Council and its advisory committees – and most of all on the small Secretariat.

Most of the human resources of the R&D&I Council and its Secretariat are currently devoted to developing the annual R&D&I budget proposal and to the definition of the Evaluation Methodology. Given the limited number of staff in the Secretariat, the Council has a low level of internal analytical capacity and heavily relies on external experts for the development of its strategic intelligence.

3.3.2 Processes for R&D&I Governance

A centralised and formalised model has governed policy design and implementation processes since the 2002 Act on R&D Support set a legal framework for this approach. The objective was to improve the efficiency of the R&D support system through the development of common planning processes and implementation procedures, including evaluation. Subsequently, there has been a trend to change the initially “soft” approach – providing structures for planning and evaluating interventions - into a “hard” one, i.e. aiming to connect the results of policy design and implementation processes back to budget allocation, with the idea of rewarding good performance and punishing bad. The effect is centralisation: strengthening the top-down steering of nationally funded R&D&I activities accompanied by increased control over the responsible administration bodies.

A main conclusion to draw from international practice in relation to the use of indicators and performance contracts as a way to steer research performers and

agencies is that these appear generally to be tied into a bigger process of *dialogue-based 'soft' steering* and the use of *distributed strategic intelligence*. For this purpose, *stakeholder involvement* is an increasingly important component of the policy making process. However, stakeholder involvement is by no means the only aspect of strategic intelligence that needs to be distributed. Crucially, *analytic capacity* and the ability to generate strategic intelligence and design programmes and other interventions need to be present at several levels in the system. International experience also shows that fundamental for the effectiveness of a policy making process is good *linkage between the different levels* in the governance structure.

In the policy-making processes implemented in 2008/2009 in the Czech Republic, the “vertical” dialogue was limited: ministries were involved in the discussions only in the final decision-making process and ongoing involvement was limited to the two major Ministries, i.e. the Ministry of Education and the Ministry of Industry and Trade. No ministry was represented in the R&D&I Council, which tackled the 2008 Reform and set thematic priorities.

The policy making process implemented in the years 2008/2009 resulted being effective in terms of the establishment of a consistency in policy priorities between the strategies defined at the various levels of R&D governance (the National R&D&I Policy and the departmental Strategic Concepts). In contrast to the common impression among policy-makers, our analysis showed a good coherence between the strategies at the different R&D&I governance levels, suggesting that the Ministries in practice possess rather stronger analytic and policymaking capabilities than their critics would suggest.

In terms of horizontal co-ordination, at the level of the R&D&I Council, the degree of *consensus building among stakeholders* appears to have been limited in the 2008/2009 policy making exercises. Discussions most often took the form of pure inter- institutional negotiations. The pattern was one of an exclusively indirect involvement of the stakeholder communities - normally through their representatives in the R&D&I Council itself. There was no direct involvement of the broad stakeholder communities in 2008/2009 and open consultations involving the individual actors in the research communities did not take place.

We see a similar pattern emerging in the current priority-setting exercise that is to define the new priority areas (problem-oriented rather than thematic) and to *re-distribute the budgets* based upon the relative importance of the newly defined priority areas. The process is in practice dominated by the research community, with limited industrial involvement or contact with other stakeholders.

In general, we note little willingness to have open communication with broader stakeholder communities and the general public about discussions within the R&D&I Council. Collaboration between the Expert Committees that act as advisory bodies to the Council and the Council itself turns out to be difficult: there are clear signs of dissatisfaction and frustration on both sides.

Unlike at the R&D&I Council, at the level of the ministries and agencies, stakeholders are involved in both the policy-making and programme management processes. For the development of the Concepts and programmes, stakeholder involvement was indirect through the ministerial Advisory Bodies, but in most cases also direct. The “distribution of labour” that was adopted for the development of the Strategic Concepts and the Programmes varied from Ministry to Ministry, depending on the role that Advisory Bodies traditionally play within these public agencies. We especially note two ministries with fundamentally different approaches: the Ministry of Health that essentially *delegated* the development to the stakeholder communities, with a minimal involvement of the ministerial staff, and the Ministry of Industry that exclusively relied on its *own internal expertise*.

Finally, several ministries indicated also inter-ministry collaboration for the development of their concepts or programmes. We note an increasing level of such

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collaborations, aiming at an improved coordination of the research funding as well as an improved response of the funded research activities to the needs of user communities beyond the traditional sphere.

Equally, most ministries commissioned studies in support of their policy making, but references to past programmes were more related to vague “past programme experiences” than specific evaluation studies.

3.3.3 Programming

An important way in which the New Public Management has been expressed in innovation and research funding has been through the **use of programming** in research and innovation activities conducted for socio-economic purposes. Policy makers (often in ministries), in effect, write performance contracts with programme managers, who act as *agents* in the delivery of policy goals. The programme managers in turn write performance contracts with project performers. Since the managers need the performers in order to deliver the policy goals, the performers often end up having a large say in, sometimes even controlling, the way resources are allocated⁴¹ at programme level. This is especially true in research councils, but also – to a considerable extent – among innovation agencies. While this type of capture of agents by beneficiaries is not unique to research and innovation funding, it is a particularly strong feature of the area. It follows that such institutions must be open and transparent and contain a system of checks and balances to discourage rent-seeking behaviour.

Part of the audit involved examining the way key Ministries and Agencies programme their R&D budgets and comparing this with good international practice. Our assessment is that overall the procedures established by law reflect international common practice in their attention to the general principles of rigour, transparency, objectivity and fairness, and efficiency. We noted good practice especially in the simplification and rationalisation of procedures across the funding providers, in the publicity of process and selection criteria using online submission and in the selection of the reviewers. Generally, the staff members involved are experienced and competent in the field of research being funded. However, the fact that performance standards are built into legislation while it is more difficult to legislate for the capabilities of the people involved raises a concern that Agency governance may focus overly on process at the expense of capabilities. Good funders work well because good people use good processes in intelligent ways. Simply defining or legislating the use of ‘good practice’ does not lead to positive results.

The only Ministry where process issues appeared was the Ministry of Health, in particular in relation to the transparency and fairness of the process. This may be related to two major differences in the procedures adopted by this Ministry compared to those implemented in the other Ministries: the procedures for the nomination of the experts and the transparency of the evaluation criteria upon which the appraisal is based.

Another major difference between the Ministry of Health and the other Ministries regards the division of labour in programme management. In the Ministry of Health, this task is entirely delegated to the Internal Grant Agency, which is a legal entity separate from the Ministry R&D department. In the other Ministries, common practice is that Programme Committees are set up, including stakeholder experts as well as Ministry employees. Such expert/employee collaboration is an important facilitator for the enhancement of distributed strategic intelligence within the ministry departments.

⁴¹ See Dietmar Braun, ‘Who governs intermediary agencies? Principal-agent relations in research policy making,’ *Journal of Public Policy*, 13 (2), 1993, pp135 – 162

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The Science Foundation is efficient and effective and maintains a very traditional approach to its 'research council' function. In a context where past funding practices have sometimes been thought to be arbitrary or liable to 'influence', it is of course especially important to have processes that are not only fair but also transparent and 'squeaky-clean'. Our only concern was that the strict and traditional exclusion of the staff from decision-making processes could lead to conservative decisions, with innovative or inter-disciplinary proposals running the risk of 'falling between stools'. In this connection, we note that a number of other research councils – most notably the US National Science Foundation – allow programme officers greater opportunities to help identify funding opportunities for such proposals and also often to solicit proposals in areas of especial research interest, without at the same time over-ruling the academic committees.

For the Technology Agency, it is early days. Like the Science Foundation, law prescribes many of its performance standards. It has a small and young staff with limited experience of industry or hands-on technological research and innovation. There are opportunities to strengthen the staff in this respect. Following the model of the Nordic innovation agencies, the mission of the Technology Agency can be seen as encompassing two components: first, to fund research and innovation activities that would not be done in response to market forces alone –compensating for 'market failure' and through the adoption of a broad policy mix. Second, to act as a change agent by encouraging interest in new and emerging technologies and encouraging needed structural changes.

Establishing the Technology Agency from scratch is a very large task, especially given the broad scope of its intended operations, the need to recruit a cadre of competent people, many of whom should be technologists, and the requirement that staff members should be or become well networked with clients and stakeholders. The Agency has put some simple programmes in place to allow it to start to function and is developing more, chiefly using foreign models. But the practical problems of starting a new and sophisticated organisation are such that this can only be done slowly. The current situation of the Agency combined with what we know of similar agencies abroad suggests the following recommendations.

- The role and activities of the Agency are likely to shift over time, so it should have a legal basis sufficiently flexible to allow such changes to take place
- It should be equipped with an internal analysis and strategy group able to investigate the need for interventions, plan them and integrate them into an Agency strategy
- Where programmes will tackle particular groups of stakeholders, such as branches of industry, these should be involved in a Nordic-style process of design involving stakeholder groups. More abstract studies, such as foresight exercises, can be useful but are not adequate substitutes for the 'on the ground' knowledge of stakeholders
- In programme design and operations, governing committees should involve stakeholders with knowledge of R&D and industrial needs in the relevant field(s)
- Dialogue-based processes of 'soft steering' need to be developed with ministries that no longer hold R&D budgets, in order to ensure that their needs are met and that they can access the amount of budget appropriate to meeting those needs
- The Agency should develop a standard process for accompanying programmes through the policy cycle. This will involve agreed principles for programme design and agreement on monitoring needs for each individual programme and how these relate to any standard indicators collected
- Programmes should have a fixed term (what that is depends upon the nature of the programme) and a plan for both formative evaluation and summative evaluation of outcomes and impacts as well as outputs

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- The Agency should strive to avoid ‘copy/pasting’ foreign programmes, but perform research and analysis to determine how generic programme types can best be modified and exploited in the Czech context
- A lot of the knowledge the Agency needs to develop itself exists in tacit and codified forms elsewhere among European innovation agencies. The Agency should make best use of the TAFTIE network to access this knowledge
- Early success is important in establishing the Agency’s reputation and building trust. The Agency should look for and propose ‘low-hanging fruit’ that will provide rapid and conspicuous returns

3.3.4 Strategic intelligence

One of the most important problems emerging from our analysis was the provision and use of strategic intelligence, including evaluation. We noted crucial gaps in the set of strategic information that the policy makers had at their disposal in the years 2008/2009. There was a set of statistical and analytical background studies that provided information on failures related to the R&D system and innovation; failures specifically related to the governance of national R&D support emerged from some monitoring exercises focusing on the implementation of the National Policy and – especially – the National Research Programmes. However, the analytical component of these studies was limited; most importantly, analyses that looked in-depth into the *systemic causes* of these failures were rare, and studies analysing the factors determining the success or failure of previous *policy interventions* in terms of impact achievement – thus allowing for policy learning, were close to non-existing.

Consultation with stakeholder communities governed by means of a direct involvement of key staff members of the ministerial departments provide an important opportunity for the creation of *distributed strategic intelligence*, i.e. the transfer of sectoral knowledge from the stakeholders to the institutional programme managers, which is a crucial factor for the overall efficiency and effectiveness of R&D support administration. The distribution of this intelligence is even more enforced in the procedures implemented by the Ministries for their programme management, creating ad-hoc Programme Committees for each programme that involve stakeholder experts as well as Ministry employees.

Strategic intelligence is key to both policy development and to individual interventions. While in formal terms it may be the business of ministries to set policies and of agencies to implement them, the distribution of strategic intelligence explains where the real policymaking goes on. Normally, the **balance of evaluation effort** among different parts of the policymaking and implementation system reflects the distribution of strategic intelligence.

3.4 Evaluation

3.4.1 Policy for R&D&I evaluation

The **National Policy on R&D for the years 2004 – 2008** included an attempt to improve the quality of the evaluation system. It said that a stronger ‘evaluation culture’ was needed and stressed the importance of evaluations as inputs to policy development and decision-making. The Government asked MEYS and the R&D Council to review R&D evaluation practice. They concluded that programmes were failing to set specific and measurable goals and that evaluations were not adequately testing programme achievements against programme goals. Some of their conclusions were built into **Government Resolution No. 644 on the evaluation of R&D and its results** (June 2004), which set the basis for evaluating R&D institutions, programmes and final evaluations of projects, including the ‘research intentions’ through which institutional funding was at that time awarded.

The Resolution set out general principles of assessment

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1. Evaluation is regular and repeated after some time (i.e. not just the entry proposal assessment but also continuous assessment and final assessment)
2. There is a previously set out specific objective (of programme, project, research plan, institution, ...) which can be specific for each case and which is to be achieved in a given time and which can be decided on whether it was satisfied or not
3. Evaluation criteria should be
 - i) known and binding
 - ii) clear-cut (not contradictory)
 - iii) quantifiable, measurable, evaluable
 - iv) related to a given objective

At the same time, the Resolution listed potential data for use in evaluation – all of which were indicators of output rather than outcomes or impacts.

The 2004 document is very ambitious in aiming to improve evaluation at all levels of the research system at the same time. It diagnoses a strong bias towards ex ante evaluation and tries to balance ex ante and ex post evaluation in response. It stresses that the development of the Czech evaluation system should be based on international experience with research evaluation and foreign experts included. In addition the document stresses the importance of respecting the differences among disciplines when evaluating research results. The 2004 document is not completely clear about the appropriate balance between quantitative and qualitative evaluation. Sometimes it indicates that mechanical evaluation should be only part of the evaluation system and sometimes it stresses that both research inputs and results need to be quantified. Although it says that the evaluation of results should be taken into account when distributing state budget for R&D it is certainly not stated that it should be the only basis for institutional funding.

Based on the Resolution, Evaluation Guidelines were first issued in 2004 and have since been revised annually by the R&DI council, initially in conjunction with MEYS. The 2004 guidelines stressed the importance of assessing R&D results by referring back to the explicit goals of the research and to focus the final evaluation of the results on quality assessment and the applicability of the R&D results (usefulness). Although some continuity can be observed over the years, the transformations in the evaluation system especially catch the eye. Most prominent is the change from the comprehensive Evaluation Guideline covering all different layers of the research system in 2004 to a much more narrow Evaluation Methodology that focuses almost solely on quantifiable outputs and the explicit connection of the Evaluation Methodology to the distribution of institutional funding in 2009. Hence, most of the effort has involved successive refinements to the Evaluation Methodology to be used in allocating institutional funding; rather less effort has gone into programme or project evaluation methodologies.

While the 2004 Resolution invoked international comparison and good European evaluation practice as ideals, over-focus on outputs at the expense of considering outcomes and impacts is a fundamental flaw that has affected the Czech R&D evaluation and policymaking system ever since.

3.4.2 The Evaluation Methodology for institutional funding

The Evaluation Methodology (EM) relies heavily on the national R&D Information System set up in response to the 2002 R&D Support Act, in which research performers are expected to list their research outputs across a range of publication types and innovation outputs such as patents, prototypes, software, methodologies and so on. Each output earns a category-specific number of points for the organisation concerned. These evaluation results are then used to determine institutional funding, with the organisation receiving a certain number of crowns (this varies by year) for each point. Thus the EM drives a Performance-Based Research Funding system where the outputs of the previous five years work drive next year's institutional

funding. The intention was to transition the basis of institutional funding to this arithmetically based system over a three-year period. The final cutover was interrupted, owing to dissatisfaction with the scheme.

The Evaluation Methodology with its reliance on quantitative indicators is driven by a desire to de-politicise and de-personalise the funding process. By relying only on (proven) past achievements, it aims to act against nepotism, corruption and lobbying. It sends out a clear signal: no outputs, no institutional funding. As such, it addresses the issue of low productivity in some research organisations. At the same time, it is intended to improve the quality of research outputs.

However it suffers important weaknesses. One is reductionism, in the sense of reducing the complexity of performance to an overly simple category of outputs. Despite successive refinements, it also failed adequately to address differences (both in types of outputs among disciplines and in the costs of producing them) or to take account of policy requirements such as the national thematic priorities. It also treats all institutions in the same way, regardless of their mission. While the intention is to take account of this by using a long list of differently weighted output categories, the weights are in practice arbitrary.

Evaluation needs to have consequences if it is not to be an empty exercise but using the EM to drive institutional funding has unfortunate effects. It leads to opportunistic behaviour ('gaming the system') by researchers and makes institutional funding unpredictable. It leads in some cases to large swings in funding and encourages short-term focus by punishing investment in the development of new fields and capacities that have few short-term outputs.

The Evaluation Methodology has been changed annually, mostly to correct the most obvious imbalances. The changes often represented detailed refinements or restrictions. The frequent changes of the Evaluation Methodology cause confusion, with researchers no longer being sure what counts and what does not. The Evaluation Methodology has little support among researchers or research managers. Not all the effects of the EM are understood. In particular, it is argued that it discourages collaboration.

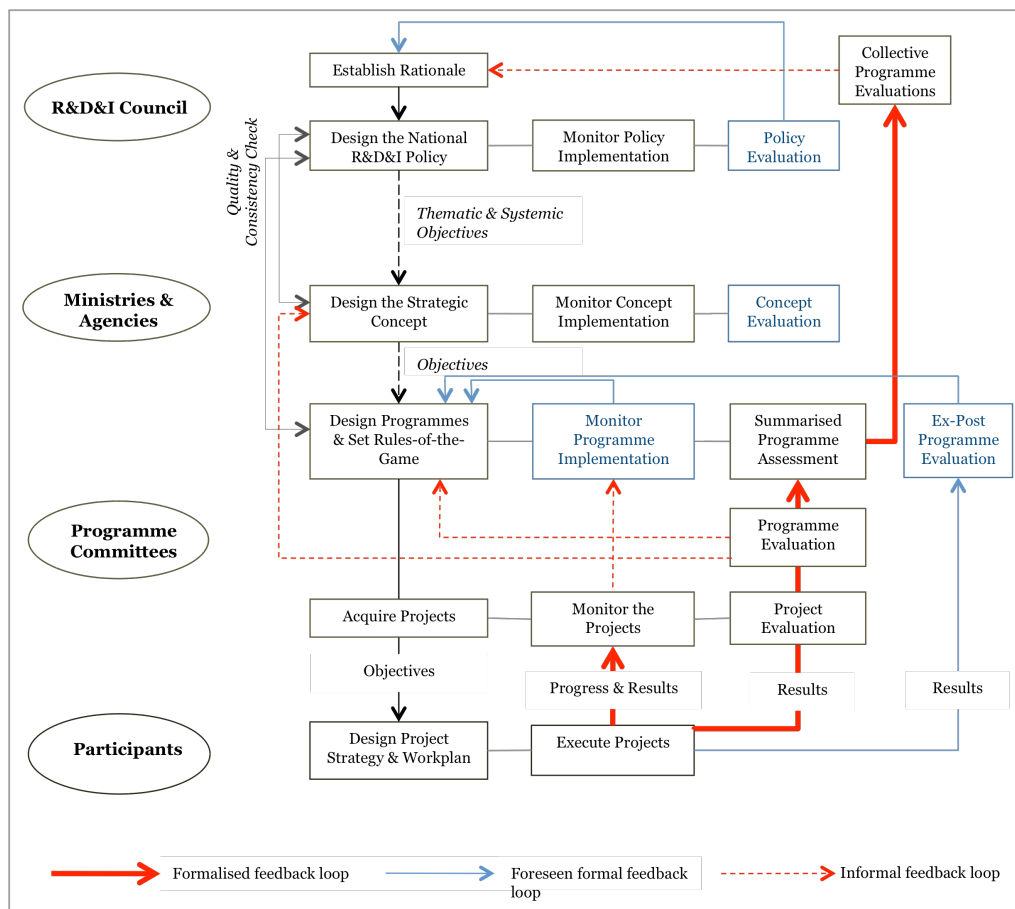
The EM was conceived as a mechanism to determine institutional funding. Most organisations also use the EM formulae to allocate this institutional funding internally to research groups. This fragments the research effort in the sense that the organisation does not prioritise or invest selectively in specific areas to build critical mass.

3.4.3 Evaluation of R&D&I policy more widely

Essentially, the Evaluation Methodology for Completed Programmes is currently the only framework for programme evaluations. Rather than being "methodology" papers, the descriptive documents merely indicate the basic information that the administration bodies should provide to the R&D&I Council for the implementation of the Collective Programme Evaluations. The methodology adopted for this 'collective' evaluation is purely quantitative, based on a calculation of an input/output ratio. Its declared key objective is to provide the R&D&I Council with a view on the efficiency of programme implementation by the intermediary bodies.

The National R&D&I Policy 2009 – 2015 introduced substantial changes in the evaluation system. Figure 11, below, depicts the current evaluation system within the "mainstream" policy cycle in the Czech republic. It indicates the actors in the system and the activities that they are expected to perform in terms of the design and implementation of the policy instruments and the monitoring and evaluation of their effects. Current formal feedback loops (in terms of input from evaluations to other assessments or policy interventions) are highlighted in red; evaluations foreseen in the National R&D&I Policy and their feedback loops are indicated in blue.

Figure 11: The Evaluation System in the Czech republic for targeted national R&D support



However, the current flaws in the evaluation system in the Czech Republic from the perspective of the quality of the evaluations and the role of evaluation in the policy cycle will only partially be corrected once the measures envisaged by the National R&D&I policy 2009 – 2015 are implemented.

- The responsibilities allocated for the implementation of evaluation are problematic. Each level in the structural hierarchy evaluates its own activities. This ultimately undermines the credibility of the evaluations.
- The approach established by the “Evaluation Methodology for Completed Programmes”, which focuses exclusively on efficiency and R&D output indicators, heavily dominates the evaluation culture: during our meta-evaluation of 7 recent evaluations, covering all evaluation typologies currently implemented in the Czech Republic, we noted a prevailing focus on efficiency, with little to no consideration of the extent to which the intended effects on S&T fields, industry sectors, or society as a whole were actually reached – or were in the progress of being reached. The quality of the input variables does not allow for more sophisticated analyses related to outcomes and impacts, such as the level of science-industry collaborations achieved or the level of cooperation between organisations located in different regions.

Most important, the concept of the evaluation system as being intrinsically part of a **policy cycle** is not perceived. Evaluations were – and for the moment still are – predominantly monitoring exercises. We found only one Ministry’s Strategic Concept

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that explicitly established a link between its policy objectives and the attainment of the objectives at the level of the programme that implemented the policy. Our contacts with the various Ministry and agency funding bodies indicated that project-level monitoring and evaluation is well done but evaluation - in the sense of evidence-based analysis to understand the degree to which public interventions have relevant goals and actually reach them - is little practised in the Czech R&D&I system. It produces little that is useful for policy learning or improving implementation. Thus, monitoring and mid-term evaluation exercises are largely absent, so there is no chance to make evidence-based mid-course corrections to programme design and implementation. Ex-post evaluation is absent at all levels, making policy learning difficult.

The Ministry or Agency operating the programme often does programme evaluation. This is poor practice, since evaluation is not then independent. Internationally, we normally see a 'waterfall' of responsibilities where Ministries commission evaluations of agencies and agencies commission evaluations of programmes. The exception is the 'Collective Programme Evaluation' implemented by the R&D&I Council. This evaluates programmes solely in terms of inputs and outputs listed in the national R&D results database.

4. Performance

The performance of Czech research as measured by the number and quality of publications has been steadily improving, though it remains below world average levels. Researcher productivity is improving, measured both in terms of output volume and impacts. Increasing collaboration inside and outside the country and the gradual build-up of capacity mean that performance is likely to carry on getting better, provided the pattern of increasing funding of R&D can be maintained or is at least stable.

While many Czech researchers have worked abroad and have international contacts, the degree of internationalisation of the research community is low, in part because of regulatory obstacles. Lack of strategy at both national and institutional level means that the Czech Republic under-exploits international opportunities – which is especially important given the role of international cooperation in improving national quality. The Czech Republic gets a poor return from participating in the Framework Programme and has very limited cooperation beyond Europe.

Research management, in the broadest sense, is problematic. Larger group sizes, better human resource planning and more explicit strategies will help reduce the current fragmentation and boost output. A key ingredient would be reduction in funding uncertainties, to allow institutions to set and deploy longer-term strategies.

The approach to human resource development in the Czech NRIS has been rather unsystematic. One reason for this is the rather old-fashioned style of governance and organisation that promotes fragmentation of research. This is also reflected in the extremely low proportion of researchers who are women. Public research organisations need to take stronger central responsibility for human resource management (and other aspects of research management), enabling career pathways to become more flexible, reducing the degree of in-breeding and reducing fragmentation through devices such as local and international graduate schools.

Science-Industry Links (SIL) are of variable strength. University research income from industry is minimal. Industry cooperates more with the RTOs. The low-value activities of many of the MNCs mean they do not easily become embedded in the Czech NRIS. Thus, many of the existing links are with medium-sized firms. Both the operation of the Evaluation Methodology and the lack of public RTOs militate against links with such firms. Measures are needed better to embed the multinationals in the Czech research system and to provide the appropriate level of coordinated support to less capable firms at national and regional levels.

While the Czech Republic has state of the art IPR legislation and there is a small community of experts in the area, outside this group there is little understanding of IPR. This applies both to patenting and to the much broader set of IPR instruments. Moves to establish Technology Transfer Offices in the universities and institutes are in their infancy and many organisations have not yet built up much experience in how to trade off formal technology transfer (through patents and licences) with the broader knowledge transfer functions of public sector research.

4.1 Publication Performance

Publication performance is a useful indicator of the development of a research community. Of course, it is a rather one-dimensional measure and so it is especially important to take account of the views of the peers who reviewed a number of strong research groups in the Czech Republic with us. It also has well-known limitations owing not least to differing communication traditions in different disciplines and its bias towards English-language journals. However, the use of bibliometrics is

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increasingly reflected in the view especially among ‘hard’ scientists that publication in international, peer-reviewed, high impact factor, English-language journals is the ‘gold standard’ that defines quality and they adapt their behaviour accordingly. (As the engineers like to say, ‘what you measure is what you get’.)

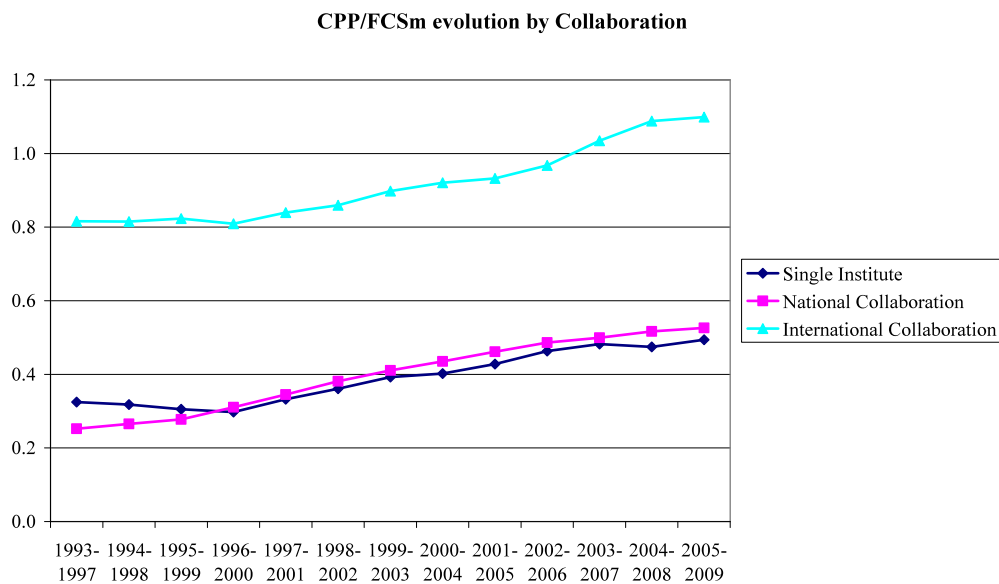
We analysed the total output of 85,572 indexed publications from the Czech Republic in the period 1993-2009. The number of articles produced per year more than doubled in the period while the number of times the average paper was cited (excluding self-citations) went up eight times, indicating a dramatic improvement in quality. Productivity improved: Czech researchers increased their rate of production of indexed journal articles per year and are now about 50% more productive than they were in 1993. At the same time, the impact factors of the journals chosen rose steadily, indicating growing confidence and ambition as well as quality. At the start of the period, over 70% of the papers were never cited but by the end this proportion had fallen to 50%, indicating a great improvement in the international visibility of Czech research. The quality of the publications (indicated by field-normalised impact scores) did not change much until around 1996, when an upward trend began that carries on to this day. However, on any impact measure average quality is still below the world average.

In the period 1993-2009, the largest field is physics & materials science, providing over 18% of the total Czech output, followed by chemistry & chemical engineering (with over 16%). Thus the Czech Republic has a rather traditional continental European research profile, similar to the profiles of particularly Germany, France and Italy and unlike the Anglo-Saxon profile, where the life and medical sciences play a more important role. Clinical medicine provides only 10% of the national publication output. Other disciplines producing more than 5% of national output are basic life sciences, biomedical sciences and biological sciences. In all of these disciplines, however, we observe low impact scores.

The Czech Republic has traditionally had a strong focus on the natural sciences and mathematics but the country’s publications profile is now slowly changing so that (bio)medicine and health sciences play a somewhat stronger role. Only a few disciplines reach average international quality levels: mathematics and statistics; environmental science and technology; plus a number of small fields including literature and management and planning. The proportion of publications related to physics and chemistry has declined over the years. Impact factors have increased particularly strongly in physics and materials science and in clinical medicine.

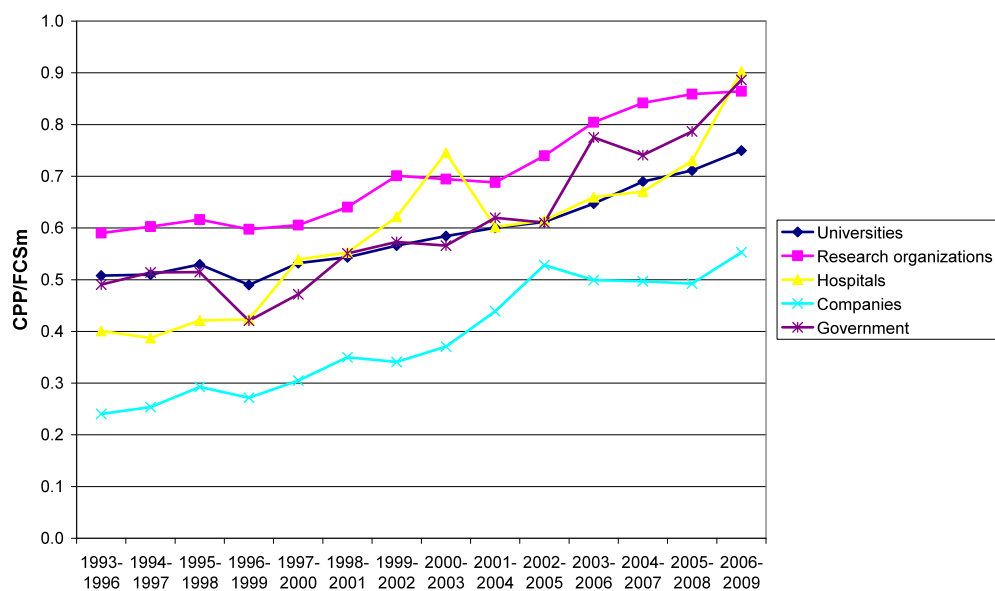
Over time, the Czech Republic’s research community has both become more coherent (in the sense that authors from different organisations are increasingly publishing joint papers) and better embedded in the international research community, indicated by a growing proportion of articles co-written with authors abroad. As is the case elsewhere, joint papers tend to be of better quality than those written by a single author, so collaboration – in particular international collaboration – seems to be one of the ways in which the research community is learning how to perform better. Figure 12 shows changes in the field-normalised impact factors of Czech publications relative to the world average in three categories. (CPP/FCSm indicates the impact of an institute/group’s articles, compared to the world citation average in the (sub)fields in which the institute/group is active.) It highlights the fact that for the last few years the mean quality of internationally co-authored papers has risen above the world average.

Figure 12: Impact development of the three collaboration types, 1993-2009



Universities and Research Organisations (ie the Academy plus other government research laboratories) account for the lion's share of Czech Republic publications. Quality is improving among all groups of institutions but the Research Organisations (ie primarily the ASCR) tend to perform the best (Figure 13).

Figure 13: Evolution of CPP/FCSm by institutional sectors



Co-publication among Czech institutions and between Czech institutions and others abroad has increased; the number of publications from single institutions has stagnated. Other important findings were

- While the output of most institutions focused on international collaborations, certain of the regional universities were more focused on national collaborations

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- The growth of international collaboration as well as the level of production in international collaboration is higher for universities and research organizations (mainly the Academy of Sciences), while national collaboration has a major importance for hospitals, governmental institutions and especially companies, reflecting the fact that a lot of company innovation activity is related to catch-up. Much of this internal collaboration will relate to the RTOs
- Some universities and institutes have for a long time been well linked into international R&D networks, so their share of international collaboration does not change much over time (this is the case of the Academy of Sciences as a whole, the Charles University in Prague and the Institute of Physics of the Academy of Sciences). Other institutions, such as for example the Czech Technical University in Prague, show a remarkable growth in the share of international collaborations during the period of analysis. This university saw a large increase in the impact of its papers in international collaboration during the last years of the period

Czech publication performance is developing in a very positive manner – rather similar to developments in Slovenia and Hungary – and looks set over time to converge with international performance levels. Of course, if we compare with the leading small research-performing countries such as Sweden, Finland and Denmark there is clearly still a long way to go but Czech output and quality are growing faster than is the case in these more established research-focused countries in Western and Northern Europe.

The empirical basis upon which meaningful international bibliometric comparisons of productivity could be made does not yet exist. While it is possible to produce comparable indicators in the hard sciences, psychology and economics, in many social sciences and the humanities such indicators are less comparable. Even more important is the lack of adequate series of input data not only at the level of field-specific detail that would be needed for meaningful comparison but even at the aggregate level. Where international ‘productivity’ comparisons are made, therefore, they tend to be done by comparing bibliometric indicators and population data. These are not true productivity measures because they use populations as proxies for inputs, even though we know that inputs (ie money spent on research) per head of population differ widely among countries. Here we compare **changes** in bibliometric indicators of outputs and quality over time. Absolute productivity comparisons remain beyond the state of the bibliometric art today.

Figure 14 shows the results of the **analysis on productivity**. Here we used the population statistics retrieved from the OECD database on population statistics for eight countries. We used the 2010 data, covering population statistics over the period 1003-2008⁴². The choice was made to use population data rather than researcher data, which are strongly affected by definition issue. We calculated as the mean annual number of publications per inhabitant over the period analysed. So the productivity scores over 1993-2009 are based on more years, and a relatively lower number of inhabitants, compared to the more recent period (here we have less years, but an increased output, and an increased number of inhabitants). We have compared changes in the **productivity scores (Delta P)**, and the **impact scores** between the periods 1993-2009 and 2005-2009.

The Czech Republic has the third largest increase in productivity per inhabitant, after Slovenia and Hungary (with increases of 59%, 58%, and 48%, respectively). Furthermore, the analysis of the change of impact shows that the Czech Republic has realised the largest increase in impact (an increase of 25%), followed by Hungary (with an increase of 19%).

⁴² For Slovenia we had to retrieve the data from the Slovenian Statistical Office as these were not included in the OECD dataset (we had to work with 2007 data, as more recent data were not yet available).

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Figure 14: Bibliometric statistics for Czech Republic and the eight benchmark countries, on productivity based on population statistics, 1993-2009

	Productivity 93-09	CPP/FCSm 93-09	Productivity 05-09	CPP/FCSm 05-09	Delta P	Delta I
AUSTRIA	0.0010	1.05	0.0012	1.18	27.07	11.91
CZECH REPUBLIC	0.0005	0.64	0.0007	0.79	47.95	24.94
DENMARK	0.0016	1.27	0.0019	1.36	20.36	7.86
FINLAND	0.0015	1.19	0.0018	1.20	19.03	0.32
GERMANY	0.0009	1.06	0.0010	1.16	18.56	9.50
HUNGARY	0.0005	0.78	0.0007	0.92	58.03	18.77
NETHERLANDS	0.0014	1.30	0.0017	1.34	22.58	3.83
SLOVENIA	0.0008	0.72	0.0013	0.78	58.97	8.10
SWEDEN	0.0018	1.20	0.0020	1.25	14.11	4.29

4.2 Internationalisation

Strong forces push national research and innovation systems to internationalise. These include: the need to participate in global scientific communities in order to operate at the frontier; globalisation of industry and industrial R&D; the need to build scale and specialisation (for example, in response to the shift in competitive arenas towards the European level as the EU tries to realise the European Research Area); the need to tackle global challenges beyond the reach of a single country.

The Czech Republic is among the countries that follow what we refer to as the **narrow STI cooperation paradigm**, where the drivers are mainly to improve the quality, scope and critical mass in science and research by linking national (financial and human) resources and knowledge with resources and knowledge in other countries. The drivers originate from within the science community and are translated in science and research policy instruments. This can have a two-directional aim: to obtain access to state-of-the-art knowledge abroad as well to attract state-of-the-art knowledge or people to the 'home' country. From the view of the research community, joint research activities are conducted for scientific problem solving. In less R&D developed countries an important 'intrinsic' driver is to build up national STI capabilities through cooperation.

A smaller number of countries follow a **broad STI cooperation paradigm**, where other non-science policy objectives interact with the 'intrinsic' science oriented objectives and STI cooperation becomes a means to reach other policy ends, namely

- Improving national competitiveness
- Supporting less developed countries by developing STI capabilities
- Tackling global societal challenges
- Creating good and stable diplomatic relationships

International collaboration appears to be one of the drivers of quality improvement in Czech publications. Four-fifths of the Czech Republic's international collaboration papers are with European countries although the USA is also a major partner. Czech international R&D collaboration is greatest (by absolute numbers of papers) in the fields of physics and material science, chemistry and chemical engineering, basic life sciences, clinical medicine, biomedical sciences and biological sciences. International collaboration in several social science disciplines is weak compared to this subject group's national significance. The ASCR and Charles University dominate international co-publication patterns, suggesting that there is scope to increase the collaboration performance of the other organisations.

Our survey of researchers found that two thirds of all projects done in collaboration have at least one international partner – mainly from European countries. Some 92% of all researchers who collaborate internationally have done collaboration with a

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partner from EU 27 / EFTA, and 16% with a partner from North America. 83% of all Czech researchers have been abroad in the context of their research at least once. Interestingly, more than one third of the respondents claim to have been employed by a foreign organisation; for senior staff (e.g. rectors) the share is above 58%. Those who have worked abroad say that re-integration is not a major problem. Researchers like to internationalise to enlarge their networks, to pursue personal research agendas and to get a better publication profile. There is little collaboration with foreign industry but those who do it say it has high value. By and large, the majority of Czech researchers feel that their organisations recognise international activities and support them. However, they regard the national system as comprehensively failing to support or encourage collaboration with European and even more with non-European partners and they regard the integration of foreign actors in national programmes as poor.

Less than 40% of the organisations that responded to our survey had an explicit internationalisation strategy, but a further 49% plan to have one within the next three years, indicating an overriding importance of internationalisation in the future. ASCR institutes are slightly less likely than others to have an explicit strategy and dedicated budgets but are already more internationalised – at least in terms of co-publications and the share of their projects that are international. While most organisations had few international projects, two thirds of them had strategic inter-organisational partnerships, mainly with organisations in the EU 27/EFTA and the USA.

A further measure of internationalisation in organisations is the level of foreign staff. The vast majority of organisations report fewer than 10% foreign staff, with shares at ASCR institutes being slightly higher. The share of organisations recruiting internationally is only 14%; again, ASCR institutes are more international in their recruitment than other organisations. Vacancies in leading institutes (and leading university departments) are increasingly open to international competition and we did find evidence that the international collaboration profile of applicants is considered, if not always systematically. ASCR institutes are much less likely than Universities to have international members on their advisory boards. On the other hand, the use of international peer reviewers in periodic reviews of ASCR institutes appears to be increasingly the norm.

The directors regard their organisations as being on the whole supportive of international activities. The major issue of concern appears to be brain drain and the need to increase the attractiveness of the Czech system for Czech and foreign researchers alike.

Funding, especially lack of openness of national grant programmes to foreign participants, for foreign researchers to visit or to take up positions remains a major barrier. High teaching loads, even in leading university departments, also present a barrier to international research collaboration and medium-term mobility. There are also barriers to teaching internationalisation, including the legal requirement mainly to teach in the Czech language. There is also a perception amongst many researchers that national funding is 'easier' to obtain than EU funding. EU funding brings little personal reward to the individual researcher to compensate for the additional effort and complexity involved in obtaining it.

Governance of and funding of RTI internationalisation is primarily in the hands of the Ministry of Education, Youth and Sports (MEYS), which is responsible for policy formulation, strategy development and the implementation of almost all programmes for international R&D cooperation including those for industry.

Most policy attention and effort is focused on European initiatives. Funding for participation in international organisations such as ESA, ESO, COST, EMBL, EUREKA and CERN have the majority of the budget funding. Other major initiatives are related to several Joint Technology Initiatives (Artemis, Eniac, IMI and Eurostars). The Czech Republic also has some active bilateral co-operations with non-European countries (Russia, S-Korea, China, Japan, Israel, Argentina and the US) that includes

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funding for research projects on the basis of an open competition. The emphasis of S&T collaboration policies is on establishing links for the public research organisations. Industry oriented R&D collaboration through funded programmes is relatively small and focused on the Eurostars programme.

The political importance of international R&D cooperation has grown and national budgets have increased. The most dramatic success story in recent years is probably that of infrastructure, where the Czech Republic has worked to shift the emphasis in planning towards the new member states and has successfully mobilised structural funds to support the development of an Extreme Light Infrastructure presence in the Czech Republic.

Nevertheless, according to policy makers, co-ordination problems remain at the policy level and barriers remain at the organisational and individual level, notably an inward looking culture in the research community and a lack of experience with international networking (particularly for those in research management positions). Some scientific domains have a sufficient international reputation to attract foreign researchers - however this is not monitored systematically.

Based on our comparison of the Czech governance arrangements for internationalisation of research with those seen in selected comparator countries (Ireland, Finland and Germany) we suggest that Czech policy makers should consider the development of an explicit internationalisation strategy embedded in a wide range of policy domains, including education, economics and industry policy, diplomacy and foreign policy) which considers not just EU FP funding but also bilateral cooperation with EU and non-EU countries, the use of R&D as an element to attract foreign direct investment, as well as help for Czech companies to better links with RTI partners around the world. Czech research organisations should develop more explicit international strategies. Funders should consider seriously the benefits that might come from opening up national research programmes and organisations and from removing possible barriers for foreign partners and individual research to work with Czech partners or to locate in the Czech Republic.

Finally, European research collaboration, and especially the Framework Programme, will continue to remain of major importance, opening Czech researchers up to competitive, peer review based funding, providing crucial opportunities for international collaboration and providing a significant share of funding in itself. The success rate of projects with Czech participation has increased in the last two Framework Programmes. However, despite high levels of national support for Czech applicants, overall mobilisation is not particularly strong when compared to other New Member States. The number of coordinators in successful projects is very low indeed.

Worryingly, in terms of broader internationalisation, there is very poor participation in the FP schemes that allow for extra-European collaboration, such as INCO and SICA. In terms of purely monetary return on investment, the Czech Republic does not quite get a 100% 'retour'. For a country still trying to establish itself at the forefront of European research, the investment in co-funding and supporting arrangements appears to be more than worthwhile, but an in-depth evaluation of the various supporting and co-funding schemes would be important to establish a clearer argument for the added value of these measures. More broadly, our interviews have confirmed the findings of the earlier evaluation of FP 7, namely that there is a lack both of a national strategy but also of individual institutional strategies for promoting FP participation within the context of a broader internationalisation strategy. This poor internationalisation performance may well be connected to the fragmentation of research groups and the lack of sophisticated research management referred to in Section 4.3.

4.3 Research management

In order to investigate other aspects of quality than publication, we selected (largely based on publication performance, but also mindful of the need to get good regional, thematic and institutional coverage) 15 high-performing research groups across the ASCR and the university system plus three RTOs and invited them to cooperate in an external review. Each completed a short self-evaluation review and obtained feedback from the international peers following a site visit.

The criteria on which the peers made their judgement included the existence and number of high-level academic publications, the scientific standing of key staff in the more academic types of research; a clear understanding of users and the access to users in more applied environments. Coherence and compactness of the research portfolio was another important criterion. Many of the institutional environments in which the groups worked were challenging, and the peers were generally impressed that they were able to produce work of a high standard under circumstances that often were difficult.

The majority of the research groups evaluated were of good to excellent quality measuring up to international standards. Especially in the fields of natural sciences, technical sciences and economics, we have encountered groups that are very well embedded in the international research community. They have achieved their international profile either through the training of the research group leaders in the United States and/or Europe, or through the development of extensive collaboration with international universities or companies. This international experience and international contacts seem to have helped them understand and reach international standards and also inspired the organisation and management of the research groups. Nevertheless, also these outstanding research groups are not always able to organise themselves as they wish, due to limits of the Czech research system.

Other research groups have come a long way. While the Czech Institute of Egyptology is a good example of a research institute from the social sciences and humanities that is internationally recognised, the other research groups we reviewed in this field are not at an international level yet. This is not surprising as several disciplines needed to be completely (re)established after the Velvet Revolution.

A final category of research groups still needs to improve considerably in order to reach international standards. In particular, the applied research institutes visited were mainly nationally oriented. Although a national focus is in line with their mission, they do not live up to international standards of contract research. They are not yet very entrepreneurial and risk that their target audience may prefer to go elsewhere. This last category needs improvement in terms of research quality and especially the organisation and management of (applied) research.

A number of general but important research management issues emerged from these interactions. While our survey of directors indicated that many of the needed procedures and policies were in place, the evidence from the site visits was that a lot remains to be done in research and human resource management. For example, 96% of the directors responding to our survey claimed to have a gender policy, yet we saw almost no women during the site visits. There is a clear need for organisations to make use of external knowledge in developing their management.

Fragmentation. In the natural sciences, medicine, and technical sciences research groups tended to be small, especially when they were located within larger institutions. This fragmentation was caused by the high level of autonomy enjoyed by many professors and the shortage of the kind of incentives increasingly seen in other countries for working in larger centres. Research topics are generally determined at the level of the individual professor, rather than there being wider strategies implemented by many people. Political trajectories, particularly from the communist period, also support the tendency to create small research niches (which, in

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communist times, were perceived as places where there was relative freedom to work, to exchange ideas, to travel, etc.).

Lock-ins. Fragmentation also meant that it was difficult to alter the research trajectory by doing interdisciplinary research, orientating towards applications, doing long-term development or establishing strategic partnerships. These things require firmly established competences in core activities as well as having resources available for exploring new topics. Small units typically do not have enough resources to do both, impeding innovation (particularly in the absence of leadership at higher organisational levels).

Reluctance to do interdisciplinary or application-orientated research. The peers were surprised often to find that groups were reluctant to make contact or collaborate with others outside their discipline. As a result, they fail to benefit from the opportunities provided by interdisciplinarity to make breakthroughs (which often occur at disciplinary boundaries) or to benefit from the supply of new research challenges provided by tackling applications.

Little awareness or room for manoeuvre in human resource issues. While some of the units evaluated staff with a good balance in terms of age and experience as well as access to young researchers, many suffered from an unhealthy age structure, problems in recruitment, and mobility.

- Several groups were dependent upon a single leader, who was ageing but was also critical to the group in terms of leadership, reputation and external networks. The problem was most acute in small groups, which had failed to develop middle-level staff or do succession planning
- Many groups were in-bred, with careers characterised by a Master thesis, PhD thesis, research position and professor position within the same group, sometimes with only little international experience and exposure. This limits the perspectives of the researchers and reduces their options for participation in international projects (which are often based on personal networks). The present recruitment policy aimed at hiring the best PhD students from one's own group for staff positions should thus be linked with open recruitment policies.
- Small group size also means that there is not the flexibility required for people to be internationally mobile. Stays abroad are mostly restricted to a couple of weeks and at best months, limiting the opportunities for learning. More international scholarships are needed together with more serious human resource planning and mobility has to be rewarded in appraisal and career development schemes.
- Limited collaboration between universities and Academy of Sciences. The evidence is that this is improving, but at the research group level it was clear that many opportunities to benefit from cooperation are being missed. The use of cross-institution graduate schools (as is done, for example, in the Netherlands) would reduce this problem and at the same time improve the training of young researchers in the Czech Republic.

Funding policy as a major cause for short-termism. Groups struggled with aspects of both the national and the international funding regime.

- There is a lack of continuity, owing to continuous rule changes in institutional funding, which is exacerbated by poor financial planning within research performing organisations. Rather than having a research strategy and using that as a basis for internal allocation of funds, organisations tend simply to pass through whatever institutional funding the Evaluation Methodology allocates
- Project funding tends to be small-scale and short term, further impeding the development and deployment of research strategy
- While the need to allocate money using evidence and transparent criteria was universally recognised, the Evaluation Methodology was widely seen as promoting short-termism, lock-in to existing structures and encouraging perverse behaviour

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- Participation in EU programmes was generally weak, partly because the problems of small size mean groups have weak international networks. Organisations need to prioritise participation in international programmes and to support this through professional research management and the provision of support and training for researchers

4.4 Human Resources in R&D

A systematic approach is required to human resources development in R&D. Highly qualified researchers and academics are essential for a successful NRIS. Such systems need qualified R&D workers at all levels in universities, research institutes and in industry.

Developing and securing human resources for R&D&I is a long term and complex process including multiple activities and measures targeted at different groups including science communication; science learning centres; support for students in the technical and natural sciences; support for researcher mobility; support for young and talented researchers from abroad; and platforms and networks linking researchers and industry.

The concentration of human resources is very important for the ambition of the Czech Republic to be an economy based on research and development and innovation. Without effective and comprehensive policy on human resource development, especially in R&D, and its successful implementation it will be very difficult to achieve this ambition. The lack of skilled personnel is seen as one of the main factors hampering innovation activities in general.

Research **career structures** in the Czech Republic suffer a number of weaknesses. Groups' own PhD graduates are expected to take 85% of posts in the near future, underlining an acute problem of in-breeding at all levels – partly owing to HR policies and partly to the disinclination of Czech academics to move between institutions. Czech researchers seem broadly dissatisfied with their pay and conditions but while average salaries are below the EU-25 in exchange rate terms they are about the same as the average in terms of purchasing power parities. Salaries have a significant performance-driven component, which in many cases is driven directly by previous outputs counted in the Performance Based Research Funding System (PBRF).

Career progression is cumbersome and rigid. More than 50% of senior scientists are over 50 while the proportion of women is half the EU-27 average. These proportions seem rather stable, so deliberate measures will be needed in order to correct these imbalances. There is both a lack of qualified academic personnel and insufficient training opportunities. Human resource management in the research system is primitive, making little use of career development plans. Reforms are in hand to make career progression and competition for posts more transparent.

The development of staff management systems that recognize and coordinate the contribution to university objectives will be instrumental in achieving these goals. The principles of open competition for positions and transparency of appointment and promotion procedures should be given particular attention. Adherence to these principles as laid down in the European Charter for researchers and the Code of Conduct for the recruitment of researchers are relevant to establish better career conditions for researchers. These should be strongly applied at the institutional level. More flexibility is needed in careers to make it easier, for example, to hold joint appointments and more diverse criteria, better attuned to career and institutional objectives are needed in HR management. Multi-annual research budget allocations will make that easier to achieve.

Low researcher **mobility** has been identified as a problem in the latter part of the last decade. Policy measures involve creating a competitive post-doc programme, supporting internships at foreign universities, encouraging placement of university graduates in industry and some simplification of immigration. The latter has not been

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very effective: the visa administration remains complex and non-EU citizens' social entitlements are poorer than those of EU citizens. There are few foreign researchers active in the Czech Republic, and of these over half are in fact Slovakian. The lack of arrangements for temporary leave or sabbaticals make it hard for researchers to spend limited periods abroad.

Czechs mainly return for personal reasons. They see low income levels, limited career opportunities and the Czech social milieu in research as the main barriers. More generally, intransparent hiring procedures and the requirement to teach predominantly in the Czech language impede mobility.

Doctoral education used to be the job of the ASCR, but since the transition the universities have acquired responsibility for granting doctoral degrees. While there is some cooperation between individual ASCR and university groups on doctoral supervision, the opportunities for systemic cooperation have not been addressed. One result of this is that about 80% of PhDs are training in the traditional 'apprenticeship' model, rather than in graduate schools. This limits the quality and scope of doctoral training and reinforces the problems of inbreeding. More open practices such as advertising positions on web sites are spreading, but it remains hard to attract foreign doctorands. Doctoral grants are small, so completion times are often long and many doctorands drop out before completing.

While the Czech Republic has fewer researchers than would be expected given its population, there is not room for all the new PhDs to find work in the academic system. Doctoral training has yet to adjust to the new reality where most PhDs will work in industry, so neither the kind of skills learnt in doctoral degrees nor their setting (which in other countries can increasingly involve some sort of relationship with industry such as co-supervision) have changed. However, there has been progress in establishing bilateral graduate training relationships with foreign universities.

There are a number of challenges in **investing in HR for R&D&I** through a coherent national and regional approach that makes good use of the large ongoing investments in European Structural Funds. In order to support industrial development, there is a clear need to strengthen areas outside the main core region, Prague, Central Bohemia and the South West, without undermining Prague's strength and attractiveness as a service core for central Eastern Europe. A spatial analysis would suggest a need for a polycentric hub region in the central belt area (North East, South East) capable of supporting a dynamic urban hierarchy in Central Moravia with developing functional linkages to the dynamism of Lower Austria, Vienna and the Bratislava city region. The revitalisation of the North West and Moravia-Silesia is a substantial longer-term challenge, which will in all likelihood be more influenced by the longer-term evolution of the Czech economy than by direct ameliorative interventions in the short-run.

Overall, there is a need to increase the quality of high-school education and proportion of people getting a higher education, in order to enable the Czech Republic to increase productivity and sustain the national position as a value location for investors. There are regional imbalances in the proportion of people getting higher education that need to be reduced in order to support the development especially of higher-technology industry. While there are also imbalances in the regional division of public and private R&D employment, the main priority should be to build strong R&D poles of relevance to regional clusters and to network them with other national strengths in similar research rather than to try to establish monopolies. New investments risk duplicating existing technology transfer structures so coordination between national and regional levels is necessary to create a national architecture for innovation support. OP investments tend notoriously to focus in capital infrastructure, in order to spend the money within the available time window. This creates a problem of funding subsequent operations that is easier to tackle if the investments are made in a pattern that is coherent with existing ones and with developing national needs.

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Graduates are often sources of company start-ups but their ability to play this role in the Czech Republic is constrained by the lack of financing for high-technology venturing and remaining lack of clarity about the ownership and manner of exploitation of intellectual property generated in the universities and ASCR institutes. At both first and higher degree level, it is important to ensure that students have some training in the elements of entrepreneurship. This will not only support those who choose an entrepreneurial path but also encourage additional people to do so.

More broadly, there are blockages and rigidities that need to be tackled in research career pathways in order to secure the needed future flow of R&D-capable people for industry and the research and higher education sector.

While there has been a lot of policy discussion about human resources, there is a **gap between strategy and implementation** that means the rate of change is slow. HR has been addressed in the Strategy for Economic Growth of 2005, the major Operational Programmes for education and research, the green and white papers of 2008, and so on. A new action plan for HR in 2011-2017 is being drafted. While there have been many policy ideas, however, they have rarely been implemented. A consistent policy consistently implemented over the kind of time horizons needed is absent. In the context of constant changes in government, the politicisation of R&D&I policy undermines the formation and implementation of consistent policy.

Weakly implemented HR policy undermines many other parts of R&D&I policy, undermining researcher careers and depriving the NRIS of a key 'factor of production'. Lack of a comprehensive approach to HR development across the Academy and the universities fragments the research system and undermines the quality of PhD training as well as the opportunities for science-industry links. We do not want to fall into the Czech habit here of saying that because some things don't work then nothing works: there are many high spots of inter-institutional cooperation and production of high-quality HR. But at the systemic level, the treatment and development of HR requires considerable improvement.

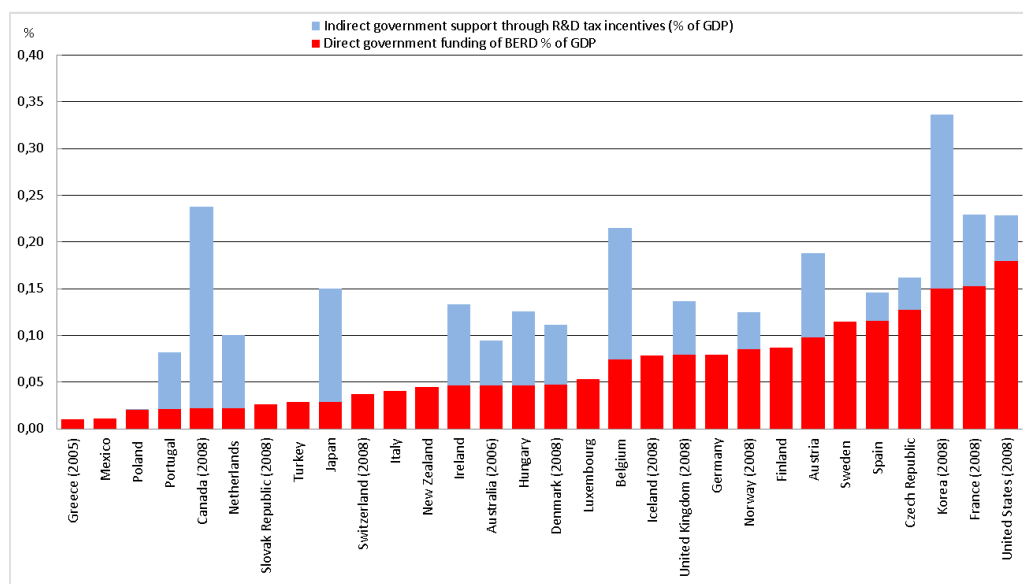
1. The implementation of policies and strategic intentions needs to be tackled systematically. Many critical issues have addressed in analytic and strategic documents drafted by various bodies (ministries, advisory bodies, etc.) but implementation has lagged behind.
2. Co-operation between the various key actors needs to be strengthened – especially the Ministry of Education, Youth and Sports; Ministry of Industry and Trade; the Council for R&D&I; and other relevant players. All measures and programmes need integration into a comprehensive set of complementary tools targeted at various levels of the education and R&D&I systems.
3. Increased attention should be paid to measures and programmes supporting science-industry links in general. These projects can have a significant impact on human resource development.
4. Detailed monitoring and evaluation is essential in the area of the new R&D infrastructure funded by the OP R&D&I. The newly built capacities will require high quality human resources. At the same time, the Prague region (still a leading locality in terms of the quality and quantity of R&D) is entitled only to a small fraction of the EU structural funds in the 2007-2013 programming period. Developments in Prague in terms of human resources in R&D&I in comparison to the rest of the Czech Republic should be carefully analysed.
5. The contribution of the education system at all levels to developing human resources for R&D&I should be carefully analysed. The recommendations of the OECD Thematic Review of Tertiary Education in the Czech Republic need to be acted upon.

4.5 Science-Industry Links

OECD R&D statistics give a partial insight into science-industry links (SIL). Overall the Czech Higher Education system gets a very low proportion (0.7%) of its research income (HERD) from industry. This compares to a level of about 7% for the EU-27. Its total income from industry (4%) is also below the European average of 6.5%⁴³. Our survey of funding at the research group level suggests that responding groups in general universities obtain 4% of their research funding from industry while equivalents in technical universities get 9% – a figure well below the levels that would be expected in, say, Sweden or Germany.

At the overall level, Czech state funding for research in industry **appears** to be very generous (Figure 15). The state funds 13% of BERD, compared with the European average of 7%. However, a significant fraction of state research funding of industry, goes to the ‘Professional, scientific and technical activities’ sector – essentially the privatised research institute system. If we ignore this funding (which is functionally misclassified – it should be considered as part of the research and higher education sector), then the level of direct funding of BERD is normal – without this element, the Czech Republic would be somewhere in the middle of Figure 15. This suggests links between companies and the RTOs are much stronger than between companies and the universities.

Figure 15: R&D Support to Industry in 2009 (% of GDP)



Source: OECD (2010)

Most innovation in business does not involve public research-performing organisations (‘science’) and much does not even involve R&D; but when it does, the links are important. The justification for state funding is traditionally market failure but can also be capability failure, so funding can encourage links when (1) acquiring new knowledge is too risky or expensive to be a feasible private investment or (2) the firm lacks the skills, knowledge or equipment to support a needed technical change. The more technologically capable a company is, the more advanced or ‘scientific’ its objectives are when it links up with ‘science’, so large and capable firms do many things in-house for which SMEs have to get external help. In most countries, a fairly natural segmentation appears in which advanced companies interact with universities

⁴³ EUA study referred to in Module Report 1

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and other institutions that do basic and applied research, including RTOs, while smaller companies get simpler forms of help from applied research institutes (RTOs), regional colleges and/or consultants. In many systems the RTOs can play a pivotal role by interacting with universities, large and small companies often helping knowledge 'trickle down' the industrial hierarchy.

The structure of industry in the Czech Republic is a crucial determinant of what is needed and what is possible in the area of Science-Industry Links (SIL). Many of the large companies that in other economies would naturally have strong links to the universities and institutes are MNC subsidiaries, which do some research in the Czech Republic but most of whose R&D is in fact development and adaptation (even if they account for some 55% of BERD in the Czech Republic). They naturally look to the R&D facilities at headquarters for technology inputs – what they do is essentially 'downstream' of the headquarters work – so they interact little with Czech universities or institutes. To retain the MNCs in the Czech Republic, it will be important that their local activities become more knowledge-intensive and that they are increasingly embedded in local supply chains that themselves are increasingly knowledge-intensive. As Ireland demonstrated in happier days, supporting MNCs' local managers in attracting more knowledge-intensive work is key to embedding them in the economy and within the NRIS. In this way they not only enrich the economy but function as a training school for local innovators and managers.

If we look at the rest of industry, we see the same pattern as in other countries: the bigger the company, the more it interacts with the universities and institutes. This size effect has two causes. First, the larger the firm the more it tends to make multiple products and the wider its technology needs become. Second, as firm size increases so does its tendency to employ technicians, engineers and scientists and to do R&D. Hence, its absorptive capacity⁴⁴ – the ability to look outside the firm, identify, internalise and exploit useful knowledge – increases with size and that in turn drives up its demand for knowledge. To the extent that much of Czech industry is still behind the technology frontier, its external knowledge support needs will tend to focus on choosing, understanding and unbundling existing technologies rather than science. Of course, in some branches like Chemicals where Czech industry has traditionally been strong, SIL are likely to be much more prevalent than in others.

Most of the innovation support programmes in the Czech Republic are orientated towards individual company innovation efforts. The TIP (launched in 2009) is currently the only programme addressing SIL more or less directly. Only in 2011 has the ALFA programme (bringing together applied research and experimental development) and the competence centres programme (fostering clusters of innovating companies and research groups) been launched by the Technology Agency. Programmes on seed-funding for start-ups are under preparation. Both researchers and companies surveyed were dissatisfied with support measures for SIL but there appeared to be limited understanding for the need incrementally to develop MNCs' local capabilities.

Some of the structural and research management problems identified elsewhere also inhibit SIL. The small size of research groups impedes SIL and industry is also worried about the ageing of key researchers who appear not to have successors. Our survey of research directors suggested that the main driver for research-performing organisations to seek SIL was money. This is disturbing. Successful, sustainable SIL builds on shared interests and signalling about needs rather than short-term rent seeking.

⁴⁴ W Cohen and D Levinthal, 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, No 35, 1990, pp 128 - 152

The Evaluation Methodology tends to impede SIL. It focuses strongly on academic outputs, creating a disincentive for industry cooperation. It does take account of certain categories of innovation output such as patents and prototypes, but its accounting is based on the idea that researchers themselves will commercialise results of research, potentially in competition with existing business. It therefore ignores the predominant 'open innovation' models where industry and 'science' work together or in parallel and where commercialisation occurs largely on the industry side. This pattern is the predominant one in the Framework Programme and is also visible in many other research-industry cooperations, whether bilateral or in programmes. The EM also neglects the important role of SIL in rediscovering, manipulating and transferring **existing** knowledge.

A surprisingly high proportion of researchers surveyed (48%) claimed to cooperate with industry, and the share was highest among the technical universities that have the strongest links with industry and are industry's favoured partners in the university sector. However, even in the technical universities, few researchers have links with MNCs – most of the cooperation is with indigenous SMEs. ASCR researchers tended to have personal relations with companies while university researchers were more likely to use formal mechanisms for SIL. This is consistent with the basic research focus of the Academy. Links between industry and more fundamental research rely on industry having a comparatively high level of absorptive capacity. In general, those with no experience of SIL saw barriers to linkage as bigger than those who did have experience, suggesting that educational and 'taste and try' mechanisms could be powerful in increasing SIL.

We were unable to collect evidence about this but speculate that the privatisation of the RTO function has impeded SIL. Normally, RTOs use subsidy income to develop internal capabilities that they exploit in support of company customers. Typically, they help customers go 'one step beyond'⁴⁵ what they could do without external support. They increasingly rely on tight links and overlaps with universities through PhD students, shared appointments and joint projects. The Czech system discourages such overlaps through the legal form of the institutions involved, using an incentive system that encourages competition rather than collaboration and fails to provide supportive mechanisms that would encourage the RTOs to work in collaboration with universities and Academy institutes. Rather than foster open innovation and the kind of passing back and forth of signals about needs and opportunities and the development of integrated communities of practice and knowledge that helps shape the development of successful innovation systems, the institutional structure and the EM both encourage 'ghettoisation'.

SIL has an important regional dimension. The concentration of research capacity in Prague and Brno promotes development of critical mass and of regional networks able to offer wide capabilities to industry, which is (except at the lowest levels) often prepared to travel some distance in order to connect with needed external capabilities. In practice, Czech cluster policy is driven from the regional level and involves very local partners in the knowledge infrastructure of organisations able to support companies with research and innovation. There appear to be untaken opportunities to connect the national system of research and innovation better with the emerging, regional, cluster-based one.

⁴⁵ Sverker Sörlin (chair), Erik Arnold (rapporteur) et al, *A Step Beyond: International Evaluation of the GTS System in Denmark*, Copenhagen: Forsknings- og Innovationsstyrelsen, 2009

4.6 Intellectual Property Rights

Formal IPR instruments, notably patents, are little used in the Czech Republic. This is consistent with the importance of technology adoption and use rather than the generation of new-to-the-world innovations in industrial development but also reflects traditions and habits from communist times and the fact that the developing European Patent Office and system has largely been irrelevant to Czech industry. While the Czech Republic has state of the art IPR legislation and there is a small community of experts in the area, outside this group there is little understanding of IPR. This applies both to patenting and to the much broader set of instruments such as trademarks, registered designs etc that form modern IPR management. While there are important exceptions – not least the Institute of Organic Chemistry and Biochemistry of the ASCR (which generates significant licensing income for the Academy) management in both industry and the research sector tends to lack knowledge and experience of IPR management. Several types of institutions, which should provide at least basic referral and information services, do not have such offerings, the most prominent being the majority of chambers of commerce and business associations.

Moves to establish Technology Transfer Offices in the universities and institutes are in their infancy and many organisations have not yet built up much experience in how to trade off formal technology transfer (through patents and licenses) with the broader knowledge transfer functions of public sector research. In many situations, an open innovation approach or strategic partnerships can be more effective ways to obtain social returns on government investment in research than formal mechanisms.

The Evaluation Methodology provides incentives that align badly with the needs of an effective IPR or knowledge transfer strategy. It values utility models, which are not examined for quality in any way, and rewards patenting activity as such, as opposed to the selective use of patenting to create value.

5. Conclusions and Recommendations

In this final Chapter, we draw a number of principal conclusions and make recommendations. These and others are discussed at greater length in the individual module reports, published alongside this synthesis. Together they provide the best part of a thousand pages of evidence and analysis, tackling issues in more detail than can be provided in a short report.

5.1 Conclusions

Our most important conclusion may be the hardest to address. It is nonetheless the case that the low overall levels of trust, and in particular the distrust of government, is a major obstacle to the further development of an NRIS that has many of the ingredients needed for success and that given its endowments and circumstances ought to be able to develop rapidly. In our experience, Czech levels of cynicism and instability in political life are much higher than can be observed in most wealthy OECD democracies. There may be good historical reasons for this, but it appears to drive behaviour and policies that are counter-productive. The Evaluation Methodology is a glaring example. It is an attempt to depersonalise resource allocation through the use of arithmetic because many feel that individual people cannot be trusted to make impartial and objective decisions. Equally, power has shifted towards the R&D&I Council because many do not trust the Ministries to do their job properly. These and other recent policy developments are well-intentioned sticking plasters that neither cure the patient nor address the disease.

Trust cannot be built overnight. It needs good examples and transparency coupled with a high probability of public punishment and humiliation for those who break it. The failure to implement the civil service reforms identified as necessary when the Czech Republic acceded to the European Union is for us a puzzle. A neutral, competent and independent civil service is essential for an effective state. If ministers can hire and fire civil servants on a whim, the effectiveness of the state is undermined and it truly becomes untrustworthy.

The Czech NRIS has made great strides since the Velvet Revolution. Privatising the research institutes and deciding whether to keep an Academy structure were decisions that had to be taken quickly. Two decades later, it would be right to ask whether the current division of labour and pattern of cooperation among the institutions is still appropriate in the light of the increasing convergence of their tasks and the growing interconnectedness of the innovation system.

There has been enormous growth in the R&D effort of both industry and the state, even if both are still below the levels needed for the Czech Republic to realise its potential eventually to match the industrial and scientific performance of leading small countries in the West of Europe. Better links are needed both in governance and in daily cooperation between the research and industrial systems, in order to support the needed balance of research and human capital development between areas that support catching up and areas that will enable the growth of R&D-based innovation. A good balance of basic and applied research is needed, accompanied by ways to signal about needs and opportunities. That is one reason why industry has to play a stronger role in policy development and governance, while of course being managed through checks and balances that include the voice of science.

In research policy, it is easy to focus on the hope of scientific discovery and to overlook the role of research in human capital development as well as the importance of signalling between research and society. This is especially the case at the Czech stage of development, where industry is not as well able to articulate needs as, say, the

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sophisticated Swedish multinationals that influence Swedish research policy. Correspondingly, the Czech research institutions and governance institutions need to listen more carefully than the Swedish ones.

The Czech Republic has made huge efforts to reform the R&D&I system in recent years, not least in trying to modernise it and improve its governance. While there is a clear, internationally based vision of what the NRIS should eventually look like, there is also a tendency to try to use rules (such as laws about how agencies should administer their affairs or again the famous Evaluation Methodology) when the main need is to develop capacity.

State funding of R&D&I has grown rapidly in recent years, to a considerable extent through increased institutional funding of university research and significant growth in 'targeted' or competitive, project-based funding both in the research and higher education sector and in industry. Taken together with the use of the Evaluation Methodology as a basis for allocating all institutional funding for research, this means that probably too high a proportion of funding is competitively allocated, making it hard to develop strategy and invest in the research sector. A better balance is needed among funding forces that promote quality, stability and restructuring.

The Czech Republic has shifted its governance of the NRIS from one traditionally rather focused on science to become much more inclusive of innovation. But the governance has also become more centralised, increasing the distance between decisions about research and innovation funding and the stakeholders affected by them. As the young Technology Agency evolves, there are opportunities to strengthen these stakeholder links but this depends crucially on the willingness of the R&D&I Council to do less micro-management. More broadly, there is a need to empower the various state actors in the NRIS, encourage the creation and use of distributed strategic intelligence and refocus the Council as an arena for discussing and setting broad-brush policy, as opposed to a negotiation table where institutional representatives fight it out for their share of the budget.

Evaluation works badly in the Czech R&D&I system. The Evaluation Methodology for institutional funding is not fit for purpose. It distorts behaviour, reduces the stability of the research system and hampers its performance. Evaluation more generally pays most attention to the wrong things. It is over-focused on outputs and provides little information about whether state interventions are successful, and programmes meet their goals. Radical changes are needed in the practice and use of evaluation in order to make it useful in accountability, policymaking and policy improvement.

The performance of Czech research as measured by the number and quality of publications has been steadily improving, though it remains below world average levels. Researcher productivity is improving, measured both in terms of output volume and impacts. Increasing collaboration inside and outside the country and the gradual build-up of capacity mean that performance is likely to carry on getting better, provided the pattern of increasing funding of R&D can be maintained or is at least stable. A key driver for improved performance is the growing integration of Czech researchers into the world community; so it is important to pursue internationalisation, not least through better use of the opportunities provided by European Union programmes but also in making better connections to the rest of the world. The Czech Republic gets a poor return from participating in the Framework Programme and has very limited cooperation beyond Europe. While many Czech researchers have worked abroad and have international contacts, the degree of internationalisation of the research community is low, in part because of regulatory obstacles. Lack of strategy at both national and institutional level means that the Czech Republic under-exploits international opportunities.

Research management, in the broadest sense, is problematic. Larger group sizes, better human resource planning and more explicit strategies would help reduce the current fragmentation and boost output. This depends in turn upon the universities

and institutes modernising their governance and management, developing more explicit strategies. A key ingredient would be reduction in funding uncertainties, to allow institutions to set and deploy longer-term strategies.

The approach to human resource development in the Czech NRIS has been rather unsystematic. One reason for this is the rather old-fashioned style of governance and organisation that promotes fragmentation of research. It is also reflected in the appallingly low proportion of researchers who are women. Public research organisations need to take stronger central responsibility for human resource management (and other aspects of research management), enabling career pathways to become more flexible, reducing the degree of in-breeding and reducing fragmentation through devices such as local and international graduate schools.

Science-Industry Links (SIL) are of variable strength and do not adequately support development. University research income from industry is minimal. Industry cooperates more with the RTOs. The low-value activities of many of the MNCs mean they do not easily become embedded in the Czech NRIS. Thus, many of the existing links are with medium-sized firms. Both the operation of the Evaluation Methodology and the lack of public RTOs militate against links with such firms. Measures are needed better to embed the multinationals in the Czech research system and to provide the appropriate level of coordinated support to less capable firms at national and regional levels.

While the Czech Republic has state of the art IPR legislation and there is a small community of experts in the area, outside this group there is little understanding of IPR. This applies both to patenting and to the much broader set of IPR instruments. Moves to establish Technology Transfer Offices in the universities and institutes are in their infancy and many organisations have not yet built up much experience in how to trade off formal technology transfer (through patents and licences) with the broader knowledge transfer functions of public sector research.

5.2 Recommendations

The following recommendations flow from our overall analysis. More detailed discussions and recommendations are contained in the individual module reports.

1. Building trust in government and among members of the R&D&I community is a precondition for successful performance in the NRIS. Such trust is based on fair principles transparently and impartially implemented combined with conspicuous punishment for those at any level who break the rules. **The promised civil service reforms should urgently be carried out. The state's organisations that aim to manage the NRIS – from the R&D&I Council, the Ministries, the Science Foundation and the Technology Agency – should be required to make details of decisions and reasons for making them public. Oversight processes, including the use of international peers, should be in place so that there are credible guarantors who can test and vouch for the independence and objectivity of decisions.**
2. The size and quality of the Czech R&D&I system have been increasing for a number of years but remain below international levels. **The state should continue to increase its investment in R&D, in line with the policy of spending 1% of GDP on R&D by 2020. Measures need to be in place to encourage industry to spend a further 2% of GDP on R&D by that time, in line with the expectations of the former Barcelona Goal and the new Horizon 2020 policy of the EU.**
3. There are signs that the division of labour and institutional boundaries among the universities, ASCR and RTOs are not optimal and that opportunities for more closely working together are being missed. Outdated forms of organisation and management appear in some cases to impede effectiveness.

The R&D&I Council should launch an inquiry into the organisation, performance and division of labour among the universities, ASCR and RTOs with a view to proposing measures to modernise and potentially reallocate roles among these organisations. Updating human resource and research management practices should be key elements of the resulting reforms. Measures should urgently be introduced to combat the shockingly low level of female participation in research, which represents a massively inefficient waste of talent.

4. Recent reforms have tried to combat lack of trust in government, perceived improprieties in decision-making and perceived lack of capabilities in the Ministries by centralising responsibility for R&D&I budgets and policy in the R&D&I Council. This overburdens the Council with a level of responsibility with which it cannot realistically cope and makes it hard for it to take good and informed decisions. It makes it into a quasi-Science Ministry without linking it properly into the government or the democratic process and distances it from the system-wide knowledge and strategic intelligence required to link policy to needs. **Alongside the civil service reforms, Ministry capacities should be strengthened and the Ministries re-empowered to act in R&D&I by having their own budget lines. The R&D&I Council should refocus on setting broad strategic directions rather than budget allocation and micro-management. The Science Foundation and Technology Agency should be given principals in the form of Ministries. As with the Research Council of Norway and Austria's FFG, multiple Ministries should be able to use them as funding agencies for their R&D&I activities. The relationship between the principals of the funding agencies and the agencies themselves should have the character of performance contracts. The agencies should be managed by objectives; their actions and activities should not be micro-managed by the R&D&I Council or others. The character of steering should therefore shift towards soft steering with the involvement of relevant stakeholders.**
5. Good international practice in R&D programming is to involve stakeholders, so as to ensure a fit with needs and opportunities. This is of course subject to checks and balances and the planning and implementation processes must be transparent. **Czech R&D programming practice should respect the international tradition of stakeholder involvement combined with scrutiny to ensure objectivity and independence.**
6. The proportion of research funding in the Czech Republic that is delivered under competitive conditions is too high, exceeding levels that many countries regard as dangerous. **Institutional funding should comprise at least 50% of research funding. It should be quality-assured but on a slow (5+ year) cycle that creates stability and opportunities to plan rather than on an annual basis.**
7. The Evaluation Methodology is not fit for purpose. It introduces structural and behavioural distortions and impedes many aspects of the NRIS' development. **The Evaluation Methodology should be replaced by a system of performance contracts that have both prospective and retrospective components, supported by a combination of objective indicators and international peer judgement.**
8. The system of R&D evaluation in the Czech Republic more broadly focuses on counting outputs at the expense of understanding policy interventions and their impacts. It therefore provides information that is at best of limited relevance. **Evaluation practice should be the subject of root and branch reform, refocusing on outcomes and impacts in addition to**

outputs and contributing to policy and programme development and planning. Inter alia, this will involve implementing the ‘waterfall principle’ that involves levels in the steering hierarchy using independent expertise to evaluate levels hierarchically below themselves but not in effect being able to do self-evaluation.

9. The Czech NRIS lacks an Internationalisation strategy. This inhibits its development. **The R&D&I Council should launch a consultation and study to generate a Czech R&D&I internationalisation strategy.**
10. Intellectual Property Rights (IPR) are poorly understood in the Czech Republic. Few understand the breadth and usefulness of a proper IPR strategy. **The employers’ organisations or chambers of commerce should launch a campaign of IPR education for industry. At the same time, the universities and institutes need to develop clearer IPR strategies. This does not mean that there should be further pressure to patent the irrelevant – rather, understanding IPR properly allows rational decisions to be made about what not to patent and how best to share knowledge with industry and other organisations outside the research and higher education sector.**

Appendix A List of Abbreviations

ANBERD	Analytical Business Enterprise Research and Development
ASCR	Academy of Sciences of The Czech Republic
AVO	Czech Association of Research organisations
AWT	Dutch Advisory Council For Science and Technology Policy
BERD	Business Expenditure on Research and Development
CEE	Central & Eastern Europe
CERN	European Organisation for Nuclear Research
COST	European Co-operation in the field of Scientific and Technical Research
CR	Czech Republic
CzK	Czech Koruna
CZSO	Czech Statistical Office
EFTA	European Free Trade Association
EM	Evaluation Methodology
EMBC	European Molecular Biology Conference
ERAWATCH	A research policy observatory of the European Commission
ESA	European Space Agency
ESO	European Southern Observatory
EU	European Union
EUREKA	European R&D Funding Initiative
EZ	Dutch Ministry of Economic Affairs
FP	Framework Programme
GA	Grant Agency
GBAORD	Government budget appropriations or outlays on R&D
GDP	Gross Domestic Product
HE	Higher Education
HERD	Higher Education Research and Development
HR	Human Resources
ICT	Information and Communications Technology
IMI	Industrial Management Institute
IPR	Intellectual property rights
MEYS	Ministry of Education, Youth and Sports
MNC	Multinational Company
MIT	Ministry of Industry and Trade
NPV I	First National Research Programme
NPV II	Second National Research Programme
NRIS	National Research and Innovation Systems
NRP I	First National Development Plan 2004 – 2006
OECD	Organisation for Economic Co-operation and Development
PBRF	Performance-Based Research Funding
R&D	Research and Development
R&D&I	Research and Development an Innovation
RCN	Research Council of Norway
RTD	Research and technological development
RTI	Research and Technology Innovation
RTO	Research and technology Organisation
S&T	Science and Technology
SIL	Science-Industry Links
SME	Small and Medium-sized Enterprise
STU	Swedish National Board for Technological Development
TA	Technology Agency
TAFTIE	Association for Technology Implementation in Europe
TIP	Programme of Ministry of Industry & Trade
UK	United Kingdom
US	United States

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