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Research and Innovation Challenges and Policy Responses in Member States

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Synthesis

Summary: The report on research and innovation challenges and policy responses in Member States highlights recent, topical STI policy developments in these countries, mostly stocktaking on ERAWATCH 2010 Country Reports but also taking into account various other sources. Moreover, it synthesises these national policy trends and policy contexts for each country as well as it runs comparative analysis within and across 8 country groups, the latter clustering countries of similar innovation performance. In this way, we are able to deduct policy implications with regard to the Common Strategic Framework and the Innovation Union Flagship Initiative.

1 Introduction

The EU2020[1] Flagship Initiative entitled 'Innovation Union' was announced in a Communication from the European Commission (EC) in October 2010.[2] It set out "a bold, integrated strategic approach…whereby innovation is the overarching policy objective, where we take a medium- to longer-term perspective, where all policy instruments, measures and funding are designed to contribute to innovation, where EU and national/regional policies are closely aligned and mutually reinforcing, and last but not least, where the highest political level sets a strategic agenda, regularly monitors progress and tackles delays".

The same month, the EU Budget Review[3] proposed that the full range of EU instruments for research and innovation (R&I) should work together in a Common Strategic Framework, a proposal subsequently supported by the European Council in February 2011.[4] With the publication of a Green Paper[5] the EC launched "a public debate on the key issues to be taken into account for future EU research and innovation funding programmes" and, in parallel, readied itself for the production of a related ex ante impact assessment.

In order to understand the potential impacts of EU R&I policy proposals on the R&I policies and activities of Member States, some understanding of current and recent policy developments in these countries is needed. As a contribution to the ex ante impact assessment

[1] European Commission (2010), 'Europe 2020: A European strategy for smart, sustainable and inclusive growth', COM(2010) 2020
[2] European Commission (2010), 'Europe 2020 Flagship Initiative Innovation Union', COM(2010) 546
[3] European Commission (2010), 'The EU Budget Review', COM(2010) 700
[4] European Council (2011), 'Council Conclusions – 4 February 2011', EUCO 2/11
[5] European Commission (2011), 'From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation funding', Green Paper, COM(2011) 48

of future EU R&I policies, this report therefore focuses on R&I policy trends in Member States (MS).

It takes as its main source material prepared in the context of the EC's ERAWATCH information platform.[6] In addition, the report also draws upon material contained in the National Reform Programme (NRP) 2010 documents prepared by all MS[7] and material presented by a select number of MS at an ERAC Mutual Learning Exercise in January 2011.[8]

This report presents a synthesis of the findings of eight separate Country Group reviews, all presented as appendices (see Exhibit 1 for a description of the Country Groupings). Each appendix focuses on a particular cluster of countries, grouped together on the basis of similar knowledge capacities and economic structure.[9] Important developments in individual countries are identified and intra-group similarities and differences highlighted. Inter-group similarities and differences are covered in the main synthetic part of this report.

The structure of the main report echoes that of the individual appendices. Section 2 identifies the main challenges confronted by R&I policymakers in the MS, based on analyses of the strengths and weaknesses of their R&I systems and the factors limiting effective policy responses. Section 3 then reviews the range of actual policy responses to these challenges. Section 3.1 focuses on the issues of prioritisation and the formulation of policy mixes customised to address specific challenges, while Sections 3.1 to 3.4 address issues that underpinned many of the proposals contained in the Innovation Union Communication and that were addressed by MS in the ERAC Mutual Learning Exercise in January 2011. In particular:

- Section 3.2 – "Smart fiscal consolidation" examines the notion that budgets supporting research and innovation need to be safeguarded and even increased if possible;
- Section 3.3 – "Efficiency of public support" reviews efforts made towards strengthening knowledge base, reducing the fragmentation of research policy support, and focusing research policy on support measures likely to stimulate private sector investment in research;
- Section 3.4 – "Framework conditions for business R&D and innovation" reflects the issues of the need to do more to stimulate innovation as a whole and to ensure that good ideas reach the market, primarily by enhancing access to finance for innovative companies, helping to create a vibrant market for innovations, and capitalising fully on Europe's creative potential.

Finally, Section 4.1 offers some conclusions relevant to the development of the Common Strategic Framework (Section 4.1) and to the implementation of the Innovation Union Flagship Initiative (Section 4.2).

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[6] See http://erawatch.jrc.ec.europa.eu/

[7] See documents uploaded in the documents & report section on http://ec.europa.eu/europe2020

[8] Unfortunately, documentation was not made publicly available.

[9] The membership of Country Groups is based on an analysis contained within the forthcoming EU 'Research, Innovation and Competitiveness Report'. It is included as an additional Appendix.

Exhibit 1 Country Groupings

Group 1	Very high knowledge intensity countries	Finland, Sweden, Denmark
Group 2	High knowledge capacity systems with a specialisation in high-tech manufacturing	Germany
Group 3	High knowledge capacity systems with a mixed economic structure	Belgium, the United Kingdom, France and Austria
Group 4	Medium-high knowledge capacity systems with an economic specialisation in knowledge intensive services	Ireland, Luxembourg, the Netherlands
Group 5	Medium knowledge capacity systems with an economic specialisation in low knowledge sectors	Spain, Portugal, Greece, Estonia, Latvia, Lithuania and Malta
Group 6	Medium-low knowledge capacity system with a strong service-based economy	Cyprus
Group 7	Medium-low knowledge capacity with an important industrial base	Czech Republic, Slovenia, Slovakia, Hungary and Italy
Group 8	Low knowledge capacity systems with a specialisation in low knowledge intensive sector.	Bulgaria, Romania, Poland

2 Main challenges confronting national R&I systems

The central concern in G1 is the maintenance of high knowledge intensity activities, whereas G2&3 have aspirations to expand their high tech sector shares, while having a medium tech focus. G4&6 are mostly targeting a more balanced structure between manufacturing and (dominant) service sectors, whereas G5 has ambitions to change structural economy features away from SMEs towards larger, more R&D active companies as well as shifting from medium tech to medium-high tech sectors. Medium-low tech sectors in G7&8 struggle with low innovation and cooperation culture in national RDI systems as well as with the instability of public R&D support and underperformance of science systems. In this way, G7&8 are still at developing and building stages of STI governance (e.g. as a potential consequence of long-term economic transformation and Eastern integration), limiting the extent of policy responses and dedication to specific aspirations. In any case, policy aspirations seem to play a key role in explaining a good deal of the policy responses documented in the country reports.

In general, some of the (often limited in scope) policy responses on challenges in G5&7&8 are initiated outside the national policy domains i.e. on EU/international/other national level activities such as R&D by multinationals or EU structural funds. In contrast, STI policy-making in G1-4 tends to be rather concerned with fine-tuning national responses and comparative STI advantage relative to on-going global changes in policy and business domains. While slow progress on structural change has been reported in most countries, the financial and economic crisis has halted these trends, sometimes setting them back a couple of years. This is particularly true for G4,5&8. As mentioned above, progress made and the quality of responses are often subject to improvements in STI governance institutions and practices. While G2&3 countries experience problems of fine-tuning and coordination on different levels of governance, on regional/national and/or national/EU and international levels, all other country groups (with the exception of G1) experience, with varying degrees of severity, a lack of coordination across policy domains related to STI (e.g. education and innovation ministries), lack of continuity and/or delayed policies, often becoming evident in the design and implementation of cross-cutting instruments or policies, such as knowledge transfer (KT) policies or overall development of strategic frameworks.

Closely related to the issue of governance is the extent to which evaluation culture and evidence-based policy-making has evolved in country groups. In the country groups where STI governance is less developed we can, however, observe notable efforts to improve evaluation and monitoring practices and related institutional change, such as the establishment of evaluation agencies in most countries. This seems to be linked to further advancements in the quality of scientific institutions and output as well as (in a few country groups) to further advancements in terms of excellence in science. More generally, open modes of/more integrative approaches to STI policy-making are missing in some country groups, namely G5&7&8, leading to insufficient involvement of and resistance from stakeholders in national innovation systems with respect to strategic/thematic framework setting new evaluation mechanisms as well as horizontal policies.

Evidence in all country groups, with the exception of G1&2, suggests low levels and/or inefficient policies related to academia-industry interaction. In the majority of these groups this is mainly caused by failure in one or more domains of the knowledge triangle e.g. limited absorptive capacity of businesses and/or low innovative aspects of the scientific output. In this way, any KT policy engagement, given structural features observed, may prove ineffective, in particular in G5-8. In G3&4, KT policies seem to suffer from a lack of accountability and assessment of such measures. While for the latter groups progress on this challenge may be achieved in the short-run, the former groups may have to await longer term changes, potentially requiring a re-prioritization of the overall STI agenda (with less focus on KT), accompanied by successful STI governance reforms.

Managing the inputs and outputs of the science system and general national innovation systems is another challenge for national policies. Depending on the level of aspirations, G1-3 pay significant attention to human resource issues, in particular with respect to high-tech business demands, as well as optimizing and fine-tuning potential matches between skills and demands. In this way, given that they compete in scientific and innovative markets on global levels, all these countries consider building (or maintaining) excellence of science and innovation and provision of high-growth/-tech firm environments (including a favourable R&D finance and entrepreneurial environment) as major STI objectives. In addition, there is a focus on attracting multinationals, in particular by smaller countries, and of excellent researchers from abroad. In contrast, responses to challenges in G6-8 are less pro-active in nature as e.g. these countries often experience brain drain, limited openness and attractiveness of lower quality science systems and limited national participation in international research activities (frequently due to limited public budgets and country size). G4&5 have a mixture of both trends observed, the former being closer to G1-3, the latter closer to G6-8 challenges.

While, the causes vary across the countries, all the MS currently face and/or will face a potential shortage of highly skilled professionals. Some of the countries still face massive brain drain, which partially is converted in other MS into brain gain. While this dynamics has functioned fairly well for some time, on long term this may trigger long term negative effects. The countries suffering brain drain will continue to have limited access to many of the FP programmes which through their nature fund excellence and in time will face long term R&D human resources shortage. Overall, this situation can generate a decrease of quality S&T graduates in all EU countries. In compensation, new focus is on attraction of researchers from third countries, which, although on short term may have a positive impact, on long term may generate negative side effects. The impact of the crisis has already shown that the Multinational Companies tend to reallocate the R&D centers in countries were the costs are lower. A viable solution must be foremost found inside EU; this should enable the creation of a uniform EU R&D landscape and labor market for researchers, increasing the attractiveness of research careers.

Challenges and aspirations may partly explain why e.g. G1-3 rank higher on the agenda policy responses such as "framework conditions for business R&D and innovation" while G6-8 places much of their reform efforts on "efficiency of public support", as will be shown in the following sections 3.4 and 3.3, respectively.

3 Policy responses

This chapter reviews the range of policy responses to these challenges, focusing on specific aspects such as their timing and appropriateness. In particular, the next section focuses on the issue of prioritisation and the formulation of policy mixes to address specific challenges.

3.1 Challenges and thematic priorities

With the exceptions of fairly homogeneous G1&2, all country groups show heterogeneous patterns of commitment to and implementation of thematic priorities and framework setting practices. G1&2 explicitly consider thematic priorities including societal challenges and have advanced implementation mechanisms in place and have experienced learning on framework setting activities (frameworks being in 2^{nd}-3^{rd} generation). In contrast, in G6&8 framework priorities mostly are inexistent, lack budget specifications or both.

In the groups (G3-5&7), some countries within groups follow different tracks, being less compatible with strategic priority/framework approaches: STI and general economic policies are oriented towards bottom-up, indirect or actor-specific mechanisms and/or R&D funding streams are predominantly institutional (rather than project/programme or competitive) in nature[10], both limiting implementation efforts and overall power of priority frameworks. This is true to varying extents for Slovenia and Slovakia in G7, for most countries in G5, some in G4 and the UK and Austria in G3. In addition, the overall size of national public R&D budgets/country size as well as crisis impact may hamper implementation of frameworks developed. Similarly, implementation may be delayed to announcements as changing only the foci of newly introduced STI measures (meanwhile leaving foci of existing funding schemes unadjusted as was the case in G3) or implementation suffers from general weak STI governance (G5&7&8). Weak governance, i.e. fragmentation and limited coordination, and limited participation of stakeholders in the process, can also account for frameworks being misaligned to national science and innovation profiles and competitive advantage or for setting thematic priorities that are too broad or too ambitious in high-tech fields. In some of the G7&G8 countries EU practices have affected priority setting to a certain extent (e.g. Romania). In some countries research policy defines a limited number of thematic priorities, but given the lack of clear funds distribution among them, they function rather as broad guidance than financing prioritisation. There are also countries in which the lack of concrete national research priority stands as one of the major STI challenges (e.g. Bulgaria, Cyprus)

Societal challenges were included in most countries (G1-6). Thematic selection within strategic frameworks from time to time can be subject to supplementary policy goals such as public-private knowledge circulation or explicitly included cross-cutting policy components and activities (G2&5).

In addition, framework-setting exercises are likely to have had positive, long-term effects on STI governance efficiency in a number of country groups (namely G5&7), triggering institutional change in STI governance, likely to heal to a certain degree fragmentation of funding, leading to better coordination across STI policy domains or enhancing articulation (mechanisms) among STI stakeholder opinions for future or different exercises.

[10] However, even in specific country groups where institutional funding has been the dominant pattern many country reports evidence national trends towards competitive schemes, namely Bulgaria and Poland in G8, most countries in G5 and the Netherlands in G4, potentially making fast and effective implementation more likely as well as empowering the role of overall framework on national policy agendas.

3.2 Smart fiscal consolidation

As mentioned before, country groups G4,5&8 and consequently the related private and public R&D activities were among the most affected MS in the context of the economic and financial crisis. However, policy responses with respect to fiscal consolidation efforts are found across all country groups[11]. In general terms, the relative importance of the role of publicly funded R&D appears to have increased compared to business R&D spending across many of the country groups, at least in short-term and based on the current crisis impact assessment. In this way, relative gains in importance can be, at least partly, explained by a variety of reasons which significantly differ across and within groups:

a) public R&D budgets and policies having increased in absolute terms and being prioritized, respectively, as in G1&2, or by responsive STI policy design and rapid implementation of new measures (G7),
b) R&D budgets being exempted from overall public budget cuts, as it is mostly the case in G2&4,
c) Launch of short-term, anti-cyclical government expenditure programmes i.e. economic recovery packages with potential R&D side-effects, with thematic or infrastructure foci in G2&3 and in a few countries of G5&7, mostly larger ones, and, lastly,
d) contractions in business R&D investment and/or national GDP being relatively more pronounced than public sector cuts.

While items a) to c) may be considered smart consolidation efforts, d) is not. Impacts of the crisis on overall R&D activities have been less in those country groups (e.g. G1&2) where business R&D spending was continuous or less volatile during the crisis. In addition, the relative importance of EU structural funds in national public R&D budgets has increased raising MS' concerns on long-term sustainability of national budgets, in particular within the groups already heavily depending on such sources. This funding source is likely to have contributed to short-term stability of national budgets as delivering early policy commitments of co-financing and re-allocation flexibility of budgets on national levels.

What specific cuts were (not) made in national STI budgets? Budget cuts are mostly affecting HEIs and PROs with either short-term consequences, e.g. reductions in researchers' salary (G3&5&7&8) as well as temporary interruptions of R&D support measures, or, in very few countries, long-term implications, e.g. cuts in institutional funding prospects (again, G3). In few countries the crisis has caused a discontinuation of R&D subsidies and of scientific quality assurance mechanisms or KT measures such as TTO financing (G4&5, respectively).

In groups G3&5 consolidation effort of a majority of countries has shifted relative focus from direct funding measures to indirect R&D finance related ones such as loans or credit for businesses, or the extension of tax credit schemes for R&D activities. As with all of the above mentioned consolidation efforts made, at this stage, with the crisis on-going in many countries and given the reports' evidence, it is difficult to make an ex ante assessment of the long-term value or "smartness" of one or the other policy response, be it based on additional public expenditure or explicit exemption from cuts. Among the positive side-effects from budget cuts on national STI governance are seemingly more coherent funding efforts (meaning less fragmentation) in a few countries (G7). Anyhow, some country correspondents have raised

[11] In general, very little information on specific consolidation efforts was documented in CRs.

concerns on competition for funding expected to shift towards "fast cash" measures, at least in crisis times (G5).

3.3 Efficiency of public support

This section analyses the efficiency of public support with respect to knowledge triangle policies, advancement in evaluation practices and policy responses shaping the quality of the knowledge base. Review of country groups suggests that all three side of the knowledge triangle of STI policies are/have been high priorities on STI agendas in the last couple of years and seem heavily interlinked.

Knowledge triangle policies are in place across all country groups. With an increasing policy emphasis on value for public money invested and efficiency concerns in R&D expenditure, national sets of measures in place have been continuously broadened in the last couple of years, complementing "traditional" cluster and intermediary KT policies, with the exception of G6&8. Newly introduced measures have thus either targeted specific actors (such as SME or entrepreneurs, as in G2&3), have focused on downstream or close-to-market development stages of R&D activity or mobility schemes (G3&7), frequently co-existing with complementary policy goals such as regional development or being part of general collaborative research support schemes (G2&3). However, the overall performance of new and existing measures can be considered as insufficient. Thus, KT policies have been subject to further refinement and experimentation in most groups.

The broad evidence from country reports for G4-8 countries indicates that the performance of KT policies can suffer from structural features of national economies and, thus, systemic failure. In service-dominated economies such as those in G4, KT activities and collaborative outcomes in many cases result in consultancy rather than research output, while in G5-8 business responsiveness to KT policies is low (mainly due to the limited absorptive capacity of businesses). Private demand failure is not or little targeted by modified instruments, e.g. SME-targeted ones, in some country groups (G7). At the same time, in other countries, this has been addressed by specific measures but has proven inefficient (G4) to overcome structural features of economies. In many places systemic failure is embedded as it is complemented by low HEI responsiveness to KT policies (with some exception, G5 countries).

Some of these policies have been fine-tuned or coincide with EU level initiatives (e.g., structural funds), likely due either to funding requirements or to profit-seeking behaviour among MS (G5&8). The process of KT policy establishment and expansion may be perceived as having improved coherence and coordination among STI policy domains, and, thus, for overall STI governance in many countries (G4&6). Interestingly, in a few countries (namely, G3&5) overall funding allocation (ex ante) has been altered towards applied science institutions with the purposes of empowering technology transfer (ex post). In addition, trends in the levels of competitive funding superseding institutional funding in some country groups may have enhanced overall budgetary scope and potential impact of KT policies (G4) while limiting the latter where no such trends existed (G7) or where STI governance was weak (G8). Funding re-allocation in favour of KT-prone applied science was less frequently accompanied by creation of new applied science research institutions (G3). However, in other groups given institutional arrangements i.e. the public research "landscape", was perceived as satisfying with respect to KT policy goals (G2). Furthermore, some country reports, namely in G2&7, document an inherent policy trade-off between excellence-driven science initiatives and success of knowledge transfer policies and their likely countervailing incentives for public researchers.

In all the groups, policy measures are implemented with the aim to enhance the link between science and business world and to stimulate industry driven and results driven research. Nevertheless, the effects are limited, although the reasons behind it are different among country groups. While in G1, there is an inadequate return on public investments in R&D (high inputs and low output), in G6-G8 the public push occasionally changed into substitution effect (the public investment in private R&D replacing the private one) and/or into minimal results due to the limited absorptive capacity from industrial sector. In G5-G8, the measures targeted to increase the RTD potential in the business sector did not find an adequate response, given the prevalence of traditional industrial sectors in the economic landscape and occasionally the administrative burdens. In these countries, most enterprises tend to concentrate on low added value activities, the role of the business community remaining marginal. The financial crisis has further deteriorated an already unfavourable context: contraction of revenues, reduced bank liquidity and negative business expectations discourage firms from risky investments.

Currently, in G6-G8 countries, the macroeconomic situation, the structure of the economy, the overall framework conditions for R&D have very unfavourable impacts on RTDI activities of firms. The STI policy cannot counterbalance these effects and it is unlikely that R&D investment targets can be achieved simply by providing more public funding.

In G6-G8 policy risks are also related to the implementation process. While in few of these countries, a fairly good RDI policy is in place, the well established institutional routines, habits and customs, the design of ministries, agencies and policy mechanisms may make difficult to implement effective the RDI policy.

G2&3 and some exceptional countries in G5 deal with maintenance of scientific excellence Most other country groups evidence more or less pronounced efforts to improve the overall quality and performance of their science system (G5-8). This includes efforts on advancements in evaluation practices and new, related institutional arrangements and undergoing reforms, being largely perceived as a minimum requirement/milestone to further knowledge base enhancement. Evaluation culture is, however, already well developed in country groups 1-4; in some instances, quality of the science base is arguably under threat even there as trends in funding favour competitive money (G4). Countries with lower levels of evaluation culture are oftentimes improving their practices foremost regarding competitive money and to some extent also institutional/block funding requirements (G5,7&8), frequently facing stakeholder resistance, lobbying efforts (upon implementation) and, hence, delayed implementation. High monitoring and evaluation requirements related to EU funding seem to leverage national efforts to a certain degree, both in quality of the knowledge base as well as evaluation practice. However, many countries where evaluation culture is already relatively advanced continue on a learning track expanding practices with respect to systemic evaluation approaches and assessment of STI governance performance.

3.4 Framework conditions for business R&D and innovation

This section focuses on two specific aspects of framework conditions for innovation.[12] On one hand, these include adjusted conditions for an enhanced (access to) finance for R&D, in

[12] Please note and consider that some of the country groups also highlight and discuss other aspects of framework policies, e.g. human resources related ones, in related sections of the Annex.

particular SME and entrepreneurs, as well as provision of incentives to capital providers. On the other hand, they include the role of demand-side public procurement.

There is little evidence on innovative public procurement across all country groups, if any, policy responses being only at exploratory stages and mostly not ranking high on STI agendas. Policies are mostly nonexistent in G8 or, as in G6&7, are at very preliminary stages, with a one-off, marginal character. Countries within G5 show a heterogeneous picture of patterns observed in G6-8. In contrast, policies in G1-3 are developing more rapidly (even though mostly missing out an explicit procurement strategy on national level); however, some countries recently have experienced changes in legal framework conditions for public procurement in favour of innovation, awaiting first impact assessments. Furthermore, informational stages of procurement policy in these country groups highlight staff training initiatives or best practices exchange, while at even more advanced implementation stages, pilot phases and shared planning actions/coherent strategy among procuring agencies have been launched.

Independent of the level of elaboration of innovation procurement policies, national policy trends oftentimes are triggered/leveraged by EU level initiatives (G3&5). Similarly, a focus on SME actors, high-tech-sectors, and/or on themes is frequently observed, again, independent from stages of policy developments, this seemingly making procurement policies a vehicle likely serving other (than demand-side ones) policy goals/purposes at the same time.

As EW country reports document, the access to finance is perceived as a major structural weakness/challenge of most economies. The only exception is the UK in G3 having one of the largest risk and venture capital markets in the world. Even when favourable conditions of access are in place, as is the case in G4, this seems to remain a weakness. Thus, in all other countries and country groups, policies try tackling the issue but with relatively very little efforts dedicated. These include (among others):

- Specific measures improving tax regulations for SME's R&D as well as enhancing the financing of SMEs with equity capital (G2).
- Tax exemptions/reductions to academic institutions (G6), individual researchers and/or multinationals (G7), while tax incentives for risk capital providers such business angel investments are not or only very randomly observed across all these groups.
- Other, financial means such as bank guarantees (in order to get eligible for loans) and/or direct granting of credits, mostly arising in the recent crisis context (G7&8).
- Again, due to the crisis, most countries have established (newly or additional) public and/or private, risk capital funds, oftentimes with a focus on high-growth actors and/or in high-tech or high-priority fields (G3&5&7).

Where in existence, R&D tax or guarantee scheme incentives in some countries (namely, G6&8) suffer from administrative burdens of overall tax system, over-selectiveness of instruments, business non-response or incentives not unfolding, e.g., as corporate tax is already very low.

In general, information given in country reports relevant to this section is most scarce as compared to the one documented in the all of the above/other policy response sections. E.g., information on public procurement towards innovation is completely missing on countries in G4.

Interestingly, some entrepreneurial policy mixes target entrepreneurs as well as their financers, whereby coherent approaches seem more effective than other, singular ones (G5). The same may hold for entrepreneurial policies that comprehend establishment of public-private fund structures.

4 Conclusions

An assessment of policy responses *based on national challenges*[13] suggests that, firstly, KT policies responded in most groups but oftentimes in an inadequate fashion, sometimes policy aspirations and challenges themselves being misled or misperceived in the first place, leading to systemic failure. Secondly, a variety of responses to the financial and economic crisis are fortifying the role of STI (and related budget shares) in governments across EU. However, the *de facto* impact of the crisis as well as the outcome from recent policy response are rather difficult to assess presently. Thirdly, with respect to finance and public procurement framework conditions for innovation, instruments and incentive schemes are still perceived as insufficient, even though some modification and expansion of policies were observed during the crisis.

Sections 4.1 and 4.2 elaborate in further detail on the various policy implications for future work on the Common Strategic Framework as well as on the Innovation Union Flagship Initiative, respectively.

4.1 Conclusions relevant to the Common Strategic Framework

Does inclusion of grand challenges to the next generation FP generate EU added value? The synthesis documents (in particular, section 3.1) that there are different capabilities in articulation among MS in procedural terms of setting societal priorities. This suggests that MS more or less successfully integrate all relevant stakeholders and priority implementation is largely dependent on general performance of STI governance. In some MS policies are bottom-up, indirect or dominantly institutional in terms of funding allocation, leaving thematic priority framework-setting exercises unlikely to be fully/fast implemented or even to emerge. However, if national frameworks exist, *themes are seemingly converging across many country groups* (among others, e.g. towards green tech). In other words, national challenges on society, given national stakeholder opinions are neatly reflected, oftentimes coincide with *unique* European ones.

In this way, multiple national research efforts make breakthrough results in short-term more likely, but may also cause inefficiency due to duplicative research efforts among MS, if not adequately balanced by EU coordination and exchange mechanisms, e.g., by enhanced knowledge and technology transfer between MS in the specific fields of European societal challenges. Thus, a re-focus within collaborative FP's support schemes *on these fields* in and across science and industry domains may create EU value added. This would also benefit specific MS that have not fully succeeded in national coordination on and/or implementation of societal challenges (as long as it does not largely interfere with potential STI governance learning from national setting-exercises). Alternative EU-level policy responses further

[13] Please note furthermore that some policies questioned in the challenges section are not touched in response sections by original definition of the brief's scope, e.g. migration/mobility policies as response to brain drain.

comprehend: a) an expansion of existing or creation of new measures that *further promote cross-boarder KT activities*, e.g. adjust FP funding accordingly or encourage smart national funding schemes for HEIs/PROs in one MS and exploitation and market introduction of research output in another, national roles depending on national competitive advantage in cross-boarder knowledge triangles, and, b) *ex ante re-allocation of institutional funding* to applied science institutions and/or establishment of the latter type of institution within ERA.

However, policy effectiveness of a potential CSF alignment to societal challenges by refocusing EU level KT policies may be doomed to fail or favour more advanced countries (in terms of business capacity and science base quality) as evidence on structural features of economies and on weak performance of the science base in some country groups in section 3.3 suggests. As national KT policies are largely undergoing modification and oftentimes not delivering sufficient results as not adequately timed and adjusted to present structural features of economies and other policies relevant to structural change one should be cautious with any such alignment. Unfortunately, the initialization of KT policies by EU funding schemes as documented by some country correspondents may have led national STI policies on inefficient policy tracks in the first place. In this way, a non-differentiated CSF alignment may further encourage such misleading *national policy tracks that underrate the role of the science base as well as absorptive capacity of businesses* in these countries. Furthermore, e.g., an integration of the R&D related measures of CIP into CSF may be a useful, synergetic approach as long as it lends additional support to overcome systemic failure highlighted in some country groups and resulting patterns of national participation in EU schemes.

In addition, as observed on various national levels and documented, again, in section 3.3, the potential *policy trade-off between excellence-driven science aspects and KT aspects* (of CSF and/or national support schemes) and their likely countervailing incentives for public researchers should be treated with cautiousness when reshaping the next FP's design.

4.2 Conclusions relevant to the Innovation Union Flagship Initiative

As instruments and incentive schemes associated with finance and public procurement of innovation are still perceived as insufficient (or inexistent) as documented in section 3.4, this, naturally, calls for policy action on EU levels, in particular with respect to the Innovation Union Flagship Initiative.

What are the main fiscal effects emerging from the crisis? Firstly, *the role of publicly funded R&D seems to have increased in relative importance* - compared to business R&D spending and/or other than R&D public spending priorities - across many country groups, and, more generally, there is an *increased role of EU funding schemes for stability* (not necessarily sustainability) of national R&D budgets. Secondly, tax and risk capital related policies targeting the financing of innovation and entrepreneurship have experienced a certain boom due to the crisis, this making *governments more willing to temporarily share risks* with businesses.

The first effect may contribute to further advancements in evaluation culture, science-based policy-making and overall competitiveness/quality of the science base on national levels, expecting a *positive leverage from increased participation (and requirements of) EU funding schemes*. In any case, given SF and/or CIP R&D related measures may not fully be aligned with policy goals of the Innovation Union Initiative it is now high-time to fine-tune these efforts as one would expect a high impact of EU level adjustments on national innovation and policy domains across many country groups, e.g. by securing continuous access to finance in early growth stages of businesses. The second effect suggests that EU level initiatives, e.g., with respect to *thematic coordination, EU buy-in or opening-up of newly established or existing, national public and/or public-private risk capital funds* are likely to help to return European economies on a positive growth path as well as foster structural changes within MS economies. Furthermore, an Innovation Union framework-setting that encourages *more coherent entrepreneurial policy mixes* that target entrepreneurs as well as their financers may support latter changes. In addition, given less risk-averse government policies, there might be a need to mutually learn on public risk management in the aftermath of the crisis.

Will the Innovation Union benefit from innovation procurement initiatives? With respect to public procurement policies country reports document inexistence or only developing stages, i.e. demand-side policies ranking low in STI agendas of MS. Again, this may set the ground for EU level framework-setting and complementary intervention with EU added value. However, when looking at the evidence, continuous coordination and extensive information exchange among stakeholders, i.e. all procuring agencies on regional, national and international level, seems to be the key obstacle in overcoming the inherent principle-agent problem of innovation procurement when it comes to implementation. Concepts, be they triggered on national or EU level, are likely to fail if they miss out a *coherent, joint strategy and regulatory reforms of procurement* including all procuring levels that does not account for risk aversion of public service agents responsible for spending of tax-collected money. Even though, an explicit, overarching procurement strategy (given the experience from e.g. EU's lead market initiative) on EU level may add a level of governance and, hence, may increase overall coordination needs, *collective efforts of limited national public budgets and priority dedicated to procurement create critical mass* of such activities and, thus, likely EU added value. Such an approach may be complemented with a thematic focus on joint EU grand challenges, e.g., green innovation procurement.

Appendices

Appendix 1

Country Group 1 - Challenges and policy responses

Denmark, Finland, Sweden

1.0 Main challenges confronting national R&I systems

1.1 Denmark

- The main barriers for private R&D investments are capital shortages and increased unemployment (from 3.3% in 2008 to 6.0% in 2009), both consequences of the financial crisis;
- There is still a significant need to improve the research infrastructure;
- The list of prioritised R&D areas still seems very diverse and difficult to accomplish;
- Establishing a risk capital fund remains a vital step for helping new start-ups.

1.2 Finland

- Many new instruments have been introduced during the past decade by a various public actors, causing the system to become too complex to access and administer;
- There is no clear focus on thematic priorities;
- Better coordination between various instruments that promote business R&D investment is still needed;
- University reform may have negative impact on research funding in the short term;
- Large number of non-innovative firms;
- Research programmes may be too academic and policy programmes are too fragmented to be able to address societal problems.

1.3 Sweden

- There is no formal and obligatory arena for coordination between the research and innovation policies;
- The 'Swedish Paradox' concept is still relevant: inadequate return on public investments in R&D (high inputs and low output = low productivity);
- Some evaluations point to imbalances in the Swedish system, such as the focus on 'knowledge creation' rather than 'value creation';
- Sweden's economic growth and resilience to the financial crisis will most likely have a positive effect on further public investments in research. Yet, the nominal BERD decreased during the crisis;
- Most R&D has been performed by large companies (MNC) and to a lesser extent by SMEs. The crisis is more likely to negatively affect R&D investment from SMEs, which will further impair the level of research activities. On the other hand, increasing globalisation and competition promoted MNCs to reallocate their R&D investments abroad;
- The entrepreneurial climate in Sweden remains relatively poor in comparison with many other European countries: Sweden ranks in the lower half of the Global Entrepreneurship index;

- There is lack of venture capital of in the earlier stages of the innovation process.

1.4 Intra-group similarities and differences

- All these Scandinavian economies have come rather well out of the economic crisis. However, due to receding markets, companies are expected to act somewhat cautiously for a while, which will probably result in further decreasing R&D investment from industry. Governments can choose to compensate for these losses and allocate funding to industry and stimulate inter-sector collaborations;
- Overall high level of public R&D expenditure, which is minimally affected by the crisis due to long-term planning;
- The working conditions for researchers are attractive in all of these countries: a flexible labour market and a small remuneration gap between men and women;
- There is some concern that the Scandinavian researchers may be reluctant to share their resources with foreign colleagues as long as the R&D support in other countries do not have similar standards as the national ones;
- The rate of unemployment has generally increased during the crisis. Decreasing number of science and technology (S&T) graduates. The shortage of highly skilled labour is critical for growth in high-tech sectors.
- In Sweden, R&D investments are mainly concentrated in the largest companies. Sweden has a relatively low level of R&D in SMEs compared to a high level of collaboration between the public and SMEs sector in Finland; in Denmark the share of R&D expenditures by SMEs is relatively high: 29% of R&D expenditure in 2005 came from SMEs.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

2.1.1 Denmark

In 2008, research financed by general university funds (GUF) accounted for the main share of Denmark's GBAORD (43%), while the second largest socio-economic objective was 'non-oriented research'. Research on human health (7.6% of GBAORD), agricultural production and technology (3.8%), industry production (10%), energy (3.9%), and the environment (2.5%) are high priority for the current Danish R&D financing, the last two showing a clear increase during the last 4 years.

Thematic S&T priorities are implemented by different R&D funding institutions, such as the different programme committees from the Danish Council for Strategic Research (DCSR) or the Danish National Advanced Technology Foundation. The DCSR supports strategic and policy-oriented research, financing programmes focused on the following thematic priorities: sustainable energy production and use; food, nutrition and health; nanotechnology, biotechnology and ICT. Energy and climate challenges are addressed by the energy policy agreement and the Climate Adaptation Strategy that covers the 2008-2011 period and foresees several new R&D funding areas: i.e. an annual fund of EUR4.7m for R&D on electric cars and EUR3.4m on solar power. Cooperation with Asian countries, such as Japan, China and India focuses on life sciences and biotechnology, while the research collaboration in the Nordic region focuses on food safety, environment and renewable energy, all connected to grand challenges.

In order to further increase funding for thematic areas of relevance to the Danish society, the Ministry of Science, Technology and Innovation organised a broad process to identify the strategic knowledge demands. As a result a catalogue of strategic research priorities was developed in 2008, named FORSK2015. The document identifies 21 strategic research fields distributed over six key research areas: energy, climate and environment; production and technology; health and prevention; innovation and competitiveness; knowledge and education; and, people and society.

2.1.2 *Finland*

There are several general scientific priorities mentioned in various policy documents although there is no document which outlines the national thematic priority areas in a strategic and coordinated way. In 2006, the Development Plan for Education and Research Policy which defines the strategic plan for R&D identified the following priority research areas: bio and nano-fields, new materials, knowledge-intensive services, and forest, metal and ICT industries, adding the last three to the main sectors requiring "sufficient knowledge" in 2008. Various individual initiatives and organisational strategy documents define thematic areas in a more detailed way. Tekes, in particular, has defined nine R&D priority clusters: ICT, metal, forest, well-being, chemical and bio, environmental, energy, real estate and construction, and food. In 2006, the decision to establish Strategic Centres for Science, Technology and Innovation (SHOK) reinforced prioritising funding for these large thematic clusters. In addition, various ministries have their own research programmes, targeting relevant specialisations. The research programmes funded by the Academy of Finland and many of the bilateral research programmes (including Nordic activities) address major societal challenges.

As a response to the lack of clear strategic priority areas, the Ministry of Employment and the Economy launched an extensive evaluation of the national innovation system, aiming to identify the major drivers of change in the system and assess how well they are addressed in the innovation policy. One specific focus area in the evaluation was "demand and user orientation", which is emphasised in the National Innovation Strategy. Another important dimension was "Education, research and the economy", which addresses the capabilities of education and research to meet the needs of the economy. Another positive development (2008) was the Impact Framework and Indicators for Science, Technology and Innovation (VINDI), a project by the Academy of Finland and Tekes, which aimed to create an impact framework of effectiveness of science, technology and innovation, identifying the changes in knowledge and expertise in Finland.

2.1.3 *Sweden*

A number of research areas were identified as strategic priorities for partnership programmes between public and private sectors. In the latest policy bill, *A Boost to Research and Innovation Prop. 2008/09:50*, three strategic areas are mentioned: medicine, technology and climate change. These areas were selected using three guiding criteria: research that can help find solutions to important global challenges; areas in which Sweden is already conducting world-class research; areas where companies in Sweden are already conducting research. The R&D thematic priorities reflect global challenges, for example the climate change related topics being especially prioritised and receiving an increase of EUR33m from 2009 to 2012.

2.1.4 *Intra-group similarities and differences*

- All the three countries show strong political will to foster further development of the knowledge-driven economy, trying to identify strategic R&D areas for intervention; Denmark and Sweden have well defined thematic S&T priorities, addressing the grand challenges to a large extent. Specific programmes are designed and increased R&D budgets are devoted to these grand challenges. However, Finland's R&D thematic spending is not coherently and explicitly coordinated, yet recent policy developments aim to systemically respond to this weakness. An important strength of the Swedish system is the fact that economic specialisation and industrial needs coincide with the public system's research focus.

2.2 Smart fiscal consolidation

2.2.1 Denmark

Exhibit 1 Denmark – Basic statistics

Denmark	2006	2007	2008	2009	EU average 2008
GDP growth rate	3.4	1.6	-1.1		0.5
R&D intensity (GERD as % of GDP)	2.48	2.58	2.87	3.02 (e)	1.92
GERD per capita (EUR per inhabitant)	998.5	1064.6	1157.5	1218.4 (e)	476.2
GBAORD as % of GDP	0.72	0.79	0.85		0.71
Business sector R&D intensity	1.66	1.58	1.91	1.82	1.21

In 2008, Denmark's GERD was 2.87% of GDP and the estimated value for 2009 rose to 3.02%.

Securing long-term investments in R&D has been one of the priorities of the Danish National Reform Programme and its Globalisation Strategy. According to Denmark's National Reform Programme (2008) the public R&D investments shall reach 1% of GDP in 2010. The private sector is expected to provide 2% of GDP. The public budget for R&D increased in nominal value from EUR2.242bn (2008) to EUR2.375bn (2009), reaching the 1% public R&D expenditure target.

2.2.2 Finland

Exhibit 2 Finland – Basic statistics

Finland	2006	2007	2008	2009	EU average 2008
GDP growth rate	8.5	10.5	5.8		0.5
R&D intensity (GERD as % of GDP)	3.48	3.47	3.72	3.96	1.92
GERD per capita	1096.2	1183	1296.3		476.2
GBAORD as % of GDP	0.33	0.29	0.3		0.71
Business sector R&D intensity	2.31	2.37	2.62	2.7	1.05

In 2009, Finland was the EU country that invested most in R&D relative to its GDP. In the same year, in terms of euro spent per capita, overtook Sweden. Since Finland has already been above the 3% GERD target for a long time, a new target of 4% was set in 2008. The worsening economic situation has actually helped Finland towards achieving the R&D investment objectives since the decrease in GDP has been higher than the decrease in total R&D spending. In 2009 the R&D expenditure intensity reached 3.96%, but it was estimated to decrease to 3.90% in 2010.

Nominal public sector R&D spending continued to increase during the economic crisis. In the last 5 years, BERD fluctuated but remained above EU level, showing 8.5% growth from 2004 to 2008. Although the nominal BERD decreased in 2009, the relative share of BERD increased, due to the higher GDP decrease.

During late 2008, two key policy documents were published: the *National Innovation Strategy* and the Science and Technology Policy Council (nowadays Research and Innovation Council) strategy document *Review 2008*. They specifically addressed the need for providing resources for research as a means to increase competitiveness and welfare. Both strategy documents follow the guidelines and targets set earlier in the government programme to secure long term investments in research. *Review 2008* states that public R&D funding should be increased significantly (40%) by 2011.

2.2.3 *Sweden*

Exhibit 3 Sweden – Basic statistics

Sweden	2006	2007	2008	2009	EU average 2008
GDP growth rate	4.3	3.3	-0.4		0.5
R&D intensity (GERD as % of GDP)	3.68	3.4	3.7	3.62	1.92
GERD per capita	1295.5	1310.3	1341.0		476.2
GBAORD as % of GDP	0.5	0.81	0.81		0.71
Business sector R&D intensity	2.79	2.66	2.78		1.21

In 2008, the total R&D expenditure amounted to 3.7% of GDP. However, in contrast to many other countries, the volume of R&D investment has decreased in recent years from a peak of 4.13% in 2001. The decrease was triggered by a BERD decrease: from 2.81% in 2005 to 2.65% in 2007, while the public spending continued to increase.

Every electoral period, the Government presents a research bill, setting the framework for government-funded research for the coming four years. In the latest bill *A boost to research and innovation*, the Government announced a successive increase of public R&D funds (of EUR463m) during 2009-2012 therefore reaching the 1% public R&D expenditure target. An interesting measure to secure long-term investment in research is publicly funding strong centres of excellence, committing funds for a 10-year period.

2.2.4 *Intra-group similarities and differences*

- In all of these countries the R&D intensity is above the EU average. Denmark with a GERD of 2.87% in 2008, is well above the EU-27 average, but considerably lower than the two other Nordic countries: Sweden (3.7 % of GDP) and Finland (3.72 %). However the estimated value for 2009 indicates that Denmark also reached the 3% target, while Finland clearly overtakes Sweden.
- Sweden and Finland set the 4% R&D intensity as national target.
- Public R&D expenditures increased even during the crisis in all these countries. In 2009, in Sweden, the total R&D intensity fell mainly due to the BERD decrease, caused by MNCs relocating their R&D activities.
- R&D is prioritised in the political agenda in all of these countries, and there is consistency and coherency between political statements and actions.

2.3 Efficiency of public support

2.3.1 *Denmark*

The Danish research governance structure has changed since 2001, when the government embarked on a reform of the entire public RDI systems in order to enhance its efficiency. As an outcome, currently the research, higher education and innovation policies are fairly well coordinated, within one ministry (Ministry of Science, Technology and Innovation). In addition, this ministry is coordinating action in the field of innovation and entrepreneurship, along with other ministries.[14] The central governance of the national research and innovation system is effective and has improved considerably over the last few years, but the existence of a multitude of policy measures makes this task challenging.

An increasing trend of the competitive funding can be noticed in recent years. The share of competitive funding in universities was expected to constitute 50% of the total public research funding by 2010 at the latest. A new distribution model for core funding to the universities was reached in 2009 and is to be introduced stepwise over 2010-2012. Distribution for 2012 is planned as such: 45% education appropriations, 20% external R&D funding, 25% bibliometric indicators, and 10% number of PhD graduates. The most important competitive funding instruments are governed by two research councils which manage 11% of the Ministry of Science, Technology and Innovation's budget.

Denmark's publication output has clearly increased. When applying fractionized publication counts, Denmark's publication output has increased from 29.120 in the 1999-2003 to 32.448 in the 2004-2008. Compared with the world average, Danish scientific publications are highly concentrated in clinical medicine, biomedicine and agriculture. The Government's goal in terms of quality of research is that the quality of public research should be comparable with the best in the world. The implementation of the Norwegian bibliometric research indicators Norwegian model is meant to enhance the quality of research. In 2007, the fragmentation of the government sector was reduced dramatically due to most research institutes merging with the universities.

The policy portfolio addressing science-industry linkages and commercialisation of public research results has been at the centre of policy developments over recent years. The promotion of Promoting private-public R&D cooperation is covered by a broad range of measures, such as the establishment of the Renewal Fund and the start of Green Labs DK subsidy programme, to be run by the Ministry of Climate and Energy with a funding volume of EUR28.2m over the next three years. In 2010, a new initiative to strengthen entrepreneurial universities was launched.

One target for Danish innovation policy has been the commercialisation of public research that results in new, R&D intensive firms. In 2010, the Danish Ministry for Economic and Business Affairs decided that financial support to be given to Danish enterprises in 2011 would amount to EUR2.9bn, the main part of this financial support being given via tax measures (EUR1.7bn).

[14] Below the ministry level there are two subsystems: the advisory level (the Danish Council for Research Policy) and the funding subsystem consisting of three councils.

2.3.2 *Finland*

Finland has adopted a fairly centralised research policy planning and decision-making system consisting of four operational levels.[15] The systems show efficient cooperation and coordination between different actors involved. Education, research and innovation policies are closely tied to those affecting research and these different policies are increasingly considered as a whole in the policy making, forming a broad entity, called 'systemic approach' in official documents. The objectives to increase public R&D investments are closely connected to selected reforms and new measures such the university reform, the sectoral research reform, new research infrastructure policy (connected with ESFRI) as well creating Strategic Centres for Science, Technology and Innovation.

The institutional funding provided for universities and public research institutes amounts to 46% of the public sector R&D. Although, both Finnish universities and PROs have a large degree of autonomy in ensuring the academic research quality, the Academy of Finland performs evaluation of the whole research system every three years, the evaluation criteria mainly focusing on the publication outputs. The Academy is the main external funder of universities, the funding being based on open competition and independent peer review. The main competitive public funding instruments for RDI in Finland are the Tekes programmes. Recent R&D funding instruments are the Strategic Centres for Science, Technology and Innovation, which are managed collectively by industry, universities and research institutes.

Among OECD countries, Finland had the 4th highest publication number relative to GDP, ranked the 8th in terms of citation impact and is above average in terms of triadic patents per capita (OECD, 2008). Finnish research shows excellence particularly in social sciences and education, medicine, agriculture, environment, computer science, biology and biochemistry.

All Academy of Finland Research Programmes and Tekes Programmes are evaluated 1 or 2 years after programme completion and focus on the outputs of the research funded. One of the new policy initiatives to improve quality and excellence of knowledge production has been to widen the scope of the 'Finland Distinguished Professor Programme' (FiDiPro), which funds the recruitment of internationally renowned researchers into Finnish universities and research institutes. The promotion of excellence is not only limited to national policy but also includes a Nordic dimension. In 2008, the Nordic Ministers of Research approved a large-scale common Nordic initiative to promote cutting-edge research within climate, energy and the environment. The project, known as the Nordic Research Excellence Initiative, was launched in early 2009 with a budget of about DKK350m (about EUR50m) over the next five years.

The percentages of HERD (7.2%) and GovERD (14.2%) financed by business sectors are much higher than the EU-27 average. These figures imply that university-business R&D linkages and public research institute-business linkages are rather active compared to the rest of the EU. Since the beginning of the 1980s, the Tekes programmes have provided important venues for knowledge circulation, while starting special programmes in 1993, which have been dedicated to supporting commercialisation of research and academic spin-offs.

[15] The Parliament and the national government are responsible for decision making at the highest level. The key ministries with respect to research policy (Ministry of Education and Culture and the Ministry of Employment and the Economy) represent the second level. The cooperation has increased significantly between these two ministries in issues related to science and innovation. The third level consists of the R&D funding agencies such as the Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation. The fourth level includes research organisations.

Another important venue for improved collaboration between public and private R&D sectors are the research services and technology transfer organisations (TTO) of Finnish universities, that offer counselling about IPR issues and help academic staff find suitable partners or service providers. Co-founded professorships with the business sector are also improving the academia-business collaboration. Private enterprises participate in defining the research area of a professorship and totally or partially provide its funding. In 2005, there were 189 externally funded professorships at Finnish universities. The private sector is also become increasingly involved in HEI governance and has a substantial representation in PROs. The collaboration between PROs and universities is also relatively common in research projects.

The main support for R&D activities in Finnish SMEs is provided via Tekes funding. In 2000-2007, more than 50% of Tekes funding was allocated to SMEs (Tekes, 2008). Although much of the funds are directly allocated to in-house R&D activities, it is also typical that the support is directed at collaborative projects between universities and SMEs or SMEs buy research services from HEIs or PROs.

There are also various incubators activities in Finland, mainly maintained by various local and regional Science parks and Technology Centres. As opposed to some other countries, there has been no centralised funding model for the incubators in Finland, which have collected the funds from various sources through projects.

Despite these positive measures, it has been argued that more collaboration and joint structures in the 'interfaces' are needed to better meet the society needs.

2.3.3 *Sweden*

Sweden has a disparate governance system and, while policy formulation is carried out largely at a ministerial level, different agencies are responsible for designing and implementing individual policy instruments. The government ensures policy coordination at ministry level. At agency level, policy implementation is in principle dispersed and the coordination is carried out informally and on an ad hoc basis. No formal and obligatory arena for coordination exists in the area of research and innovation policy, the lack of comprehensive coordination being a recognised weakness. While the implementing bodies are fragmented, there is also a high level of independence from general policy makers. In general, decisions can be made faster. A response to this deficiency was the investigation undertaken in 2008, regarding the role of different implementing bodies and the results indicated that a new, coordinated agency should be established.

Nearly half (46.9%) of the Swedish HEIs' R&D funding is institutional. The rest is competitive funding from research councils, other government agencies, companies, municipalities, public research foundations, etc. Whether this constitutes an adequate balance is disputed, very much depending on perspective of the debating party, since monitoring and evaluation with international participation are well established practices. The strategic research areas are also subject to a monitoring approach common to government, funding agencies and universities.

The research carried out is of high quality, as demonstrated by a number of indicators. The main research performers are the universities, mainly carrying out basic research, and industry that performs applied research. Both actors are internationally recognised for performing excellent research. However, regardless the high R&D input, the number of triadic patents surprisingly steadily decreased from 2001 to 2005 (EUROSTAT). Consequently, the emphasis on innovation and commercialisation of research results increased, aiming to mitigate the impact of the 'Swedish paradox'[16] .

Various schemes suitably support all the six policy mix routes, having some emphasis on SMEs, not yet considered to be sufficient.

The main actors in the Swedish support system for innovative starts-ups and entrepreneurship are: the Innovation Bridge, VINNOVA, the Industrial Fund, University holding companies, Nutek and ALMI Business Partner. The *Tillväxtverket* (Swedish Agency for Economic and Regional Growth) is responsible for supporting entrepreneurship, start-ups and the development of SMEs and has a wide range of measures at its disposal, aimed at entrepreneurship and SMEs. Venture capital and advice are provided at different stages of the innovation process, and by providing incubator functions (the Innovation Bridge).

The financing (€6.9m) of 'Innovation offices' in universities is seen also as a viable measure to improve commercialisation of the outcomes of research and knowledge transfer. Other important policy instruments are centre of excellence programmes and the support of strong regional innovation milieu.

Low SME input represents a private R&D investment weakness in Sweden. At policy level, the majority of programmes and activities supporting collaborations between industry and academia are also aimed at SMEs. However, the number of activities specifically for SMEs and academia are few, and the issue has not been further addressed. Regardless of various policy measures, overall, the collaboration between public sector and SMEs remains insufficient.

2.3.4 *Intra-group similarities and differences*

- In Finland and Denmark the research, higher education and innovation policies are fairly well coordinated, while Sweden has a disparate governance system. Recent investigation reported that Sweden's S&D system governance may need reform, although the fragmentation of the implementing bodies may arguably imply a high level of independence from the general policy makers. All these countries show a high level of scientific output in terms of publication, yet a decreasing level of triadic patents. There has also been some concern that these publication figures are only the logical impact of high R&D input and do not necessarily imply that the research performed is of high quality. Conversely, the high publication figures are an indication that active publication is an established practice and that the international visibility of national publications is high. Concern is generated because R&D investments have not been converted into new innovations and jobs as expected, best expressed by the Swedish Paradox. The policy response to this was emphasis on innovation and commercialisation of research results. In all of these countries, the dominant funding mechanism, however decreasing, remains to be institutional funding. Given that all the countries have appropriate mechanisms in place to evaluate organisations and universities, it is arguable if reversed balance can further improve the excellence in research.

[16] High inputs and low output = low productivity. First formulated by Edquist/McKelvey in 1991. Then it was expressed in terms of a high R&D intensity in Sweden coupled with a low share of high-tech (R&D-inte4nseive products in manufacturing as compared to the other OECD countries.

- According to the figures (HERD and GovERD financed by private sector) the interaction between the business sector and public science is still fairly weak in Denmark and Sweden: private enterprises only finance the national public R&D to a minor degree. In Finland, the business sector plays a higher role in funding the R&D performed by the public sector. Support measures are in place to support the private-public research collaboration. Among the particularities, there is public-private co-funded professorship and high involvement of business sector in HEI and PRO governance in Finland, and low SME participation in R&D activities in Sweden.
- There is a need to further strengthen and develop interactions between research institutions and SMEs. This is a particular problem for Swedish R&D investments where most of the R&D funds come from a few MNCs. While most programmes and activities supporting collaborations between industry and academia are aimed at SMEs, there is still a need for SME-specific measures.

2.4 Framework conditions for business R&D and innovation

2.4.1 Denmark

The business enterprise sector is the main R&D performer, funded mainly by the business sector and performing 70% of total R&D in 2008. In 2006, Danish industry invested 1.66% of GDP in R&D, which further increased to 2.01% in 2008.

Denmark is one of the forerunners in user-driven innovation. The business environment is also quite open and competitive. Denmark has the top position in the Global Entrepreneurship and Development Index (GEDI) and is especially strong in the activity index although somewhat weaker in the aspiration index. The activity index shows Denmark's strengths lie in offering opportunities for start-ups and the quality of human resources.

The framework conditions for new R&D intensive firms have been addressed systematically. The Danish Enterprise and Construction Authority (EBST) is responsible for the general framework conditions for business activity and start-ups. Several new policy schemes for improved framework conditions were implemented in 2008, such as Proof of Concept, the Accelerace programme, the Gazelle Growth programme, the user-driven innovation programme, administered by the EBST. There is only one fiscal scheme which promotes research careers: the 25% Tax Scheme, addressing the taxation of the salaries of well-paid foreign researchers.

Improving human capital in Danish enterprises is essential, i.e. vocational and further education and lifelong learning. The HRST share in the economically active population aged 25-64, was 51.8% in 2009 compared to the EU-27 average of 40.1%. However, when analysing the field of education the picture seems less positive. The lower percentage of HRST that are qualified in science, mathematics and computing (5.4%, compared to 10% across the EU-27) and engineering, manufacturing and construction (16.8% compared to 18.6% in the EU) are consistent with concerns regarding the lack of engineers.

2.4.2 Finland

In the past decade, programmes were systematically issued by the successive governments and co-ordinated by the Ministry of Trade and Industry (now Ministry of Employment and the Economy [MEE]) aiming to support R&D performing firms in Finland (such as the Entrepreneurship project 2000-2003 and entrepreneurship policy programme 2003-2007). The government set up a new *Policy programme for employment, entrepreneurship and worklife*

(2007), which was designed to ensure commitment to jointly establish strategic goals and a Growth Enterprises group which has the responsibility for structuring, developing and implementing the growth enterprise policy.

Tekes and the Growth Company Service of Enterprise Finland provide funding instruments to support SMEs. Finnvera and its subsidiary VeraVenture, Finnish Industry Investment and regional TE-Centres all have instruments that support innovative start-ups. Public financing on equity terms is available from Finnvera plc, Sitra and Tekes. Seed financing is provided, by Seed Fund Vera Ltd and the Finnish Industry Investment, amongst others. Among new instruments is the new business accelerator programme, VIGO, for fast growing young companies.

In 2010, the MEE outlined an action plan and policy framework outlining the key elements of a demand and user-driven innovation policy. The action plan for 2010-2013 covers the action points that promote policy implementation in the private and public sectors. The development of public procurement is one of the themes in the action plan.

In 2009, the HRST was 50.7% of the economically active population aged between 25-64 years old in Finland, which was clearly higher than the EU-27 average of 40.1%. When looking at researchers in Finland, 59% of them worked in the private sector compared with 45% in the EU-27 (2007). The university sector has been considered too fragmented, while the HEI governance is thought to be facing challenges to respond to both regional and global needs. As response to these challenges, the legislation was revised (the new Universities Act, February 2009), with the aim of enhancing universities' autonomy, rendering them as autonomous legal entities, to ensure that they would be better placed to optimise their income from capital and to better supplement their basic financing with donations and business activities. This means that in addition to new investments made by the government (see above), the size of new investments depends on the amount of donations made to the universities by enterprises and other bodies.

2.4.3 *Sweden*

The 2008 BERD as a percentage of GDP was 2.78 % and increased compared to 2007 but was less than 2006. The industry accounts for 72% of the total R&D investment with the bulk being invested in intramural research. In Sweden, *Tillväxtverket* (Swedish Agency for Economic and Regional Growth) is responsible for supporting entrepreneurship, start-ups and the SME development. The agency has a wide range of measures at its disposal, which target entrepreneurship and SMEs. Another important actor supporting businesses is *ALMI Företagspartner*, a government-controlled organisation that aims to stimulate growth and development for SMEs and innovators by providing venture capital. ALMI's strengths lie in its long-term perspective "from idea to profitable business", providing support at different stages in the innovation process.

According to the recent Innovation Procurement Inquiry it is important to consider two parallel approaches to create better opportunities for innovation in public procurement: innovation-friendly procurement and innovation procurement. The report proposes the introduction of a new procurement law: a law on commercial procurement. The law is intended to serve as an optional tool for the contracting authorities or entities that would like to procure research and development services.

In recent years, there have been concerns regarding the low number of students studying natural sciences and engineering. Having this in view, in 2009, the government decided to invest EUR11.6m to improve the quality of mathematics, natural science and engineering teaching at pre-university level.

2.4.4 *Intra-group similarities and differences*

- The framework condition for private R&D is rather positive, although there is scope for improvement, particularly with regards policy initiatives focusing on SMEs (R&D programmes specifically for SMEs and providing venture capital).
- In Denmark, the low level of infrastructure investments can be seen as critical and has therefore been addressed in several policy measures in recent years.
- Another potential risk is the shortage of highly skilled personnel and the migration patterns of high-skilled experts that may not favour mobility towards Scandinavian countries (particularly Denmark).
- Innovation-oriented public procurement still plays quite a modest role but the public procurement development is high on the political agenda.

Appendix 2

Country Group 2 - Challenges and policy responses

Germany

1.0 Main challenges confronting the national R&I system

Germany has the largest research system in the EU in terms of R&D expenditure (GERD), increasing steadily in the last decade. While GERD was about EUR50.6bn in absolute terms in 2000, it rose to EUR66.5bn in 2008. As such, it contributes significantly to EU resource mobilisation, being responsible for roughly a quarter of aggregate EU-27 R&D expenditure in 2008. However, GERD's annual growth rates for this period have been below the EU-27 average for most years. R&D intensity (as a percentage of GDP) stood at 2.68% in 2008, which is significantly above the EU average of 1.92%. Between 2000 and 2008, this ratio was fairly stable, with a slight uptake in 2009.

Exhibit 1 Trends in GERD

Germany	2000	2008	2009	Variation of nominal GERD 2000-2008	Variation of nominal GERD 2008-2009
EU-27	1.86	1.92	2.01	38%	-1%
Germany	2.45	2.68	2.82	31%	2%

Among the most important country challenges:

- Private R&D demand continues to be dominated by (world-leading) medium-high tech manufacturing while the share of high-tech manufacturing in BERD is much lower than the EU average, and is also rather stable. As such, shortage of equity capital for companies and lack of highly qualified personnel may hinder structural change.
- Even though perceived as a valuable policy instrument of R&D funding, there are currently no R&D tax incentives complementing Germany's large portfolio of instruments.
- Institutional funding of universities is stagnating. As a matter of fact the focus on scientific excellence is limited to a small number of HEIs.
- Demand-side innovation policies such as public innovation-oriented procurement are underdeveloped.
- Governance on education policy requires complex policy coordination owing to split competences among federal states, limiting to some extent policy coherence and efficiency on national level. For example, there is no national road map setting research infrastructure priorities and autonomy of PROs and HEIs is still limited.
- In terms of human resources for scientific production, even though Germany is among the top-performing MS, education careers are separated fairly early, there is a relatively low percentage of students and graduates, and a low share of foreign researchers active in this country.

- Crisis-related stability policy and public deficit cuts put pressure on research, innovation and education policy budgets, so far being exempted from cuts on national level, but not on all federal levels. Please note that a fast economic recovery and continuous business R&D investment during times of crisis may eliminate the specific challenge in the middle-term.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

The 'High-tech Strategy 2020' is a stable and predictable STI policy framework, which identifies five key priority areas of research that are linked to global challenges, funding for a selected number of technology clusters, thematic innovation initiatives ('innovation alliances' to develop key technologies). It is subject to continuous monitoring and evaluation.

The strategy's key priority areas of research include: climate and energy, health and nutrition, mobility, security, and communication. Various fields of key technologies are linked to each area. In addition, cross-cutting activities are defined for financing innovation, promoting start-ups, standardisation, public procurement, and skills supporting research and innovation activities. An element of the 'High-tech Strategy 2020' is its mission-oriented approach (not being included in the first generation 'High-tech Strategy' published in 2006) based on a number of 'future projects'. These include research on energy efficient and climate-adapted urban areas, redesigning the energy supply system, renewable resources as an alternative to oil, individualised medicine for better therapies, better health through an optimised diet, living an independent life well into old age, electric vehicles, effective communication network protection, internet use while making it less energy consuming, making global knowledge digitally available and accessible, and working conditions in tomorrow's world. The 'future projects' form the starting point for content guidelines and innovative strategies to achieve the stated objectives, which include establishing citizen dialogue platforms on grand and societal challenges. Specific support programmes related to future projects will be defined and announced by the ministries at a later implementation stage.

Direct or indirect project funding provided on the basis of competitive applications for fixed-term projects offers grant aid to enterprises, public research institutions, and universities. About 92% is direct project funding, supporting very specific research areas within thematic R&D programmes, while indirect (i.e. horizontal) project funding aims to support research institutions and firms – in particular SMEs – in their R&D activities. Indirect project funding is independent of a specific research area, while direct funding focuses on areas such as ICT, life sciences, micro-systems, nanotechnology, optical technologies, materials and production technologies, energy and sustainable development. Total federal expenditure on R&D project funding[17] was EUR5.0bn in 2008 of which the vast majority (EUR4.6bn) is allocated using thematic funding programmes. Most of the R&D programmes in Germany favour the support of cooperation, mainly between public (or private) research institutions/HEIs and companies.

[17] Most of the Ministry of Education and Research funding is provided by thematic programmes with a more or less narrow definition of the respective field of activities while, on the other hand, the Ministry of the Economy clearly favours horizontal approaches. However, none of these key funding agencies can be exclusively committed to one approach or the other.

2.2 Smart fiscal consolidation

Smart fiscal consolidation in Germany comprehends fiscal policy response in the context of the economic and financial crisis recovery as well as general funding measures and related criteria aiming at excellence and quality in scientific production. Despite the crisis, the federal government expenditure on R&D increased from EUR10.9bn in 2008 to EUR12.1b in 2009, and a rise to EUR12.7bn was predicted for 2010.

The second economic recovery programme was (partly) directed towards supporting private R&D. EUR500m were made available within the programme for research on electro-mobility and EUR8.7bn for investments in education and science to increase the education and research infrastructure in schools, universities, etc. Overall, emphasis was put on replacement investments (92% of the planned expenditures) while only 8% is spent on growth-promoting investments such as new laboratories, media facilities, or up-grading further training structures. By and large, German economic recovery programmes were successful in mitigating the effects of the short-term drop in demand caused by the crisis. However, in terms of investments in education and technology, the German measures were only given a middle ranking out of the ten national programmes as investigated by the Boston Consulting Group (EFI, 2010).

Supporting quality and excellence of knowledge production is a key objective of federal research policy and has a long-term tradition. Germany has a good reputation for producing new scientific knowledge and is able to adapt to progress within established scientific fields or to combine them to create new knowledge. Policy measures related to quality and excellence address universities and PROs and the business sector, including among other:

- Thematic R&D funding based on multi-annual framework programmes and regular calls for tender;
- The ‘Initiative for Excellence’ is the instrument towards scientific excellence at HEIs, as there is no tradition of elite universities, such as in the USA or France;
- The ‘Pact for Research and Innovation’ fosters research excellence in PROs in exchange for government's commitment to increased funding;
- ‘Clusters of Excellence’ programme focuses on regional clusters involving cutting-edge technologies.

Excellence in research is further encouraged by regular evaluations of PROs and HEIs. Funding of research projects is generally based on peer-review and quality criteria.

2.3 Efficiency of public support

Efficiency in terms of bridging publicly-funded, scientific knowledge to the marketplace has been among the top priorities of STI policies in the last decades, knowledge exchange between industry and science being regarded as one of the strengths of Germany’s innovation system. At first sight, close ties between businesses and academia are revealed by the high share of industry-funded research in universities and PROs. This is complemented by considerable regulatory efforts, including (among others):

- Knowledge triangle and cooperation-orientated, thematic R&D programmes, personnel mobility and exchange programmes, as well as funding programmes focusing on SMEs and SME R&D consulting vouchers, on federal and federal states level;

- Additional funding incentives to set up and strengthen cooperation between universities, PROs and industry on a long-term basis, provided by the 'Clusters of Excellence' programme;
- Specialisation of institutions within the science system: technology transfer and applied science-orientated PROs, technical universities and universities of applied sciences supply industry with highly skilled personnel and applied research results;
- Academic entrepreneurship programme on federal level including public financing schemes for high-tech start-ups.

Efforts to further cultivate knowledge exchange are undermined to some extent by the increasing focus on scientific excellence. Since additional funds for public research are primarily available for increasing research excellence, there is a shift towards basic research while knowledge and technology transfer activities tend to receive less attention, in particular in the HEI context. Although funding of other activities remains unchanged by the current initiatives to increase scientific excellence, the time budgets of top scientists, being the most attractive partners for industry, are limited, and an increasing share of time has to be allocated to manage activities related to excellence initiatives.

Public, innovation-orientated procurement is regarded as an alternative, demand-side means on leveraging innovation by increased effectiveness of German public spending. Even though these efforts seem to be to some extent in a preparatory phase and still underdeveloped (missing out a strategy) compared to other countries such as the UK, procurement of innovative products has increased, in particular with respect to energy efficiency. Furthermore, in 2009, the legal framework conditions have been modified in such a way that public authorities can also request innovative aspects apart from social and environmental aspects in the service specifications.

2.4 Framework conditions for business R&D and innovation

Recent measures focused more on creating a favourable regulative environment that stimulates start-up activities modifying framework conditions for private equity. The latter aim at improving tax regulations for investing into young technology companies and the financial situation of business angels as well as enhancing the financing of SMEs with equity capital by loosening the existing provisions and by adapting them more efficiently to practical needs. However, the availability of venture capital is constrained by general corporate tax legislation and has been assessed as still being too restrictive in its provisions to allow for substantial improvements as only 0.04% of GDP is used for venture capital investments.

Appendix 3

Country Group 3 - Challenges and policy responses

Belgium, UK, France and Austria

1.0 Main challenges confronting national R&I systems

Within the clustered group of countries with “high knowledge capacity systems and mixed economic structures”, at the turn of the century, all countries started off on very similar levels in terms of R&D expenditure (GERD) per GDP. While Belgium and France performed on EU averages in the last decade with only minor fluctuations, the UK and Austria significantly over-performed in comparison to most other EU MS. This is particularly true for Austria which experienced growth rates of nominal GERD twice as high as the EU average, catching up with innovation leaders among EU MS in this respect. Most recent developments (2008-2009) in the context of the financial and economic crisis, suggest weakly increasing GERD ratios in France and the UK, while they are stagnating or losing ground elsewhere, the latter being in line with current EU average.

Exhibit 1 Trends in GERD

	2000	2008	2009	Variation of nominal GERD 2000-2008	Variation of nominal GERD 2008-2009
EU-27	1.86	1.92	2.01	38%	-1%
Belgium	1.97	1.96	1.96	36%	-2%
UK	1.81	1.77	1.87	45%	2%
France	2.15	2.11	2.21	33%	3%
Austria	1.94	2.67	2.75	88%	+/-0%

1.1 Belgium

Some of the most important challenges for Belgium are:

- Fragmentation of STI governance due to institutional/regional fragmentation in research and innovation policy practice accompanied by political instability in the country, putting R&D in private and public sectors at risk (in addition to crisis effects and historically high public debt). To some extent policy coherence is missing and not fully compensated by horizontal efforts of STI actors.
- Strong dependency of national R&D activities on a small number of foreign-owned businesses while tax burden and relatively high R&D labour costs make research conduct in Belgium less attractive.
- Limited interaction between SMEs and universities despite policy efforts in the knowledge triangle.
- Low competitiveness of salaries for researchers and insufficient number of internationally prestigious research infrastructures.
- Deficits in life-long learning activities and a relative low share of S&T graduates leading to a skills mismatch.

1.2 UK

Some of the most important challenges for the UK are:

- Limited intensity of innovation activity in enterprises;
- Missing linkages between the public research base and business;
- Mismatched future skills and a limited supply of high quality labour while safeguarding the public research base's high quality in terms of output excellence;
- The crisis has a major yet uncertain impact (in terms of exact scope) with regard to levels of R&D investment, particularly from the private sector, whilst public finances are likely to be squeezed further, e.g., including a potential decline in public spending and size of public sector that may have negative impact on procurement policies;
- Cuts in research infrastructures, cuts to HEI teaching budgets and removal of the cap on university teaching fees may have long term impact on proportion of pupils going into full time HEI;
- Uncertainty over future arrangements for STI governance – key staff cutbacks in government departments e.g., may hamper horizontal STI efforts;
- Abolition of regional development agencies leaves a clear gap for regional innovation support.

1.3 France

Some of the most important challenges for France:

- Sectoral and structural features of the economy do not favour an increase in business R&D, focusing on non-R&D intensive sectors and SMEs respectively;
- bearing in mind these features, thematic priorities are set-up fairly broadly and do not necessarily reflect national innovative capacities;
- Levels of interaction between public research and private business seem insufficient;
- Excellence at scientific research institutions (on a global level) is limited to a relatively small number of universities;
- Policies addressing human resources for research neglect gender issues;
- No or little coordination between national and EU level STI policies. In this respect, international cooperation is not yet a coherent, national strategy but strategy development is left to research organisations;
- Evaluation practice on innovation policies is scarce, e.g., analyses on grand challenges at national level are not as developed as in other countries.

1.4 Austria

Some of the most important challenges for Austria are:

- Thematic programmes are increasingly introduced, but they only partly respond to grand challenges and a conceptual 'theme management' focusing on key priorities is only developing.
- R&D conducting companies are substantially subsidised by public money being critically perceived as 'funding culture' instead of 'innovation culture'. In addition, industrial R&D is mostly directed towards incremental efforts and funding schemes offer only limited incentive for collaborative R&D.

- Although research in Austria has a broad scientific base, it lacks excellence (and related funding schemes) in some respects, e.g., unstructured doctoral education, sobering perspectives of young researchers and the lack of larger R&D infrastructures.
- The relatively low share of university graduates is partially compensated by R&D personnel having secondary school attainment. However, the average time spent to finish university is still high as is the number of drop-outs. The number of graduates in science, engineering and technical fields remains very low, especially among women.
- R&D finance, especially risk capital appropriations and start-up funding, remains a structural weakness.
- Fairly high dependency on foreign R&D inflows (in some industries). In addition, Austria is only sub-critically integrated in overseas knowledge circulation, while this is not the case in the EU context.

1.4 Intra-group similarities and differences

- Thematic priority setting and strategic frameworks are being developed and refined in most countries, coherence is sometimes hindered by fragmented governance, non-compliance with general role of economic policy and bottom-up focus, or misalignment and lagging behind with grand challenges integration.
- In the educational policies, most countries face a mismatch of future skills and a limited supply of high quality labour, in particular for science, engineering and technical fields. This is independent of the level of scientific excellence observed in the national domain.
- Again, with the exception of UK effort to preserve its existing knowledge base, all countries strive for excellence in science. Country size may limit efforts in this respect.
- Similarly, smaller countries will be more dependent on foreign R&D inflows in terms of effects on funding and economic structures being outside the national policy domains.
- Even when supporting policies in the knowledge triangle are in place, levels of interaction between public research and private business are considered insufficient in most countries. This may be due to inefficient policy efforts or limitations in the accountability and assessment of such measures.
- With the exception of the UK, R&D financing, especially risk capital appropriations and start-up funding, remain a structural weakness of all countries.
- Aspects of STI governance are rather heterogeneous for this group, sometimes facing coordination problems or fragmentation, either between regional and national levels or national and EU.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

2.1.1 *Belgium*

There is a highly decentralised research system due to governance fragmentation. If any, STI strategies and frameworks based on thematic fields only exist on some regional levels, but not on a federal level, even though some horizontal, bi-lateral efforts across regions are developing slowly but were postponed since no federal government has been in place since mid 2010. This has also affected the announced STI-policy framework for 2009-2014, comprehending (among other things) '*grands projets*' to address societal problems. However, a limited number of federal policy measures are in place, e.g., R&D tax incentive schemes.

Horizontal, thematic efforts across regions include: establishing a research strategy (driven by Federation Wallonia / Brussels and Brussels-Capital regional governments), and developing and investing defining cross-cutting strategic themes such as sustainable development, renewable energies, new technologies, extending life and health.

On individual region level, action for the creation of strategic platforms was established for three ICT areas in the Brussels-Capital region in 2010. Similar initiatives exist in Flanders, e.g., a transparent policy framework for business-demand driven selection of knowledge platforms with the aim to anchor multinational companies (so called 'competence poles'). This is notably the case for automobile, logistics, mechatronics, food, materials, etc.

2.1.2 *UK*

There is a multi-annual STI framework in place providing a long-term policy context to prioritise expenditure on STI. However, this has limited thematic focus (hence, the same holds for grand challenges addressed within). In terms of the policy mix, stimulating greater R&D investment in R&D performing firms is a major objective of government policy, as evidenced by the volume of R&D tax credits (which can also act to stimulate R&D by non-R&D performing firms). Direct support measures, per se, are relatively limited and tend to target SMEs.

Anyhow, a recently published, industrial strategy aimed at post-crisis competitiveness suggested to focus - next to business environment related measures - on the following areas: broadband infrastructure to support innovation, a low carbon strategy (renewable energy and transport), life sciences and advanced manufacturing, with funding from the strategic investment fund. In addition, there is little history of policies addressing 'grand challenges', notably education and health, and societal challenges, involving extensive foresight (e.g. ageing, crime prevention and flood prevention) and horizontal scanning exercises. Societal challenges also form the focus of a number of major research funding programmes. For example, the challenge-led innovation programme supports research addressing major societal challenges and support themes such as energy, living with environmental change, global threats to security, ageing, lifelong health and wellbeing and clean technologies funding. This is also true for a few knowledge triangle related measures, e.g., most recent government venture capital funding will particularly target technologies leading to the transition to a low-carbon economy, together with life sciences, digital technology and advanced manufacturing, likely to further strengthen the UK's portfolio in these fields of technology. Interestingly, thematic focus has even led to changes in STI governance in some places, e.g., the case of UK Department of Energy and Climate Change established to bring together energy policy and climate change mitigation policy.

2.1.3 *France*

A national strategic framework[18] for research and innovation is based on challenges including three thematic fields: 1) health, care, nutrition and biotechnology, 2) environmental urgency and eco-technology, and 3) information, communication and nanotechnology. In addition, in 2009/2010, five thematic alliances were created, kicking-off collaborative efforts by the NIS'

[18] The 2009 priority setting exercise involved individuals from various communities (research, business, civil society) into nine working groups in charge of studying France strengths and weaknesses. The strategy has been drafted for the next five years and shall ground policy decisions in the field of RDI.

key public research actors in specific domains originally to better research programming coordination. Six alliances are in place in the fields of life science and health, energy, sea sciences, ICT and, most recently, social science and humanities.

Furthermore, non-thematic STI measures co-existed, such as the recently reformed Research Tax Credit system now also incentivising non R&D performers. Innovation was not placed at the heart of French regional strategies, with the exception of the Paris region, having very little spending budgets.

2.1.4 *Austria*

Policy seems to continue funding a broad spectrum of technological fields and industries (using a large variety of policy instruments) rather than concentrating resources on key priorities which, therefore cannot be identified, even though streamlining efforts on the existing funding portfolio were recommended in the last NIS evaluation. Direct, mostly bottom-up based institution financing is most common in the R&D policy mix, whereas thematic and/or structural programmes are limited in scope. However, indirect funding mechanisms such as fiscal R&D incentives have gained importance. The number of companies making use of R&D tax incentive schemes increased significantly in the last decade, partially because the eligibility criteria was expanded and a research premium scheme established, successfully attracting SMEs. Both approaches, indirect funding efforts as well as bottom-up activities, alienate Austrian STI policies further from development of thematic priorities, following a somewhat different track.

2.1.5 *Intra-group similarities and differences*

- In some countries, namely Austria and the UK, policy approaches are bottom-up or framework orientated, limiting policy efforts and budgets dedicated to strategic themes in the first place and rather emphasising actor-specific or indirect policies, e.g., SME and R&D tax credit systems, respectively.
- However, given thematic agendas are implemented (or announced), they focus on energy and clean technology, health and ageing issues, often corresponding to more general societal challenges.
- In most cases, they are complemented by a technological and scientific focus on fields corresponding to national industrial structures or medium high-tech field aspirations outside this structure/profile.
- Implementation of such frameworks may by far lag behind their announcement, the former changing only the foci of newly introduced measures (meanwhile leaving foci of existing funding schemes unadjusted).

2.2 Smart fiscal consolidation

2.2.1 Belgium

Policy responses in the context of the current global financial crisis were limited, as the generally high level of public debt in Belgium gives little scope for policy manoeuvre. Therefore, the effects on regional innovation systems expected from budget cuts are likely to be different, depending on the advancement stages in these systems, i.e., increasing budgets in Wallonia and the French-speaking community, decreasing them in Flanders. For Flanders, budget cuts were e.g. made for excellent research teams and large infrastructure funds, but were accompanied by a few newly established, but pre-crisis planned STI initiatives. As far as is relevant, since it is on relatively low scale, the federal budget for science policy was further reinforced in 2010, maintaining its commitment to supporting R&D.

2.2.2 *UK*

The government spending review introduced a set of significant austerity measures, outlining a 25% cut from the STI key funder's budget i.e. Department for Business, Innovation and Skills. The overall science budget was ring-fenced at EUR5.4bn which equates to a real-terms loss of 10%. Further efficiency savings of EUR190m per year from the research council institutes and universities are under way. Capital expenditure will have to be cut by 44% by 2014-15, with some exceptions in excellent molecular biology and health research. University budgets (excluding research) will be subject to a 40% cut by 2014-15 and the government announced that the way higher education is funded will be changed by raising the cap on university tuition fees, while the teaching grant will be reduced to offset this income from 2012. However, funding for teaching science, engineering, technology, maths and modern languages will be maintained.

Other major losers among STI governance players, seeing large forecast falls in overall budgets by 2014-15 are the Department of Environment, Food and Rural Affairs (29% cut), the Home Office (23% cut), the Ministry of Defence, a major research spender (8% cut) and the Department of Energy and Climate Change (18% cut). Winners include the Department for International Development with a 37% increase for international development and the Green Investment Bank. The Higher Education Innovation Fund as a knowledge triangle policy in the crisis context will be reformed as an incentive for universities to maximise their interactions with the private sector. In addition, the government announced significant investment over four years for a new set of applied research centres.

2.2.3 *France*

Economic recovery plans increased public investments in very large research infrastructures by 17%, benefiting transport infrastructures, higher education and research, the state real estate, housing, urban renovation or health sectors. Interestingly, within the recovery plan, anticipated reimbursement for R&D tax credits was introduced focusing on young innovative companies (protecting business operations).

However, following the economic crisis, the main (anti-cyclical) policy was the launch of the so-called 'grand loan'. Priorities involve expenses responding to future challenges and related to knowledge economy, enterprise competitiveness and supporting strategic industrial investments. A EUR35bn loan that was outlined to support five priorities: higher education (EUR11bn), research (EUR8bn), industry and SMEs (EUR6.5bn), digital economy (EUR4.5bn) and sustainable development (EUR5bn).

2.2.4 *Austria*

Although securing long-term R&D investment is one of the Austrian National Reform Programme's top priorities, the initial ambitious 4% target for 2020 was reduced to 3.76% due to the actual budget consolidation crisis, with public spending cuts being announced in late 2010. In addition, the long announced overall governmental R&D strategy was postponed due to the unclear financial situation (including reduced R&D financing from abroad during the crisis as an important source of R&D funding in the Austrian context).

On the one hand, the public R&D sector was obliged to reduce its budget at the amount of EUR320m by 2014. R&D is affected in several ways, i.e., allocations to university infrastructure has sharply reduced, basic funding grants for non-university research organisations ceased, grants including the project-preparation funding for FP7 terminated, budgets for scientific liaison offices abroad and international mobility grants reduced, budgets

for scientific events and studies reduced, subsidy cuts for the COMET-programme and reduction of appropriations to the Austrian Research Promotion Agency.
On the other hand, as a means of anti-cyclicality government spending, the government agreed to allocate more funding to universities annually (EUR80m) through its 'offensive programme' by annually EUR80m (2011-2014) and decided to increase the research premium for the corporate sector, costing around EUR100m annually. In general, Austria aims to continue securing its R&D funding path, however, there has been some shift in priority setting and severe hardship for some independent R&D performers, which are not directly owned by the state or federal states. As another 'thematic' response to the crisis, the Federal Ministry of Science and Research implemented a measure with a budget of EUR20m to support investment in 'green products' in order to create 'green jobs' in 2010. Target areas are energy efficiency, renewable energies and recycling.

2.2.5 Intra-group similarities and differences

- Long-term institutional budgets are affected in a few countries, especially affecting 'non-excellent' universities and non-university research sectors, including a worsening of teaching situations and public access to universities with unknown long-term impact on the knowledge base. In contrast, national excellence initiatives seem little affected.
- Anti-cyclical spending often had thematic responses in nature, mostly focusing on green technology funding empowering more 'green' ministries across almost all countries. In contrast, the implementation process of an overall governmental R&D thematic framework was postponed only in one country.
- Thematic responses were complemented by investments targeting large research infrastructures including additional institutional funding for universities.
- In terms of specific STI instruments adjusted, half of the countries expanded their efforts in R&D tax credit systems, e.g., France implemented an anticipated reimbursement for R&D tax credits for young innovative companies.
- In addition, the creation of public funds tried to challenge the under-supply of risk capital specific to this crisis, eventually linking financial and thematic aspects with the fund's establishment.

2.3 Efficiency of Public Support

2.3.1 *Belgium*

There is a diverse set of policy measures promoting science-industry links in all three regions of Belgium. The measures include funding for interface services and TTOs at universities; funding for incubators; research centres with links to universities and the business sector; competence poles (with various different modes of public-private interaction) and various network support programmes.

However, in particular STI knowledge triangle policies seem most advanced in the Walloon region. Following an evaluation of the networks of intermediaries, the Walloon region has set up an explicit agency in charge of technological stimulation in the knowledge triangle, improving coherence of the system and existing policies by fully exploiting the complementarities between the different actors. This includes furthermore:

- Creating five competitiveness clusters spanning across the research, technology and economic policy areas;

- Regional involvement in excellence poles funded in large part with EU Structural Funds, in order to enhance public-private partnerships, but lagging behind in expectations in terms of industrial participation and ownership;
- In addition to the last point, it has launched technological innovation partnership based on competitive calls coordinating several companies and public entities (research centres, universities, other higher education institutions) on joint research contributing to the region's scientific, technological and economic development.
- Pilot project launched in 2009 aimed at creating maturation funds for university research results, allowing them to achieve the proof of concept, downstream of evidence results and upstream of the proposed economic exploitation project, either through launching a spin-off, or by granting a license to an industrialist.

Research-programme evaluation practices vary across regional governments and according to the types of R&D instruments being utilised. Evaluating R&D policy instruments and structures is becoming more frequent throughout Belgium. However, systemic evaluations and impact assessments are not yet implemented.

In terms of excellence, the lack of competitive funding for universities is regarded as a possible impediment to reach a level of excellence in knowledge production. The allocation of funds tends to be performed on the basis of the number of students and full-time equivalent researchers. However, there are only a few regional programme approaches in place aimed at fostering university excellence increasing existing institutional funding, while funding distribution is only partially based on scientific output indicators.

2.3.2 *UK*

A large number of schemes are aimed at linking the public and private sectors, thereby promoting the flow of new research ideas into new technologies and commercialised products, processes and services: examples include several of the schemes such as Knowledge Transfer Networks, Collaborative R&D and Knowledge Transfer partnerships, innovation vouchers and platforms (addressing SMEs as well as societal challenges), and further award schemes. Despite a variety of existing, funding measures, there seems to be a weak trend towards institutional change, e.g., by creating applied research centres, potentially making knowledge and technology transfer easier.

The UK has an excellent research base, in particular based on HEIs and as documented by recent research assessment exercises. This is accompanied by being a frontrunner among EU MS in terms of evaluation and monitoring practices as well as having a government performance management system in place publishing delivery plans, scorecards and 'output frameworks' on a regular basis (not only in STI but across all policy fields). As maintenance of this base is among the top STI policy priorities, a research excellence framework is under way that will continue regular assessments of the impact of past excellent research on the economy and society. However as far as the humanities disciplines are concerned, impact assessment practices are still under debate.

2.3.3 *France*

France has been active in the last decade in reinforcing knowledge circulation between universities, PROs and the business sector, including (among others) the following measures:

- Creating and funding competitiveness clusters: the programme being in its second generation in 2009-2011;

- Carnot institutes launched in 2006, built upon the model of the German Fraunhofer Institutes
- Framework changes regarding university autonomy: partnership foundations and university foundations were implemented as funding and fund raising schemes across HEIs and between industry-academia. The main difference between the two being the origin of resources;
- Investments for the future scheme dedicates a large share to improve knowledge transfer between public research and companies, endowing mostly thematically or excellence driven PROs and existing national seed funds;
- Public calls issued in 2005 and 2010 aimed to identify (and labelling them as such ex post) a limited number of companies serving as interfaces between academia and industry in charge of patenting, managing and funding public-private research projects as well as supporting academic start-ups. However, these entities should be financially autonomous and develop sources of funding with their own revenue.

In summary, even though numerous new schemes in the strategic STI framework are dedicated to improving the knowledge circulation policy, impact is subject to low innovation and entrepreneurship culture.

Although evaluating innovation policies is a rare practice, France has tried to strengthen its research governance since the mid-2000s and revamped the research evaluation system by creating a national research and higher education evaluation agency. University research laboratories and departments (including doctoral schools) are evaluated by separate commissions.

2.3.4 *Austria*

Austria has a long tradition in stimulating interaction between different knowledge triangle actors especially to enhance science-industry relations. This resulted in a rich portfolio of R&D programmes which are targeted at inter-sectoral R&D co-operation between the business sector, on one hand, and universities and non-university public research organisations on the other. These include low-key initiatives such as ‘innovation cheques’ or the ‘research premium’ as well as more demanding institutional arrangements such as COIN or COMET. To foster a human resource based knowledge circulation between academia and SMEs the ‘young experts programme’ was launched. Under its framework Master’s theses and PhD theses can be supported by partially covering personnel costs, when firmly embedded in a company’s R&D work. With regard to academic spin-off companies, there is a specific programme which fosters the establishment of centres owned by at least one academic institution and one institution with professional knowledge in business start-up support, co-financed at national and federal state levels as well as including all stakeholders. This is complemented by national financial subsidy for non-academic, technology- and/or knowledge-intense start-ups.

In terms of governance within and across the knowledge triangle, the highest representation of industry in Austria’s RTD governance takes place in the Austrian Council for Research and Technological Development, which is actually chaired by a reputed Austrian industrialist. Moreover, the private sector is represented in the University Councils, because by law these committees should consist of members with responsible positions in society, especially from science, culture, and economy.

Efforts encouraging excellence are manifold. One is based on significant changes in university regulations in 2002 allowing for an increased (financial) autonomy by contracting on performance with government. Current, second generation performance contracting and criteria-based assessment schemes have been further improved, and most received positive results when evaluated by the national STI expert group. This is accompanied by policy initiatives such as clusters for excellence or centres of competence (dating back to the 90s). In addition, a public post-graduate academic institution explicitly dedicated to excellence in research was established aiming to be of world-leading standard and focus on emerging scientific areas in basic research, starting its operations in 2008.

In Austria, the evaluation culture is highly advanced at different levels with emphasis on peer-review based project evaluations and R&D programme assessments. In 2009, a comprehensive R&D system's evaluation, including a strong notion of governance aspects, was conducted, and Austria's performance in European RTD programmes was evaluated in 2010. In addition, R&D funding agencies are institutionally evaluated regularly but shortcomings can be identified in full-fledged institutional evaluations of public research institutions.

2.3.5 *Intra-group similarities and differences*

- Expanding knowledge triangle policies is often not only associated with following goals to bring private and public research and innovation actors together in collaborative terms, but have complementary goals co-exist such as regional development or maybe targeting specific actors in specific fields (being theme, excellence or early-career-stage driven).
- There is a general trend towards additional knowledge triangle policy instruments targeting close-to-market/downstream stages of R&D rather than early research stages, e.g., support for prototype building at universities, involving a stronger emphasis on knowledge triangle-related finance by establishing university funds or joint public-private partnership fund-raising schemes.
- In addition, in some places a similar trend seems to lead to a vital policy interest in relative changes in ex ante funding structures because of their potential impact on knowledge and technology transfer (e.g., competitive funding by businesses) as well as the establishment of PROs active in applied sciences changing the institutional R&D landscape.
- As far as the knowledge base lacks sufficient excellence, several initiatives increasing quality of scientific output are in place across all relevant countries.
- With the exception of UK being a EU frontrunner in evaluation practices (and using this expertise, e.g., for maintenance of its excellence in science), all countries in the sample are slowly developing in such practices, e.g., in terms of systemic or impact assessments of policies, mostly lacking initiatives changing this situation.

2.4 Framework conditions for business R&D and innovation

2.4.1 *Belgium*

In the context of 'society greening' the seed and venture capital for green innovation developed strongly with the increased investments in the ecology premium and the participation of the Flemish Investment Fund in the Cleantech Fund. In addition, match-making platforms between starting or growing entrepreneurs seeking risk capital and informal private investors exist as well as a few SME related financing policy tools. However, explicit policies on regional or federal levels tackling an improved financing framework for

innovation are not in place, even though the propensity to launch new businesses in Belgium is particularly low and is associated with a lack of equity and risk capital.
Again, only on a regional level, namely Flanders, initial steps to explore pre-competitive public procurement have been taken, but regulatory efforts are yet to be implemented.

2.4.2 *UK*

Again, due to its general (liberal) approach to economic policy, the UK tends to focus more strongly on an elaborated STI framework policies in this way limiting market intervention (i.e. highlighting the relevance of this section rather than the other policy response sections).

Although the UK has a very strong venture capital market (second to that of the US), the effects of the downturn are becoming evident: the crisis is bringing the steady increase in the value of venture capital investments since 2002 to an end. Consequently, the equity gap for early stage technology companies noted in 2007 has worsened. In recognition of the importance of the continued supply of venture capital investment for innovation, the government announced the creation of additional risk capital funds in 2009. As the overall situation in terms of risk capital market is still outstanding on world-levels, financial regulations have not been adjusted.

In 2009, the government launched the ‘Policy through Procurement’ action plan, which sets out its priorities for procurement to drive innovation and deliver growth and efficiency, including a focus on SMEs (lowering barriers to their participation); supporting skills training, providing apprenticeship opportunities and tackling youth unemployment; and resource efficiency focusing on carbon reduction. This strategy is implemented on different governmental levels, departments being asked to produce innovation procurement plans with the intention of sharing best practices on these levels. Currently, pilot projects are managed by the Ministry of Defence and Department of Health.

2.4.3 *France*

Framework shaping in the context of (venture or risk capital) finance for innovation cannot be observed based on the information outlined in the country report.

In 2009, legal procurement rules have been changed now favouring high-tech SMEs within procurement processes. More precisely, the derogation applies within the limit of 15% of the average amount of public bids in high-tech, R&D and technology studies, and bids targeted should correspond to state of the art technologies or knowledge in science and engineering. First evaluation of the new rules is positive, however, impact assessments cannot/have not been conducted as of yet. The measure is currently in a 5-year pilot phase.

2.4.4 *Austria*

There is a lack of private risk capital to finance small, young enterprises with high growth potential, expected to have an effect on employment and structural economic change. Thus, the creation of legal conditions for a crowding-in of private risk capital providers is perceived as valuable but not implemented so far in an explicit framework or R&D finance-related policies, with the exception of publicly supported venture capital forums bringing together young entrepreneurs and investors.

Innovation-oriented public procurement policies in Austria were substantially activated by European deliberations and initiatives. Even though procurement guidelines reflecting the EC’s handbook and good practices of state-owned enterprises have been issued, the Austrian approach towards innovation-oriented public procurement is mission-oriented (also towards lead-markets) and rather based on voluntary standards, still being in an experimental policy phase.

2.4.5 *Intra-group similarities and differences*

- Even though a lack of private risk capital to finance small, young enterprises is emphasized in most countries, there are no regulatory changes to financial framework conditions in national domains underway. If any, the focus has so far been on 'softer', intermediary policies such as raising transparency of risk capital markets by provision of match-making services.
- The group's exception is the UK, having a historically superior risk capital market, although it has decreased due to the crisis.
- However, in the context of the crisis, even with unchanged regulation, all countries have recently established additional public and/or private, risk capital funds.[19]
- Procurement policies seem to be developing in most countries, with the exception of Belgium, sometimes enhanced by mission-orientated initiatives at EU levels, focusing on SME actors, high-tech sectors, and/or, again, on themes (e.g. clean tech/sustainable procurement).
- While in some countries, procurement policies are still very much undergoing informational stages, highlighting procurement staff training initiatives or best practice exchange, in other countries, namely UK and France changed regulation is already being implemented, awaiting first impact evaluations.
- For this specific subset of countries, implementation includes pilot phases and shared planning actions in high procurement active ministries and agencies, with the overall aim of delivering a coherent procurement strategy on national level and successful, vertical implementation.

[19] See also comments made in sections on efficiency of public support and on smart fiscal consolidation.

Appendix 4

Country Group 4 - Challenges and policy responses

Ireland, Luxembourg, The Netherlands

1.0 Main challenges confronting the national R&I system

1.1 Ireland

- The Irish economy grew strongly during the early part of 2000-2010 went into a steep decline from 2007 onwards due to domestic and international factors, but primarily because of the collapse of the construction/property 'bubble'. As such, Ireland was the first EU country to officially enter the recession. The Gross National Income fell by 15.1% in 2009, while unemployment has risen sharply since 2008 and now stands at 13.2%.[20]
- Although the overall R&D intensity ratio reached 1.45% of GDP in 2008, (increasing from 1.25% in 2006), government figures show that the revised S&T budget for 2009 was down EUR117m compared to 2008 and down EUR226m in 2010. However, these figures when translated in GERD intensity relative to GDP indicate an increase given the higher GDP decrease.
- A report by a Government STI advisory board has identified three overarching barriers that impact the level of company R&D: 1) shortage of high quality industry relevant skills; 2) high cost of R&D; 3) effectiveness of HEI-industry interactions.

1.2 Luxembourg

- As the country emerges from the financial crisis, the main barrier for attaining the R&D target remains the size and youth of Luxembourg's National Research System (NRS);
- In addition to its small size and relative wealth, the other distinctive characteristic of Luxembourg is the high contribution of services to its GDP (86%);
- While an increasing number of measures encourage SMEs and stimulates new participants in R&D activities, the limited absorptive capacity remains a drawback.

1.3 The Netherlands

- The policy governance structures had become increasingly complex and fragmented and a coherent overall strategic framework for R&D and innovation policies had been lacking. Over time, this generated a lack of coordination and continuity in policy design and implementation.
- The Netherlands has a relatively large services sector, which is not very R&D intensive, while the share of high-tech sectors is relatively low. In addition, it does not succeed in attracting more R&D-intensive companies from abroad. In the longer term, more investments in knowledge may be seen and required to change the national industry structure.

[20] According to the Central Statistics Office.

- The percentage of SMEs innovating in-house and SMEs introducing innovations are below EU-27 average.
- Although the collaboration between research institutes and companies is higher than in most EU-countries, is not optimal.[21]
- Because of demographic and economic trends, a growing number of HRST is needed. However, the inflow of new S&E graduates is below EU-27 average[22] and which may be explained considering that science is not deemed an attractive career path.

1.4 Intra-group similarities and differences

- All these countries have relatively large service sectors, relatively small R&D systems (to different degrees), GERD intensity below the EU average, and were officially in economic recession in 2009.
- The most significant feature of Luxembourg's national research system is its youth. Luxembourg's oldest public research centre (PRC) is just over two decades old and its own university was established by law in 2003. Luxembourg's GERD intensity is below EU, which is due to its NRS being so new. Luxembourg's GERD per capita is well above EU average, it has a small R&D system to govern, a prosperous standard of living and an attractive taxation framework for firms that declare their R&D activities in the country although performed elsewhere, meaning that there are no strong threats to the R&D system development.
- The Irish system also can be described as relatively young and small, but reform and progress were rapid. The impact of the declining economy has resulted in public STI investment falling behind the original projections. While the political commitment for the prioritisation of the RDI activities and investments remain firm, the impact of the crisis may impose further R&D budget cuts, which may be beyond the political will.
- In the Netherlands, the policy governance had been complex and fragmented for a long time, which generated a lack of coordination and continuity in policy design and implementation. The government has not succeeded in mobilising more public research support regardless of the importance attached to education, research and innovation on the policy agenda. With a high scientific output, the performance may be under threat given the decreasing R&D input. To this date, it is not clear whether the new cabinet (2010-2014) will use the R&D strategic documents formulated under the previous cabinet, while significant budgetary cuts were announced in the new coalition agreement.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

2.1.1 Ireland

Although data on the split between thematic versus generic R&D funding are not available, the existent information points to the fact that significant amount of public funding are for research performed by HEIs in ICT, biotechnology and energy sectors with lower amounts for other research areas such as agri-food, health, marine and environment. Researcher-driven demand plays a less important role in the overall Irish research system. *Innovation Ireland* and other policy documents identify the need for innovation in areas of societal importance

[21] In the Community Innovation Survey only 12% of all innovative Dutch companies mention a university as a partner. Few innovative companies (3%) see universities as very important sources. (OCW/NOWT, 2008).
[22] PRO-INNO Europe, INNO-Metrics, European Innovation Scoreboard 2009.

such as health, energy, ageing, food and the environment. Industrial production and technology, which accounted for 14.5% of total GBOARD in 2009, is an important category of R&D funding.

2.1.2 *Luxembourg*

The CORE programme allocates funding to six R&D themes identified as priority areas by the Foresight Study (2007): 1) innovation in services; 2) sustainable resource management; 3) new functional and intelligent materials and surfaces and new sensing applications; 4) biomedical sciences/regulation of chronic, degenerative and infectious diseases; 5) labour market educational requirements and social protection; (6) identity, diversity and integration. The University has also identified five priority research themes. The GBAORD breakdown reflects the emphasis on materials science and priorities relating to education and linguistic and cultural diversity. An important feature is that Luxembourg has no defence industry and research.

2.1.3 *The Netherlands*

Since 2004, societal challenges have started to become more prominent in R&D and innovation policy: 13 'society-inspired' themes were identified and corresponding thematic programmes were launched, although budgets were relatively modest. For the coming period (2011-2014), the national research council (NWO) will focus its budget on six broad themes (healthy living; water and climate; cultural and societal dynamics; sustainable energy; connecting sustainable cities; materials: solutions for scarcity). The institutional-based funding of the research institutes is also being replaced by programme-based funding, guided by a set of (societal) themes which largely overlap the European grand challenges. The Innovation Platform has also identified relevant societal themes for which societal innovation programmes are developed.

2.1.4 Intra-group similarities and differences

- Since the early 2000s in the Netherlands, thematic public R&D funding has become relatively more important vis-à-vis generic funding in an effort to align public knowledge production with business driven knowledge demand;
- Because of its small size, Luxembourg's research foci have tended to be targeted at existing competencies and identified societal challenges.[23]
- Although the split between generic versus thematic R&D funding in Ireland is not easily available, prioritisation of funds in areas considered as representing societal challenges is evident.

2.2 Smart fiscal consolidation

2.2.1 *Ireland*

Exhibit 1 Ireland – Basic statistics

Ireland	2006	2007	2008	2009	EU average 2008
GDP growth rate	5.3	5.6	-3.5	-7.6	0.5
R&D intensity (GERD as % of GDP)	1.25	1.29	1.45	1.77	1.92
GERD per capita	527	564	591	n/a	476.2

[23] An example of the former is research in 'materials science' which leverages the presence of Arcelor Mittal, the world's largest steel company. An example of the latter is the CORE programme theme *Identities, Diversity and Integration*, which reflects the multinational makeup of the Grand Duchy's population.

GBAORD as % of GDP	0.45	0.49	0.52	0.57	0.71
BERD (BERD as % of GDP)	0.83	0.84	0.93	1.42	1.21

The overall R&D intensity ratio reached 1.45% of GDP in 2008, up from 1.25% in 2006 and the provisional data for 2009 was 1.77 %. This R&D intensity ratio increase brings Ireland closer to, but still lower than, the EU-27 average. 63% of GERD in 2008 was financed by the business sector, while 35% was financed by the public sector. The pressure on Government revenues arising from the decline in the economy has resulted in public STI investment falling behind the original projections laid out under the Strategy for Science, Technology and Innovation 2006-2013 (SSTI) and the National Development Plan 2007-2013. However, the publication in July 2010 of the Government's revised capital framework has restored a level of certainty with regard to Ireland's commitment to further strengthening its STI base.

Recent policy documents such as *Building Ireland's Smart Economy* and *Innovation Ireland* set out a vision for Ireland as an European innovation hub, placing the STI agenda at the core of national policy for economic renewal. The latter document calls for innovation to be placed at the heart of enterprise policy, noting that Ireland's future economic success depends on increasing levels of innovation across all aspects of Irish enterprise. The Government also reiterated its commitment to implementing the SSTI 2006-2013 and has set a target of investing 3% of its GDP in R&D.

2.2.2 *Luxembourg*

Exhibit 2 Luxembourg – Basic statistics

Luxembourg	2006	2007	2008	2009	EU average 2008
GDP growth rate	5.0	6.6	1.4	-3.7	0.5
R&D intensity (GERD as % of GDP)	1.66	1.58	1.51	1.68	1.92
GERD per capita	1201.2	1242.4	1240.2	1.295	476.2
GBAORD as % of GDP	0.32	0.33	0.42	0.49	0.71
BERD as % of GDP	1.42	1.35	1.41		1.21

GERD was 1.51% of GDP in 2008, which is below the EU average of 1.92%. However, in terms of GERD per capita, the level is much higher than the EU average and in 2008 it ranked as the 3rd highest in the EU (after Sweden and Finland). With post-crisis debt totalling 14.5% of GDP, the lowest in the eurozone, budgets laid out in the 2009 Plan for Innovation and Full Employment remain intact, with 2008-2010 seeing steady progress towards the Lisbon public R&D expenditure goal of 1%. Supporting policy coherence and continuity is the Grand Duchy's unusual degree of political stability. Such political stability has also facilitated the consistent provision of resources with multi-annual planning for funding sources. The National Research Fund's programmes (NRF), which provide funding to public sector research institutions, are all multi-annual, with programmes open in 2010 running to 2012 and 2014.

2.2.3 *The Netherlands*

Exhibit 3 The Netherlands – Basic statistics

	2006	2007	2008	2009	EU 2008
GDP growth rate	3.4	3.9	1.9	-3.9	0.5
R&D intensity (GERD as % of GDP)	1.88	1.81	1.76	1.84	1.9
GERD per capita	599	632	640	639	476.2
GBAORD as % of GDP	0.71	0.69	0.7	0.79	0.71
Business sector R&D intensity	1.01	0.97	0.89	-	1.21

GERD as % of GDP amounted to 1.76% in 2008, which was lower than the EU-27 average (1.9%). The BERD intensity was relatively low and declining. GovERD (% of GDP) was below EU-27 average and decreased in 2004-2008, while HERD remained stable and above EU-27 average. Although public investments in education, research and innovation were high on the political agenda, investments fell short of the ambitions.

Having learnt from the lack of coordination, cohesion and continuity in R&D and innovation investments, the previous cabinet (2007-2010) developed a long-term strategy and a Multi-Annual Innovation and Knowledge Compass (MIKK) to orientate future investments. It combined societal challenges with knowledge and innovation themes to identify areas where the Netherlands has the potential to excel economically and/or scientifically. The long-term strategy was based on the Knowledge investment agenda 2006-2016 of the Innovation Platform (IP). The level of public investments in knowledge and innovation has not been sufficient to reach the ambitious targets, of being among the top 5 knowledge economies in the world. Moreover, investments have been rather unpredictable and not guided by a long-term investment agenda. To this date, it is still not clear whether the new cabinet (2010-2014) will use these strategic documents to guide policy making and investments.

2.2.4 *Intra-group similarities and differences*

- R&D intensity in these countries is below the EU average.
- However, in terms of GERD per capita, Luxembourg is well above EU average, ranking as the 3rd highest.
- The economic crisis has affected all of these national economies: according to the latest EUROSTAT all were in recession in 2009. Despite this situation, in Luxembourg and Ireland, the governments prioritise the RDI policy and investments, and reiterate their commitments to the R&D targets. Luxembourg has the advantages of being prosperous and having a stable government that provides consistent and coherent STI policies.
- In the Netherlands, it is not clear if the new cabinet (2010-2014) will use the strategic documents and multi-annual investment frameworks established by the previous cabinet (2007-2010). Also, significant budgetary cuts were announced by the new coalition agreement and consequently many of the R&D and innovation subsidies for companies will be discontinued.

2.3 *Efficiency of Public Support*

2.3.1 *Ireland*

Government policies recognise the centrality of both research and innovation in increasing Ireland's economic performance and in achieving Ireland's ambition to be a leading knowledge economy. These policies seek, inter alia, to attract R&D foreign direct investment (FDI) to Ireland and to facilitate the commercialisation of public sector research as witnessed by increased funding for measures aimed at fostering HEI-industry research links. The

Government has endorsed the Innovation Taskforce report, *Innovation Ireland*, which recommended developing integrated innovation policies that could position Ireland as Europe's innovation hub. New administrative structures were established to put the Taskforce's recommendations into effect. These structures are separate from those set up to oversee the implementation of the Strategy for Science, Technology and Innovation 2006-2013, and raise potential issues in terms of lack of coordination between the two policy fields. An assessment of policy mix routes and their balance indicates that issues may arise in the future due to the fact that separate implementation and review structures have been developed for both research and innovation policy spheres. Another issue relating to implementation of the RTDI policy is that there is a lack of coordination between enterprise policy development which is the responsibility of the Department of Enterprise, Trade and Innovation and sectoral research policies which are under the aegis of a variety of government ministries. This lack of coordination raises concerns of overlaps in research funding and reduced potential for commercialisation.

The largest share of publicly funded R&D is allocated to the higher education sector through the Higher Education Authority (HEA). In 2008, 78% was allocated by HEA as block grant and 22% through the Programme for Research in Third Level Institutions (PRTLI). The allocation of the core grant is determined on a formula basis which considers the standard per capita amount in respect of weighted EU student (grouped in four broad subject price groups and research students). PRTLI awards are made on the basis of peer review against international standards of research excellence. The small size and relatively recent nature of the Irish research sector, allied with a national policy aspiration to be a world-leading knowledge economy, established the peer review and evaluation procedures as a customary culture. *Powering the Smart Economy (2009-2013)* states that international peer review would remain the cornerstone of its evaluation system. The Government has instituted a rolling programme of organisational evaluations; there have been major recent evaluations, for example, of S&T funders, such as the Science Foundation Ireland (SFI). SFI also uses international peer reviews as part of its selection process and assesses the outputs of research projects through the number of peer-reviewed publications produced.

Science Foundation Ireland's Annual Report for 2009 noted that Ireland's research impact in the mid-1980s as measured in terms of the quality and quantity of its scientific publications was low by international standards. Following shifts in Government policy from the late 1990s onwards, Irish research impact has increased, moving from the bottom of the table to equal or above the world, EU-27 and OECD averages. Ireland increased the number of publications but also the quality of the research.[24]

The Government has been stressing the importance of industry-higher education collaboration, with several approaches recently being used to reinforce it. One of them is the Competence Centres initiative (funds allocation of EUR56m in 2010), which clusters companies and HEIs. This was seen as an approach to favour a collaborative system where companies that might ordinarily be competitors agree to share knowledge, risk and the rewards of pooling their research resources.
The Innovation Ireland report, prioritised knowledge transfer and recommended action in a number of different areas to improve the links between HEIs and other elements of the

[24] According to Thompson Reuters Essential Science Indicators, Ireland's international citations ranking has moved from 36th to 19th. According to the Thomson Reuters InCites citations-based information service, Ireland broke into the top 20 countries for the first time in 2008. In specific fields Ireland's impact ranks even higher, indicating the particular strength of investment in specific disciplines (for example, Ireland is ranked third in immunology and eighth in materials science).

national innovation system. The report's main recommendation in relation to knowledge circulation was to establish and implement a National Intellectual Property (IP) Protocol.

2.3.2 *Luxembourg*

Comparing GERD with BERD, it becomes evident that private sector research funding by far overshadows the public sector. This is mainly due to the presence of some world-class research companies, such as Delphi and Goodyear, which have a strong R&D presence in Luxembourg and some 'home-grown' companies that perform their own innovative research. Yet, it should be noted that some R&D companies are registered in Luxembourg for fiscal advantages but actually undertake the R&D activities elsewhere.

Heading Luxembourg's research governance is the Superior Committee for Research and Innovation. The Ministry of the Economy and Foreign Trade (MECE) implement the policy and strategic objectives for the private sector and the Ministry of Higher Education and Research (MESR) for the public sector. Bridging the private and public sectors is Luxinnovation (established in 1984), the national agency that promotes research and innovation. The governing system shows vertical and horizontal coherency, however, given the size of the RDI system, it is not expected.

Policies to ensure continuing R&D quality improvement have been put in place, based on recommendations from the OECD review (OECD, 2007), the Foresight Study (NRF, 2007) and a university assessment (Alexander, 2009). Figures on patent filings indicate that Luxembourg was one of the EU leaders. PRO funding has become more selective and results-based. All public institutions have signed performance contracts which run for three-year period and are focused on establishing public-private partnerships (PPPs) and on exploiting research results. The emphasis on PPPs has forced PROs to look to the private sector as a funding source. New performance contracts for 2011-2013 are expected to increase. Supporting the private sector, a new law which came into force in 2009 offers subsidies and incentives for companies to work with the public sector as a research resource

The University of Luxembourg, focused on research, is lacking cost accounting, a system that links funding to scientific results, yet, this deficit is essentially due to the institution being so new.

2.3.3 *The Netherlands*

Main actors and institutions in research governance include the ministry of Education, Culture and Science (OCW) and the ministry of Economic Affairs, Agriculture and Innovation (EL&I). The latter is the result of a merger in 2010 of the ministry of Economic Affairs (EZ) and the ministry of Agriculture, Nature and Food Quality (LNV).

Coordination of policies across policy levels and policy areas, notably between research, education and innovation policies has not been strong. It has largely depended upon ad hoc initiatives (task forces, working groups, platforms). Historically, a strong division of labour has existed between science and basic research on the one hand, and technology and innovation on the other, both in terms of policy design, funding and research performers. As a result, two different governance cultures have emerged: while the innovation governance can be characterised as 'hands on' with an active role in policy design, programme design and programme management, the governance of the research is rather 'hands off', delegating more responsibilities to the national research council (NWO). The two worlds are, however, gradually moving towards each other with the new 'super ministry' of Economic Affairs, Agriculture and Innovation (EL&I). This may contribute to making the governance system less fragmented, and less dependent upon ad hoc 'task forces' and other temporary governance bodies.

The Dutch research system performs very well in terms of productivity, impact scores and success rates in European programme. Dutch scientists have relatively high publication output (especially in Nature and Health), being one of the most productive in the world with 72 publications in international scientific journals per 100 researchers and have relatively high impact-scores. The Netherlands also has (very) good scores in terms of patents, largely due to Philips but not necessarily due to R&D performed in the country. While the output of the Dutch research system is quite good, the input shows a declining trend. It could be argued that the good performance of the Dutch research system is the result of past investments and that the future performance is under pressure because the current levels of R&D investment are insufficiently ambitious.

While a large part of Dutch research funding is via institutional base funding, an increasing part is allocated on a competitive basis, using international peer review. In 2009, 68% of R&D budgets from all ministries was allocated via institutional funding and 32% via project-based (competitive) funding.[25] OCW is the main R&D funding ministry and allocates 79% via institutional funding, mainly to research universities. EL&I, the second largest R&D funding ministry, allocates 'only' 27% via institutional funding and this share will further decline as institutional base funding is increasingly replaced by (long-term) programme-based funding for strategic basic research by research institutes. Universities are publicly financed via three 'flows' of funds: 60% base funding, originating directly from the ministry of OCW and tuition fees paid by students; 10% NWO funds awarded to projects after reviewing the research proposals submitted by researchers; 30% a heterogeneous mix of revenues from activities such as contract research, contract teaching, consultancies, research commercialisation, endowments, etc. The quality assurance system of public research organisations functions rather well, so the increasing trend of the competitive funding is debated if appropriate to sustain the research performance.

A substantial part of the R&D policy mix is aimed at stimulating public-private collaboration. Most of the R&D funding by EL&I, for instance, is via public-private collaboration programmes. However, the largest funding streams do not target collaboration since they are represented by block funding. Overall, the level of interaction between SMEs and universities can be assessed as modest (also because there are relatively few innovative SMEs). Different sets of measures were designed and are currently implemented to improve these collaborations. Most universities have developed (or are developing) central technology transfer offices (TTO) or 'valorisation centres', which include spin-off support and have incubators and science parks for start-ups and growing companies. Knowledge valorisation is explicitly recognised as part of universities' mission. Several universities collaborate in 'centres of entrepreneurship' that encourage students to start their own business. The private sector may also be involved in the university and PRO governance bodies.

One of the policy objectives is to strengthen the alignment of higher education institutes and society (firms and societal organisations). For instance, as part of the Delta plan on Science & Technology (2005), 14 'technocentres' were established to solve bottlenecks in regional labour markets for technical professions.

[25] *Overzicht Totale Onderzoek Financiering (TOF) 2008-2014* with an elaborate overview of R&D funding sent annually to Parliament by the ministries. .

In the national policy mix, several instruments stimulate and support spin-offs directly or indirectly. For instance, the TechnoPartner Knowledge Exploitation funding programme (SKE) provides support to consortia of public knowledge institutes and private parties with regard to screening of research and scouting of entrepreneurs, patents, access to equipment, coaching and support, and provision of pre-seed funding. Also the Innovation Vouchers scheme promotes knowledge transfer from knowledge institutes to SMEs to make them more innovative and R&D-intensive. A typical feature of the Dutch innovation system is that it contains several large RTOs (e.g. TNO, the Large Technological Institutes), which have an intermediary role in translating scientific knowledge into applicable knowledge for companies, including SMEs. TNO, by far the largest RTO, has introduced an SBIR scheme (inspired by the US Small Business and Innovation Research programme) to allow companies (SMEs in particular) to commercialise TNO employees' product ideas.

2.3.4 *Intra-group similarities and differences*

- Luxembourg has a coherent and consistent policy mix coordination, with an intermediary body (Luxinnovation) which bridges the private and public sectors. Yet, the coordination of the policy is a natural outcome given the size of the country and of the R&D system.
- In Ireland different structures implement Innovation Ireland, Strategy for Science, Technology and Innovation 2006-2013 and Enterprise Policy. This may potentially have a lack of coordination and has raised concerns regarding overlaps in research funding. In the Netherlands, historically, a strong division of labour has existed between science research on one side, and technology and innovation on the other, which emerged in two distinct governance cultures in terms of policy design, funding and research performers. However, the ministries now forming EL&I have increased coordination between industrial R&D policy, industry policy, entrepreneurship policy and regionally oriented policy.
- All of these countries show good and increasing scientific performance. Yet, it should be noted, that in Luxembourg and the Netherlands the good outcome in terms of patents, is not necessarily related to R&D activities performed in the country. In the Netherlands, most of the patents are largely due to Philips: all Philips patents are applied by the Dutch head office, but approximately only half of the R&D resulting in the patents was performed in the Netherlands. In the case of Luxembourg, some R&D companies are registered in the country for fiscal advantages but actually operate R&D activities abroad.
- In all of these countries, the interaction between knowledge institutes and SMEs is still a relative weakness although various measures have been designed and implemented to improve the public-private collaboration. Measures particularly target the collaboration between universities and industry. Industrial programmes in Ireland, the performance contracts focussed on establishing public-private partnerships (PPPs) and on exploiting research results in Luxembourg and the establishment of TTOs in Netherlands must all be highlighted.
- Institutional funding is the main funding stream in all of these countries. This may be fully justified given the size of the systems and the well-established and efficient evaluation mechanism. This is even truer for Ireland and Luxembourg which emerge as relatively new systems, requiring consistent R&D input over time. The Netherlands EW CR 2010 arguable comments that the overall good quality of the broad base is under threat because of the increasing trend of competitive funding, of the high international competition and moderate national investments in research. However, on

the other side, the same report highlighted that although the competitive funding supports private-public collaboration it continues to be weak given that most funds are actually allocated through block funding.

- In Luxembourg, one of the incentives for establishing business incubators was the hope that they would house spin-offs from PROs. However, few spin-offs have been developed, implying that entrepreneurial culture is lacking. The very diverse needs of the sector and the small size of the projects made it economically inefficient to the point that the PRC reassessed its approach in this area. Public-private partnerships often target the services sector, and the output often resembles consultancy rather than research.

2.4 Framework Conditions for Business R&D and Innovation

2.4.1 Ireland

BERD has risen steadily in Ireland during 1998-2008 in current and constant prices. The *EU Industrial R&D Investment Scoreboard* 2010 indicates that spending on R&D in Ireland was up 13% in 2009 compared to 2008 and that the number of Irish companies in top 1000 companies for R&D spending in the EU rose to 16 in 2009 (from 12 in 2008). The business sectors performing the largest percentage of R&D in 2007 were the computer and related sectors and the chemicals, chemical products and man-made fibres sector. Both sectors are dominated by the Irish affiliates of multinational companies.

The *Maximising the Environment for Company R&D report* published in 2010 by the Advisory Council for Science, Technology and Innovation Ireland (ACSTI) highlights the continuing need to encourage enterprise to invest in RDI and identified three overarching barriers that impact on the level of company R&D in Ireland across all enterprise sectors: 1) shortage of high quality industry-relevant skills; 2) high cost of R&D; 3) effectiveness of HEI-industry interactions. It found that Irish R&D firms employing PhD researchers had rates of patenting 2.5 times greater than similarly active firms which did not employ PhD researchers and had significantly higher collaboration rates with both higher education institutes and other firms. The report recommended continuing investment in PhD qualified researchers but stressed the importance of aligning PhD training with the needs of indigenous enterprises.[26]

A key objective of the Irish government's SSTI 2006-2013 is a cumulative net increase in PhD student places, representing a total output of 8,858 PhD graduates between 2006 and 2013. Data produced by Forfás indicated that the number of total researchers (on a full time basis) per 1,000 total employment in Ireland exceeds the EU-27 figure (in 2007, Ireland had 6.4 researchers per 1,000 employed compared to 6.0 in the EU-27). The number of researchers in the business sector rose from 6,937 in 2001 to 8,242 in 2007. The higher education institutions and the Higher Education Authority (HEA) adopted a new approach to PhD training and education that aims to prepare graduates for careers in the business sector. This new approach, the provision of structured education programmes, seeks to provide structured relevant professional skills training to enable PhDs to develop their careers in diverse sectors of the economy.

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[26] The report's recommendations to address these barriers included:

- Greater involvement of industry in developing postgraduate programmes; Support for the development of world class Masters programmes that are industry relevant, sector specific and in which industry is engaged;
- Industrial postgraduate programmes developed, based on the model of the Danish Industrial PhD Programme;
- Give profit and loss making companies the option to offset their R&D tax credit against payroll taxes.

The stimulation of greater R&D investment in R&D performing firms, is underpinned by a number of support measures provided by Enterprise Ireland, the agency responsible for developing indigenous industry. The research and innovation supports performed by private companies, particularly those provided by Enterprise Ireland (EI) vary according to the needs of the firms and their stage of development. The funding available ranges from Innovation Voucher grants of EUR5,000 which allow small firms to access expertise in the higher education sector to multi-million euro funding for clusters of companies seeking to pursue common research agendas. In addition to direct funding supports given to industry, Ireland has a 25% R&D Tax Credit scheme since 2004 (in addition to a tax deduction at 12.5% for R&D expenditure in Ireland). The aim of the R&D tax credit is to encourage both foreign and Irish companies to undertake new and/or additional R&D activity in Ireland.[27]

With the enactment of the Finance Act 2010, the Government has given legal effect to fiscal and taxation measures announced in the Budget to increase Ireland's attractiveness as a hub for intellectual property through the expansion of the IP regime to include software and applications for the grant or registration of patents, copyright, etc., and a broader definition of know-how. Policy actions in this policy mix route category have focused on facilitating access to venture capital. In July 2010, the Government announced the launch of the Innovation Fund Ireland (IFI), a EUR500m fund to support enterprise development and job creation.

While numerous Government-initiated studies have identified public procurement as a potential driver of innovation, the actual implementation of such policies have yet to be realised.

2.4.2 *Luxembourg*

Unlike GERD, Luxembourg's BERD exceeds the EU-27 average. The most recent figures (2007) from DG Research's Key Regional Figures (KRF) indicate that 58% of BERD comes from the services sector (mainly financial intermediaries and real estate) and 42% from manufacturing. The 2010 EU Industrial R&D Scoreboard lists eight Luxembourg companies among the top 1,000 EU R&D performers. In fact, only one of the companies—steel giant ArcelorMittal—actually undertakes research in the Grand Duchy, the others only have registered offices while R&D occurs elsewhere. The vast majority of companies in Luxembourg are SMEs; in fact, only 13.9% of all companies registered have more than 10 salaried employees. The FDI flows indicate Grand Duchy's position as a financial centre—the cash flows are the result of the financial intermediation relating to investment funds rather than business knowledge demand.

Research infrastructure in Luxembourg is good and continues to improve. Pressure is on to complete the 'City of Science project', which will provide facilities for public research institutions, business incubators and space for PPP collaboration. The percentage of Luxembourg's population with tertiary education exceeds the Europe 2020 target of 40%. Luxembourg is known for its high quality of life and 43.1% of the population consists of resident foreigners. However, there are two barriers for foreign and domestic researchers. The first is the extent of fixed-term rather than permanent work contracts. Another important

[27] The R&D tax credit is available to Irish resident companies and branches on the incremental cost of in-house, qualifying R&D undertaken within the European Economic Area (EEA), provided such expenditure is not otherwise eligible for tax benefits elsewhere within the EEA. Incremental spending is calculated in comparison to the 2003 base; therefore, credit is essentially volume-based for new entrants to the R&D sector.

barrier concern issues of gender equality. In terms of female researcher representation, the *2009 She Figures report* consistently puts Luxembourg among the lowest group of countries with less than 15% of women among the research population.[28]

Luxembourg is known for its business-friendly environment. In the *2010 IMD Competitiveness Report*, Luxembourg ranks as 11th, ahead of France, Germany, the UK and even Finland. Policies such as the law concerning IP and the new eco-innovation initiative also make Luxembourg attractive for innovative businesses. Luxinnovation provides a user-friendly 'one-stop shop' both for new and established companies seeking to participate in Luxembourg's RDI opportunities. SMEs have been particularly targeted by Luxinnovation as well as by the private sector R&D subsidy provisions of the new laws of 2010. In addition to Luxinnovation, the Chamber of Commerce has established an *Espace d'Entreprises* (Business Space) to facilitate business start-ups. Business incubators are publicly sponsored and there are various loan schemes for start-ups.

One significant weakness for businesses is a lack of local venture capital. With the notable exception of Mangrove Capital Partners, famous for providing venture capital to Skype, companies seeking capital must look to business angels or abroad. Tax incentives are offered by the law of 21 December 2007 on intellectual property, which gives preferential treatment to income from patents, trademarks and other forms of IP registered in Luxembourg.

2.4.3 *The Netherlands*

The Netherlands has strengths in world-class large research facilities, but investments (e.g. in ESFRI) fall short of ambitions and are incidental rather than structural. According to the European Innovation Scoreboard 2009, the Netherlands is in the group 'innovation followers', with innovation performance below those of the 'innovation leaders' but close to or above that of the EU-27 average.[29] Within this group, the Netherlands is, however, a 'slow grower'.

The Netherlands has a relatively large services sector, which is not very R&D-intensive. There are correlations between economic, technological and BERD specialisations: compared to EU-15 average, sectors that have relatively high BERD include mining, electronic equipment and office machinery, trade, food, agriculture, construction, chemicals, ships, and basic metals. A large part of R&D businesses is performed by 14 large R&D intensive companies (Philips, ASML, Schering-Plough, Shell, NXP, DSM, Océ, Unilever, KPN/Getronics, Thales, Crucell, Corus, AkzoNobel, Stork), which together amount for more than half of all business expenditures on R&D. These companies have good absorptive capacities and are well-connected with the public knowledge infrastructure. FDI in R&D is not a major factor in business-driven knowledge demand.

The future shortage of S&T graduates is seen as one of the important barriers for enhanced private R&D investments. One of the factors that influences the future provision of researchers is ageing: more than one-third of the tertiary graduates belongs to the age group 45-64 years. In response to the predicted shortage of S&T graduates, a special Science and Technology Platform was set up in 2004 to promote the availability of sufficient technicians and engineers. In 2007/2008 there were 3,200 PhD graduates, which is an increase of 25%

[28] Women represent less than 15% of the research population in the Netherlands, Japan, Austria, Germany, and Luxembourg (She Figures, 2009).

[29] Other 'innovation followers' are Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg and Slovenia. (European Innovation Scoreboard (EIS) 2009, available from: http://www.proinno-europe.eu/page/european-innovation-scoreboard-2009).

compared to 2002/2003. HRST as a share of labour force has increased from 45.5% in 2000 to 50.9% in 2009, while the number of R&D personnel remains relatively low (1.00% of total labour force in 2008, below the 1.03% EU-27 average) and gradually decreasing. A second factor is the relatively high 'brain drain', which is not compensated by 'brain gain'. To ensure a balanced composition of scientific staff in universities, the Innovational Research Incentives scheme, stimulates career opportunities for talented researchers at various stages of their careers. A Knowledge Migrant Scheme was adapted to make the Netherlands more appealing to international knowledge workers. The share of women in senior positions in Dutch universities is low in comparison to other countries and special schemes have been set up to address this underutilisation of talent.

The effects of the economic crisis on the unemployment among knowledge workers appear to be limited,[30] in part thanks to the Knowledge Workers Scheme.[31]

In general, the framework conditions for private R&D are good. The fiscal scheme WBSO is the main generic policy instrument encouraging companies to invest (more) in R&D.[32] In general, the Dutch government aims to create an attractive climate for R&D intensive firms from abroad, an ambitious learning culture and an excellent research climate. Initiatives in this route include the Netherlands Foreign Investment Agency (NFIA) and a network of Offices for Science and Technology (TWA network) in various countries. Increasingly, the Innovation Programmes are used to create a recognisable profile (or 'brand') of the Netherlands and to attract foreign R&D intensive firms to the Netherlands. One of EL&I's main policy objectives is to create "an excellent climate for entrepreneurship and business location". Policy is aimed at removing barriers for entrepreneurs and to build on existing strengths together with companies and stakeholders (clusters, 'key areas'). One element of EL&I's policy is strengthening of the spatial economic main structure of 'mainports' (airports, harbours, etc.) PIANOo, the government's Public Procurement Expertise Centre, was established to support public procurers. It offers a platform for all contracting authorities to share problems encountered and to discuss applied solutions. With regard to innovation, PIANOo stimulates innovation in procurement by supporting innovative pilot procurements, funding them and giving advice. The government also introduced an SBIR scheme in 2004, which is a form of pre-commercial R&D procurement.

2.4.4 *Intra-group similarities and differences*

- All of these countries provide a relatively good framework for R&D investments;
- One of the common barriers for enhanced private R&D investments is the future shortage of high skilled professionals. Different measures have been implemented:
    - In Ireland, a new industrial PhD programme has been introduced, yet it is too early to assess its impact since the implementation requires systemic changes;
    - In Luxembourg, measures aim to attract researchers (including doctoral students) and make science careers attractive. The grant scheme 'Aid for Research Training' provides funding for PhDs and post-docs of all nationalities, studying in Luxembourg or abroad, providing their topic is identified as being of interest in the context of Luxembourg.
    - In the Netherlands, different types of measures were implemented: 1) aiming to increase the number of S&T graduates with relevant skills (Platform Science

[30] Unemployment among tertiary graduates is relatively low (1.6% in 2008).
[31] With this temporary scheme, industry and (high-tech) businesses that are suffering from an acute drop in turnover can be supported by a governmental fund that enables the outsourcing of researchers from the companies to public organisations.
[32] The WBSO alleviates the wage burden of R&D workers for companies through tax reduction.

and Technology); 2) increase the brain gain (Knowledge Migrant Scheme); 3) increase the attractiveness of research careers (Innovational Research Incentives scheme) and female researchers' participation;

- In Luxembourg and the Netherlands, access to venture capital remains a weakness;
- In the Netherlands, the budgetary cuts announced by the new coalition agreement will discontinue many of the R&D and innovation subsidies for companies.

Appendix 5

Country Group 5 - Challenges and policy responses

Spain, Portugal, Greece, Estonia, Latvia, Lithuania and Malta

1.0 Main challenges confronting national R&I systems

Within the group of countries with "medium knowledge capacity systems with an economic specialisation in low knowledge sectors", at the turn of the century, all countries are well below EU average in terms of R&D expenditure (GERD) per GDP. However, with the exception of Greece (being about EU average), all countries overperformed in comparison to most other EU MS' growth rates in the last decade. This is particularly true for former communist countries in the Baltic in the process of their transition. Anyhow, in terms of fluctuations due to the economic and financial crisis (2008-2009), the latter subset of countries, with the notable expectation of Estonia catching up with Spain and Portugal, experiences highest R&D reductions within the overall group.

Exhibit 1 Trends in GERD

	2000	2008	2009	Variation of nominal GERD 2000-2008	Variation of nominal GERD 2008-2009
EU-27	1.86	1.92	2.01	38%	-1%
Spain	0.91	1.35	1.38	157%	-1%
Portugal	0.73	1.5	1.66	179%	8%
Greece	0.58*	n/a	n/a	54%***	n/a
Lithuania	0.59	0.8	0.84	231%	-14%
Malta	0.26**	0.57	0.55	200%****	-6%
Latvia	0.44	0.61	0.46	374%	-40%
Estonia	0.6	1.29	1.42	462%	-5%

*2001, 2000 not announced. **2002, 2000 not announced. ***Variation 2007 to 2001. ****Variation 2008 to 2002.

1.1 Spain

Some of the most important challenges for Spain are:

- SME emphasis in industrial structure and slow structural change within, with a lack of large national firms or R&D conducting multinationals, no policies being in place to attract the latter;
- Low quality of Spanish education at all levels;
- Lack of excellence and fragmentation of the public research system and correlated low level of technology transfer, e.g., HEIs and PROs lack strategic planning to overcome such barriers;

- Limited or lacking horizontal coordination of innovation and educational policies and insufficient knowledge base lead to systemic failure, impeding overall effectiveness of recent policy changes in the innovation domain;
- While there is a lack of HEI autonomy for some aspects such as public salaries, autonomy in place does not incentivise to strive towards excellence in others.

1.2 Portugal

Some of the most important challenges for Portugal are:

- Medium-tech, structural characteristics of the economy, large firms being absent and nature of domestic demand not injecting advanced good production. In addition, very little success in attracting R&D performing FDI;
- Collaboration between academic research and potential users is limited, partially related to weak absorptive capabilities of business sector hampering effectiveness of policies in place as well as lacking research and innovation policy integration;
- Low involvement of the business community and the society as a whole in defining national research priorities;
- Insufficient volume of venture capital market financing SMEs and start-ups' R&D activities.

1.3 Greece

Some of the most important challenges for Greece are:

- Significant public budget cuts due to crisis and delays in STI governance. In addition, VAT increases and high corporate taxes create further disincentive for private R&D investments;
- Knowledge demand from and absorptive capacity of the private, low-tech sectors is relatively low, the former leading to excess supply of researchers as well as mismatched skills, the latter leading to shortcomings in the knowledge triangle;
- STI governance quality is limited and fails in horizontal coordination tasks due to a lack of competences and skills in public administration, frequent rotation of the hierarchy and lack of organisational memory;
- Scientific output and education quality is still beyond the European average;
- Effectiveness of HEI evaluation is undermined by lack of consensus among stakeholders.

1.4 Estonia

Some of the most important challenges for Estonia are:

- R&D investment and absorption capacity of knowledge production in the business sector is still relatively low;
- Even though the provision of qualified R&D personnel exists on satisfactory levels (due to the quality of national HEIs and international mobility), knowledge demand and R&D employment remain limited;
- Long- and medium-term public R&D investment capacity is limited and only compensated by large short-term EU structural fund allocations;
- No systematic approach to initiate and support coherent structural changes in economy via entrepreneurship, or tax and industrial policies exist, even though STI governance is well developed;

- Policy evaluation culture is not strongly developed as is the general awareness about its potential role in governance and public management, such practices in innovation and research fields being rather the exception.

1.5 Latvia

Some of the most important challenges for Latvia are:

- Business sector with low R&D intensity, relative small scope and limited knowledge demand. In addition, significant setback in private R&D investment induced by the economic and financial crisis;
- Misalignment between national R&D priorities and strengths of the national economy having an overemphasis on high-tech activities and weak STI governance (in terms of integration of stakeholders and a dedicated ministry);
- Weak cooperation between public research institutes and universities as well as lack/mismatch of human resources eligible for R&D activities and talent migration;
- Limited openness and attractiveness of the national research system while remaining disconnected to the international domain of science to some extent;
- Most of the R&D policy measures rely exclusively on the availability of the EU structural funds raising concerns on sustainability of public R&D budgets;
- Low performance of scientific output and lack of an adequate system of research evaluation.

1.6 Lithuania

Some of the most important challenges for Lithuania are:

- Low levels of public R&D expenditure worsened by the crisis and delayed structural fund implementation;
- Number of research priorities as outlined by strategic framework remains too broad for a small country and are not selected upon advanced science-based policy-making, emphasising an overall underdeveloped evaluation culture;
- Lack of horizontal coordination across STI governance domains even though some institutional reshuffling is underway;
- Lack of government policy on cross-border research collaboration and internationalisation causing limited openness, even though national quality research infrastructure is in place;
- Public support for HEI-industry links and cluster policies is not sufficient;
- Framework conditions are not fully adjusted as not incentivizing private R&D investment, especially non-R&D performers and entrepreneurs;
- Adequate supply of science and engineering skills, however, the quality of graduates does not fully match market demand.

1.7 Malta

Some of the most important challenges for Malta are:

- Low levels of private and public R&D investments and overall R&D performed, partly due to the SME-based structure of the private sector and its low absorptive capacity;
- In addition, there is a lack of R&D finance available for the latter as well as only low levels of entrepreneurial culture among these agents;

- STI governance lacks horizontal coordination as well as long-term, sustainable funding frameworks, in particular of HEIs. Furthermore, some of the policies are not effective due to the economy's structural features;
- Limited number of science and technology graduates as well as R&D-active staff. In addition, a mismatch between skills output and business demand prevails.
- The science system and related funding schemes are characterised by a weak evaluation culture and limited openness, respectively, worsening, e.g., trends of brain drain.

1.4 Intra-group similarities and differences

- SME-structured, mostly medium-tech economies with low absorptive capacities and limited R&D activity are dominant across all countries showing no or very little evidence on structural change.
- Even though there are STI governance and strategic frameworks in place they often lack coordination across policy domains, namely innovation and education ones, limited policy-making based on learning from evaluation and monitoring activities as well as limited integration of relevant stakeholders within strategy formulation processes.
- As such, half of the group experiences misalignments of thematic priorities with respect to either national industrial specialisation or 'high-tech' policy aspirations as outlined in strategic frameworks, being equipped with only low shares of public budget, this in turn limiting their footprint potential.
- In addition, a few country cases continued to exist showing rather unstable and short-term-orientated public R&D funding, e.g., which hinders HEIs' autonomy.
- National R&D expenditures largely dependent on the EU's structural funding as well as FDI/multinational activities, in particular for small countries, the former having a partly stabilising short-term effect on public R&D budgets in times of crisis (given that national co-financing is secured).
- Limited effectiveness of expanding knowledge triangle policies due to systemic failure stemming from either low (structural) business demands and/or limited relative quality in HEI and PRO performance and knowledge base, respectively. In addition, a mismatch between business demands and skills output worsens the overall outcome.
- Lack of scientific excellence in most countries as well as a certain disconnection of R&D and science systems due to limited international openness in most countries, with a heavy brain drain potential of national talent.
- A lack of R&D finance available for SMEs and start-ups as well as comparatively low levels of entrepreneurial culture.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

2.1.1 *Spain*

There are pluriannual national plans for R&D and innovation in place, which have a four-year time span. This framework establishes general and broad priorities and specifies the main policy programmes at national level, namely the Spanish State Strategy for Innovation 2010-2015 being an integrated part of the ERA 2020 vision (no budget specified as of yet, nor does the report specify all themes). However, the exact financial distribution of funds is decided in annual action plans. In addition, most regions develop similar R&D plans and on both administrative levels (national and regional) and there coexists a large number of – often overlapping – instruments, programmes and agencies. In fact, there is no clear division of responsibility between national and regional administrative levels and a growing number of specific issues of R&D and innovation policies have been regionalised.

The National Plan for R&D and innovation includes several societal challenges as a priority and they are included as specific 'special actions' related to strategic technological fields such as biotechnology or nanotechnology. The Spanish parliament is processing a new law on sustainable economy that includes the promotion of the new technologies related to the societal challenges such as clean energy and biotechnology, also intended to cause the economy to structurally change from traditional low-tech sectors towards emerging high-tech ones. In addition, some indirect funding is in place via R&D tax incentives, however, the uptake by companies was lower than expected.

Looking at GBOARD distribution, in addition to general university funding, there are three other fields with a high budget: industrial production and technology; transport, telecommunications and other infrastructures; and agriculture. Of the specific areas of societal needs the health sector received the highest budget followed by environment, energy, exploration and exploitation of the earth and education. Agriculture, health and TTI increased their participation while the IPT lost weight in the overall GBOARD.

2.1.2 *Portugal*

Public funding for R&D in Portugal has originated from two main sources: national budget and European funds. It encompasses direct allocations, corresponding to GBAORD, and indirect ones, corresponding to R&D tax incentives. However, non-targeted, broad instruments as prioritised in the Portuguese strategic reference framework have dominated with the overall goal of knowledge base improvement. This is confirmed by the low share of targeted and thematic funding in GBAORD (below 10%).

There are, however, signs that targeted and thematic funding will increase in the future, as: a) reform of government laboratories launched a call to create R&D consortia in specific fields; b) agreement with US Universities and the Fraunhofer Gesellschaft address well-defined thematic areas; c) creation of the Iberian Nanotechnologies Laboratory portrays a specific thematic concern; d) increased involvement in international collaborative initiatives on EU levels and focus within.

Themes such as clean energy, sustainable transport, environmental risks and ageing population health concerns have been addressed by some recent policy initiatives in Portugal. However, the selection of priorities does not stem from a broader participatory process involving the society at large, through which business interests, citizens groups or scientists' organisations are consulted about this issue.

2.1.3 *Greece*

Dependence on structural funds together with planning inefficiencies of the administration have resulted in the fragmentation of planning and funding budgets, which are now distributed across various sectoral or regional operational programmes. However, a multi-annual programming instrument i.e. framework approach is underway - having been postponed due to the crisis - which is supposed to integrate all research and innovation objectives and activities of the ministries in a single action plan concerning a small number of national priorities. At this stage, no specific budget has been allocated to the research priorities. Thematic 'prospects' include green, sustainable development based on knowledge, innovation and human capital.

2.1.4 *Lithuania*

A Lithuanian innovation strategy was published recently which establishes a stable policy framework for STI governance. Anyhow, it has been partially criticised for not following good practice of stakeholder involvement, its limited science-based making and the objectives being too broad. As such, the next generation framework in process responds to these arguments by foresight exercises and getting stakeholders on board.

The major share of funds secured for research and innovation is orientated towards developing public research capacity. A novelty in recent institutional research funding is separating funding into six research fields: social sciences, humanities, art, natural, medical and health sciences, and technology sciences. The rest of national funding is allocated for a set of specific objectives such as fostering R&D in firms, increasing business productivity by supporting acquisition of new technology and increasing collaboration between various actors in the innovation system. Direct support grants is the main type of support funding. Indirect, R&D tax incentives have only been implemented recently.

Specific programme lines either co-ordinating industry-academia implementation or funding in complex technologies focus mostly on the following fields: natural resources and agriculture, biomedicine and biotechnology, materials science, physical and chemical technologies, engineering, information communication technologies, lasers, new materials, nanotechnologies, medical sciences, sustainable environment, mechatronics, civil engineering and transport, cultural and creative industries, marine sector, agriculture, forestry and the food industry. The need for international linkages is stressed in particular within the national complex research programme, however, no national policy addresses this need.
In addition, research councils have approved a list involving future energy, chronic non-infectious diseases, Lithuania's eco-system, climate change and human factor, safe and healthy food, State and the nation: heritage and identity. In 2010, a nuclear power plant was closed, which has partly led to a national energy strategy being introduced, including an explicit research programme on future energy production, supply, and efficient consumption.

2.1.5 *Malta*

Public funding for private R&D has seen an evolution in the type of instruments supported, from those based solely on loan guarantees to a wider mix of fiscal incentives and grants for innovative projects and research and development. However, with 80% of total public R&D investment, block/institutional funding remains the most important source, especially for a single university as well as public research centres, while competitive funding schemes are limited in scope.

The existing, national framework strategy[33] is focused on four broad areas identified through extensive stakeholder consultation and SWOT analysis, i.e. ICT, health & biotechnology, high value-added manufacturing and energy and environment. In addition, as grant schemes are becoming more extensively used, they seem well-aligned with the overall framework approach as being centred on, e.g., financial assistance for environmental preservation, e-business as well as energy conservation and use of alternative energy technologies. Innovative

[33] This seems to reflect the existing industry structure, national competences and embeddedness of global production and R&D chains, i.e. Malta having attracted foreign direct investment in a number of sectors in high value-added manufacturing such as electronics and generic pharmaceuticals beforehand.

cluster funding is in place in closely related areas such as mechanical/electrical design, renewable energies and biotechnology. Some of the research and innovation measures and funds are being mobilised to address societal challenges including energy and climate change and health. In the case of energy, resources have been deployed to build a knowledge base in sustainable energy technologies, e.g., by integrating such subjects in university curricula.

2.1.6 *Latvia*

A multi-annual RDI strategy is in place but its implementation suffers from limited coordination of STI governance bodies and has been postponed due to the crisis. Continuous STI strategy and framework development as well as growth orientation of public R&D budget is safeguarded by a 2006 law stipulating the definition of a set of research priorities every four years (forming the basis for elaborating and implementing corresponding state research programmes) as well as defining the annual increase of R&D financing to comprise no less than 0.15 % of GDP. The most recent, thematic priorities approved include energy and the environment, innovative materials and technologies, national identity, public health and sustainable use of local resources.

Thematic priorities are also reflected in direct funding schemes for competence centres focusing on industrial research, experimental R&D and to purchase research infrastructure, mostly being selected for their return potential and interdisciplinary character: food industry, wood industry, chemical industry (including pharmacy and biotechnology), production of electrical and optical equipment, ICT, mechanical engineering and metal working (including environmentally-friendly, renewable resource-based power industry).

However, the theme selection seems aligned towards political interest rather than being in line with national competences, maybe with the exception of the (internationally competitive) pharmaceutical industry, as private demand for R&D and related funding in these fields is low. In addition, priorities are set based more on the existing capacities of the national economy rather than triggered by the orientation towards the European grand societal challenges identified.

2.1.7 *Estonia*

A second generation multi-annual framework is in place. In general, the role of government funding is particularly important for the intramural R&D activities in HEIs which are predominantly publicly funded (state budget and EU). This is provided via a mix of institutional non-competitive (allocated based on R&D performance evaluations) and project-oriented competitive funding. In contrast, the business sector is much less dependent on the state budget with less than 10% of businesses' total intramural R&D expenses sourced from the state budget, again, mostly provided by project-oriented competitive funding.

A focus on strategic, grand challenges is made explicit through the national R&D programmes. Thematically orientated national R&D programmes on health, environment and ITC and material technology are under preparation in 2010, in addition to existing national R&D programmes, namely, Estonian language and culture in education, energy technology and biotechnology.

In addition, the centres of excellence and competence centres' programmes following either basic or applied research tracks, clearly aim to contribute to resolving challenges in areas such as environment and new materials, health care and medicine, and ICT, although they are not thematically focused.

At a broader policy level, energy, sustainable development and environmental issues are increasingly prioritised. This is reflected in the creation of an explicit climate and energy public agency in 2010 which aims to improve energy security and reduce the environmental impact of current energy providers. In particular, it aims to support and fund educational solutions and ideas in energy innovation.

2.1.8 *Intra-group similarities and differences*

- In most countries there is a weak shift towards indirect funding mechanisms, e.g., R&D tax credits. Nevertheless, direct funding, in particular block funding remains dominant (with the exception of Portugal following a reverse trend). Regardless of the type of funding in place, countries largely depend on EU funding schemes.
- Thematic priorities tackling societal challenges have been added recently (or are underway) to national strategic R&D frameworks including health, energy and climate change issues. This has led to institutional change in STI governance in some places, e.g., creation of climate change agencies, while in other places this may partly account for priorities being perceived as misaligned or as too broad.
- Most correspondents express concerns on the sufficient integration of stakeholders in the way such frameworks have been developed.
- Furthermore, priority selection is often accompanied by supplementary policy goals such as public-private knowledge circulation. However, framework implementation has been postponed (even when safeguarded by law) due to the crisis or suffers from fragmentation and limited coordination of policy efforts.

2.2 Smart fiscal consolidation

2.2.1 *Spain*

The direct impact of the crisis on Spanish GBOARD is ambiguous. The Spanish government's 2009 anti-crisis plan included measures directly related to R&D and innovation (over 16% of the budget). However, the 2010 recovery plan (having a much larger budget) did not include an earmarked R&D budget, although innovation was considered as one of the priorities. In 2009, the GBOARD increased 3.3% while in 2010 this budget decreased by 4.4%. Although the total GBOARD remained more or less stable the percentage devoted to loans and credits increased while the budget for subsidies decreased, i.e. a de facto decrease.

In addition, there is a drop in relative levels of EU funds received from the Framework Programme as well as an expected loss in structural funds. Since the crisis, the control of inward mobility –even for scientists– has become more difficult, also limiting the possibilities to enter Spain as an employee, as related legislation is applied more strictly.

2.2.2 *Portugal*

In spite of the crisis, overall public S&T budget for 2011 has not declined (in some cases even preserving its growth trends) with regard to 2010, with R&D actually being strengthened both in terms of actual R&D spending and in terms of R&D outlays foreseen in the national 2011 budget, e.g., including the tax credit system's budgeting. However, within this process, public resources have been redistributed, leaving some funding addressees behind, e.g., HEI funding dropped by 10% and funding for technology transfer offices was ceased. In addition, HEI and PRO research staff (including public servants) are facing salary cuts and freeze since 2010, despite already being below EU average before the crisis.

2.2.3 *Greece*

The impact of the deficit and debt crisis in Greece on R&D, to some extent, depends on the outcomes of the bailout agreement between Greece, IMF and EU foreseeing a significant reduction of public expenditures until 2013. However, due to the fact that approximately 75% of the competitive research funding comes from structural funds planned public R&D funding is expected to continue until 2015, also since the Greek government has ensured the national co-funding, mainly through loans from the European Investment Bank. On the contrary, institutional funding is expected to be reduced due to researchers and academics' salary cut by approximately 17%[34] and by restructuring the public research sector through mergers. In summary, most responses to the crisis in Greece are not launched on national but on supranational levels.

2.2.4 *Lithuania*

The financial and fiscal crisis facing the Lithuanian economy has negatively impacted on the level of funding available for R&D. In 2009, investments in research suffered a decline as public R&D investments dropped by 15%.

Following the implementation of an economic recovery plan a decision was taken to reallocate structural funds dedicated to public and private R&D measures to those aimed at providing loans for business. Moreover, the government postponed the development of an explicit STI agency as well as the implementation of new innovation measures (e.g., developing greenfield sites and introducing a set of financial and tax incentives) until 2013.

In addition, the crisis increased competition between existing measures of direct support. Due to the high administrative load while preparing the application and implementing projects, businesses choose measures that guarantee 'fast cash' (i.e. direct investment in new production technologies instead of support for long-term R&D or collaboration projects).

2.2.5 *Malta*

The overall economic impacts of the downturn have been mixed in Malta. Whilst the country was not hit by the collapse of global financial markets even though a relatively large, domestic banking and financial sector exists, there were some repercussions on employment which were tackled through additional publicly funded retraining schemes. However, allocations for R&D were already earmarked for particular interventions outlined in national operational programmes, thus, R&D expenditure has only been minimally affected by the crisis, as the structural funds share of the R&D budget has already been committed for the 2007-2013 period and public funds' budget increased in 2011.

2.2.6 *Latvia*

On the whole, it can be argued that at the backdrop of the crisis the role of R&D in the national policy agenda and development strategy has weakened. The reduction of the state budget was carried out by ministries, whereby the budget of the Ministry of Education and Science was reduced by 26% in 2010 (compared to 2009). At the same time the science budget was reduced in an even harsher way by 56%, mostly at the expense of HEIs in order to secure a primary and secondary education budget. In this way, all lines of public funding have seen at least a 50% cut. GERD (as % of GDP) decreased from 0.61% in 2008 to 0.45% in 2009, while the corresponding developments in the Baltic countries showed a positive trend.

[34] According to Ministry of Finance, 17% is the average cut of salaries in the public sector. However, cuts in researchers' salaries could be different in scope.

However, the government has ensured national co-funding necessary for absorption of the EU structural funding, whereas the long-run forecasts with regard to public R&D budgets are gloomier since, in parallel to the implemented austerity measures, Latvia will have to payback the loan granted by the IMF and the EC.

In general, there is a prevalence of short-term measures for cutting budget expenses over long-term national economy development prospects. At the backdrop of the crisis, the government has chosen to place the main (none or little R&D) emphasis on export promotion. In addition, there is a high likelihood of a heavy brain drain and a sudden termination of quality-assuring mechanisms in some funding selection processes has already been experienced due to the crisis.

2.2.7 *Estonia*

In light of declining GDP, most recent statistics suggest that BERD grew by 10% in 2008 (compared to 2007) but fell slightly by 2% in 2009 (compared to 2008). Nevertheless, the share of the business sector in GERD still increased from 43% to 45% in 2008-2009. However, the overall effect on the economy is not clear-cut.

In conclusion, public finances seem to be under control in 2010, the government having used both foreign loans and state guarantee funds to ensure the financial stability of the public sector and its R&D and HEI system investments. Temporary reallocations (unfortunately, the report does not specify any further) of public funding took place across thematic R&D and enterprise policy measures in 2009. GBOARD continues to show steady growth since 2004. However, the high dependence of public R&D funds on EU's structural funding is perceived as a bottleneck to keep stable financing if national R&D funding does not increase significantly in the long-run.

2.2.8 *Intra-group similarities and differences*

- With the exception of Estonia, most countries have experienced medium-to-strong R&D budget cuts due to the crisis, in particular hitting HEI and researchers' salaries hard in science systems. However, most correspondents could not fully assess the overall impact, or argued for ambiguity.
- Only some larger countries have launched recovery packages (having direct or, at least, indirect effect on public R&D funding and business investments, respectively), smaller ones mostly being subject to foreign funding relief, if any, in times of crisis. Anyhow, the latter is perceived as either ensuring public funding in the short-run due to early commitments on co-financing or as the bottleneck to long-term, stable funding (assuming structural funds and IMF lending ending soon, and low business investment not increasing sufficiently in the meantime).
- Smart consolidation efforts were mostly shifting direct R&D funding measures to indirect R&D finance related ones, such as loans or credit for businesses. Furthermore, consolidations included termination of TTO funding and quality assurance mechanisms in funding selection. In addition, competition for funding was expected to shift towards 'fast cash' measures in some countries.

2.3 Efficiency of public support

2.3.1 *Spain*

There are a number of instruments in place promoting technology transfer among public and private agents. However, interaction between science and industry is perceived as underdeveloped (even though some KT indicators, namely business financing of HEI suggest it being at EU-27 averages or higher) and is biased towards polytechnic schools. Budgeting these measures to some extent depends on the EU's cohesion funds (substantially in eligible Spanish regions). The most recent measures in this respect are, among others:

- The 2007 university law made public university professors (civil servants) eligible for three-year sabbatical to launch a company based on technological innovation, being able to return to their post at the university;
- Other, public-private-cooperation specific schemes such as research and industrial clusters, i.e. establishing technology centres, enterprise incubators and science and technology parks, including the CONSOLIDER programme, promoting advanced excellence as well as enhanced technological transfer.

In the case of HEI and PRO excellence, only a few but unsatisfactory polices to increase excellence are implemented, such as the University Strategy 2015 or the Campus of international Excellence Programme. However, neither of the initiatives handles the main barriers for excellence, endogamy, fragmentation and the lack of strategic planning and coordination, making the plans partially useless.

In terms of quality, in the last few years, the selection procedures for most of the tenders for publicly supported projects include criteria on the proposal and researchers' quality based on external peer review, while for the most important type of projects, international experts are involved in the selection procedure. Moreover, some regional governments try to introduce quality criteria to of block funding for HEIs or PROs. In addition, there are no systematic evaluations on PRO and university quality and excellence.

2.3.2 *Portugal*

A number of policies exists fostering knowledge circulation between industry and academia. However, most of the measures seem ineffective, including:

- In the KT domain, the 2009 revision of the university teaching career statute recommended sabbatical periods for university teachers in order to provide services or conduct research projects outside university. However, regulation does not ensure general alignment of this with evaluation criteria currently defined by individual universities which potentially makes transfer activities less attractive;
- Creating TTOs in the main universities and polytechnics, however, public financial support to the latter has been discontinued due to the crisis (see above);
- Within the larger 'Compete' programme, the creation of public-private R&D teams leveraging business R&D investments is supported. Anyhow, the use of RTD vouchers within the programme is below expectations (even though access has been made easier), again, partially because university R&D units have insufficient capacity to provide services to firms;

- Furthermore, most recent, collaborative efforts within clusters and technology poles, are still awaiting assessment but anecdotal evidence suggests significant variance in their performance;
- Support to brokerage and match-making initiatives, is often fine-tuned with EU level initiatives. Again, such activities have had little success so far, but have emphasised excessive academic supply over business demand of knowledge and technologies.

Striving towards excellence supported by public initiatives does not exist in the Portuguese set of STI instruments (as not documented in CC's report). Further progress to the knowledge base remains the key goal, even though scientific output quality has already improved.

There are evaluation practices in place, but on fairly moderate levels. This includes evaluating HEIs and PROs, which already started in the mid-1990s. In general, these activities benefited from a very stable 15-year period in Portuguese STI governance (i.e. the minister responsible for STI did not change in this period with the exception of two years). In addition, internationalisation of the research system is a significant policy concern, although, public funding mechanisms do not make transnational cooperation compulsory.

With respect to evaluating specific institutions in public research, a regulation is in place that assures that 'associated laboratories' are created (emerging since 2000). This label and long-term financing is granted based on evaluating the candidate organisation's capabilities, past performance, and capacity to cooperate in achieving the scientific and technological policy objectives. However, the CC's report does not elaborate any further on specific evaluation criteria or evaluation cycles timing.

2.3.3 *Greece*

Improvement of collaboration between the research and business sector has been a priority in research and innovation policy. However, the impact of the policies so far was poor due to the structural character of the problem (e.g., low competitive funding base and missing infrastructures). Policy efforts include, among others:

- Creation of Technology Transfer Offices at HEI and PROs. However, TTOs failed to deliver the expected results and today only few of them are active.
- Programmes promoting collaboration and technology transfer in specific thematic or regional areas of national interest, e.g., microelectronic cluster.
- Programmes promoting SMEs and new firms, e.g., by providing support for subcontracting public research, or subcontracting small-scale R&D activities (innovation voucher).
- Support for creation of spin-offs including academic ones, focusing on highly knowledge-intensive sectors. However, most academics do not consider this activity as compatible with HEIs' general mission. In addition, since there are no business angels and local VCs are reluctant to support high-risk investments, ministries have made an agreement with incubators and a network of business angels in Silicon Valley to provide assistance to the most promising spin-offs.
- Regulation in place fostering short-term mobility or sharing positions in the public and private sector, e.g., allowance to work part-time for a short period on reduced salary, while retaining status.

Plans to develop thematic, collaborative research networks between research institutes on the base of multiannual research agreements are only just underway.

The Greek HEI system is of low quality having low institutional funding which is not based on performance criteria and has limited academic autonomy, as well as a poor peer review system, as well as geographical fragmentation of HEIs. However, efforts on HEI reform and introduction of evaluation mechanisms are slowly developing, being perceived as a punishment mechanism rather than an incentive scheme.[35] PROs have been systematically evaluated by thematic international expert panels on a 4 to 5-year basis, based on research excellence and justifying additional funding. HEI quality control for research and educational activities was only introduced recently, all faculties undergoing an internal and external quality assessment, with external ones being delayed or rejected by academics.

2.3.4 *Lithuania*

A few policy measures in the knowledge triangle domain exist, even though they are perceived as underdeveloped/have been postponed and not sufficiently funded. In addition, all measures have been introduced only recently, meaning that no evaluations are available yet. These measures include:

- Those related to the development of innovative clusters with the original R&D and partnership infrastructures. However, implementation is suffering as there is a lack of collaboration culture and the high requirements to apply for funding.
- Instruments aiming at the technology transfer environment, more specifically technology incubators and additional technology transfer services at science parks and HEI.
- Pilot measure providing ‘innovation vouchers’ for SMEs was launched and has proven successful and will be extended.
- Some existing direct funding programmes such as the science valley initiative have strong industry-academia aspects attached and are expected to contribute significantly to knowledge circulation in the medium- to long-term.

However, most new measures listed have been postponed due to the crisis. In addition, a higher proportion of funding is allocated for applied sciences as an attempt to foster collaboration of PROs with the business sector.

As the Lithuanian research and innovation system suffers from an imbalance of the relatively high inputs in research (public funds for R&D and available human resources) and an extremely low scientific output, block funding allocation is increasingly based on quality and outputs performance of research. Recent legislation has also led to appointing explicit actors within STI governance, now responsible for evaluating scientific production. Half of the allocated funds in block funding now depends on the number of researchers employed, and half on the results achieved (e.g., bibliometric indicators and peer review evaluation are applied). More specifically, recent changes in legislation towards PROs and HEIs monitoring also establish an external evaluation to be performed every 6 years by national and invited foreign peers, as well as self-evaluation reports every 3 years. Results will be tied not only to allocation of funds but also research institute accreditation. As such, the recent period demonstrated a shift in government attitude towards policy accountability and policy learning.

[35] Given the fact that many of the problems identified by the evaluations are largely influenced by public policy, e.g., low quality of public infrastructures, or inadequate funding levels.

2.3.5 *Malta*

Reinforcing collaboration between the university, the public sector and industry is one of the policy priorities, as evidenced by an increased number of measures and disbursement of funds to support collaborative activities. These include, among others:

- In addition to (traditional) contracts, research thematic funding approaches are often implemented jointly by private and public stakeholders, and project selection focuses on existing or emerging competencies at the university. In addition, innovation platforms for collaborative research are being/have been established.
- Public support for emerging, bottom-up industrial clusters to encourage research and innovation activity in industry and academia.
- Inter-sectoral mobility occurs through fixed-term placements in industry, e.g., public programmes encouraging student placements in vocational, industrial training both locally and abroad. Inter-sectoral researcher mobility is less common.

In general, selecting the topics within the strategic national R&D framework was partly led by policy concerns on inter-sectoral activities.

As Maltese policy evaluation culture is only developing, more advanced practices are due to EU funding scheme participation (and requirements of evaluation and monitoring within), e.g., FPs. In this way, the latter have not only exposed national research actors to EU level R&D competition but also improved existing modes of evaluation. For example, an informal review of the national R&D funding programmes undertaken in 2009 indicated an impact on training (PhDs), publications, patents and start-up creation, suggesting that project proposal selection was being increasingly based on international peer review. In addition, the university put an internal quality assurance framework in place for academic staff career progression, which considers research output, the number of courses taught, course content, students' feedback, new course development and teaching effectiveness among other factors. To date, STI governance has not focused on promoting excellence in science.

2.3.6 *Latvia*

There are a few, little effective instruments in the knowledge triangle in place, however, most innovation activities by companies have not involved collaboration with academia, with a comparatively little share of entrepreneurs treating such collaboration as meaningful. Instruments include, among others:

- Support for technology transfer offices at HEIs;
- Programmes envisaging support for applied research projects potentially facilitating the integration of science and industry in the thematic fields specified above;
- Collaborative programmes, including industry-academia links, such as the competence centres;
- An equi-important role of international technology transfer funding schemes stemming from the dependence of public R&D budgets on EU structural funds.

A lot of these transfer-related programmes have been modified or sometimes deleted due to limited responsiveness of companies and HEIs, limited public funding and structural weakness of the economy, especially knowledge demand and absorptive capacity of the private sector. Policies supporting entrepreneurial academics are not in place nor is such activity commonplace.

Latvia is the least performing country among those 'catching up' in the EU, in terms of its knowledge base and scientific production. It is currently not complying with international scientific community standards, e.g., with respect to peer review system. Therefore, the focus is on quality assurance rather than excellence. There is no quality monitoring system in place yet, nevertheless research institutes are applying for large tenders, institutional funding allocation output indicators emerge as binding criteria, and the first ex-post evaluations are underway.

2.3.7 *Estonia*

There are a considerable number of policy measures aimed at increasing extramural R&D by enterprise and public sector collaboration, support for HEI research commercialisation and knowledge transfer in place, most of them co-financed by the EU. These measures include:

- The SPINNO programme, which appears to be successful in promoting IPR and spin-off creation at HEIs. However, with the exception of two large universities offering quite advanced transfer-related services, TTOs have not been established at individual HEI levels, but a public national institute/agency is in place providing support services to emerging academic research groups across universities and free of charge.
- Innovation vouchers and product development grants.
- Large-budget competence centres and cluster instruments seem to effectively confront public-private cooperation barriers on both sides. For example, for HEIs, the need for clear strategies and improvements in administration, ability to manage IPR, boosting industrial doctoral studies and, on the industrial side, improve technology absorption and high-tech product and process development capacities.
- University representatives participate in governing bodies of science and technology parks which appears to be a sound way to get access to business feedback.
- However, the cumulative effect on knowledge circulation remains unclear (with the exception of the third point as there is no evaluation data on performance and impact available, partly given how new some measures are). Nevertheless, these programmes are very popular with the target groups and the respective funding has always been fully used.

A fairly advanced performance-orientated system has been put in place, to monitor and review the quality and performance of knowledge production by the academic sector, not including socio-economic impact assessments. This is safeguarded by a legal framework assuring that all R&D institutions operating as a public legal entity (like all public universities) should be registered and evaluated at least once every eight years, institutional and targeted financing being directly linked to evaluation results. However, the relatively long period between evaluations is a main weakness of the system, especially compared with its rather efficient, high-quality processes: evaluation committees are typically formed by independent experts (half of which are foreign) carrying out evaluations according to transparent rules and evaluation ethics.

Even though the Estonian HEI system seems to be rather competitive and comparable to the EU-27 average, explicit excellence initiatives are seldom. A notable exception are the centres of excellence established, aiming at collaborative R&D efforts across institutions and research groups, as well as side-effects on excellence in applied sciences by the competence centre approach (as highlighted in the knowledge transfer context).

2.3.8 *Intra-group similarities and differences*

- A variety of instruments associated with knowledge transfer exists across all countries. However, in most countries the measures undertaken lack effectiveness (e.g., in terms of responsiveness of businesses and HEIs, notwithstanding structural features of economies and systemic failure) and have, therefore been modified recently or newly introduced. One notable, promising exception within the sample is Estonia.
- 'Classic' instruments such as innovation clusters, technology platforms or TTO funding have been expanded to SME-focused innovation vouchers, legislative change fostering student or researcher mobility, close-to-market product development grants and academic spin-off policies.
- Some of the policies in this specific field have been fine-tuned with EU level initiatives, most likely due to either funding requirements or rent-seeking behaviour among MS.
- In a few countries overall funding allocation (ex ante) has been altered towards applied science institutions with the aim of empowering technology transferred investment (ex post).
- Lack of scientific excellence in most countries, and no such policies being in place, maybe Spain and Estonia being the exceptions with only a few, not very effective initiatives undertaken.
- Evaluation practice is only developing, with an increasing focus on block funding, high monitoring and evaluation requirements related to EU funding seemingly leveraging national efforts. Again, notable exceptions are Estonia and Lithuania where safeguarding national legislation for continuity of and quality criteria for such practices exists.

2.4 Framework conditions for business R&D and innovation

2.4.1 *Spain*

It is debated as to whether there is a lack of venture capital for start-up and SMEs (especially considering that the financial markets are drying up) or if there is a lack of good proposal to finance. Pro-active policy based on financial support and public match-making activities for entrepreneurs only exist mostly on a few regional levels, but they do not withstand R&D tax credit schemes on national levels. Adjustment of framework conditions addressing risk capitalist's needs are missing at both national and regional levels of STI governance.

Being in a preliminary phase of policy-making, public procurement was highlighted for the first time in the national strategic framework for innovation, predicting that public procurement associated with acquiring innovative goods and services would be EUR1,262m in 2010. In this respect, the key STI national ministry is in charge of presenting the annual innovation procurement proposal, indicating that the percentage of budgets for departments and (other) ministries devoted to such acquisitions, however no budgets or control/sanctioning efforts on misconduct are specified.

2.4.2 *Portugal*

As outlined in the challenges section, there is limited access to venture capital, international marketing capabilities and business angel expertise in the Portuguese economy. One of the mechanisms addressing capital needs of new technology-based firms is a 2006-launched programme wherein the government shares the risk with venture capital firms and other financial agents by providing guarantees to the new firms seeking capital. However, no changes to financing framework conditions have been made.

Establishment of several procurement initiatives is underway but rather ad hoc and occasional in nature, e.g., development of a scheme which distributes a notebook computer to all primary school children in the country. In the absence of an independent evaluation, it is difficult to determine whether it is effectively stimulating R&D and technological capabilities of domestic manufacturers. Another recent example is clustering of activities focusing on electric mobility. However, procurement policy is still marginal relative to public investment policy budgets, as the main focus continues to be the construction of a high-speed train link to Madrid and other conventional infrastructures which may have little innovation impact.

2.4.3 *Greece*

The most recent attempt of reform initiated by ministries (in the domain of regional development) regarding framework conditions for R&D finance is a change in investment laws on tax incentives for subsidies. In addition, regulatory efforts are in process which accelerate procedures for creating new firms and improve the regulatory framework for developing industrial areas and business parks. This complements public risk capital funds and credit guarantees to innovative entrepreneurs, the latter having a weak thematic focus on eco-innovation and green investments (please note that all measures are still under public consultation).

Public procurement is perceived as an important mechanism for stimulating private innovation and R&D, but no such policy is implemented as there is a lack of transparency. Furthermore, existing corruption in the public sector undermines the potential of public procurements. The government is currently reorganising the procurement system by increasing central control and improving procedures in specific areas, e.g., the health system.

2.4.4 *Lithuania*

There are no specific financial or fiscal incentives for starting a business, except for a single measure, however, the set of measures aimed at improving business access to finance are manifold. Some funds aim to improve SME access to external funding sources, e.g., by micro-crediting, venture capital fund investments, guarantees for financial obligations or partial compensation of investment credit interests. In addition, as mentioned before in the smart fiscal consolidation section, funds were reallocated to venture capital funds within the recovery plan. However, favourable financing conditions are not accompanied by measures aimed at specifically supporting spin-offs, e.g., seed capital funds at either universities or public funding agencies are non-existent, which may hamper overall effectiveness of these framework adjustments.

Demand-side policies such as innovative public procurement seem underdeveloped or very preliminary as well as being at informational and learning stages – relative to national supply-side policies. Anyhow, only recently, regulatory changes on public procurement have been implementing EC directive provisions allowing contracting authorities to procure innovative products, services or projects through a competitive dialogue procedure, to describe a wanted product through functional specification, and desired performance, so that alternative proposals and preliminary contracts can be offered. In addition, a coherent procurement strategy is still being defined, the primary tasks being now to collect, synthesise and spread information about existing innovative public procurement activities and processes, including good practices regulations, activities and exchanges performed in other countries.

2.4.5 *Malta*

There is still a severe lack of venture capital funds, despite a number of policy attempts to introduce them, having had only limited effectiveness. However, the government seeks to simplify administrative procedures for entities starting up and/or running a business, including the creation of a single contact point to access relevant information as well as R&D tax credit and microcredit schemes focusing on SMEs. In addition, a considerable number of grants issued (regardless of firm size) were centred in specific themes such as diffusion of eco-innovations and alternative energy technologies in industry, and e-business measures.

Innovation procurement initiatives are only developing in specific projects and are at informational rather than implementation phases, e.g., activities mapping the extent of such procurement measures and initiatives adopted across ministries and public sector agencies. However, most recently a thematic approach, namely green public procurement, is emerging that aims to embed green criteria in public tendering procedures for products and services. A reviewing mechanism is currently established for all tender dossiers before publication. Moreover, sustainable development has been incorporated as one of the horizontal priorities that bear weight in the selection criteria of structural funds projects, including procurement related ones.

2.4.6 *Latvia*

There are no existing or emerging procurement initiatives with respect to innovation leverage. Similar holds for entrepreneurial culture and related financing policies, making a discussion of framework conditions obsolete.

2.4.7 *Estonia*

There are an explicit, national entrepreneurship strategy and a favourable regulatory framework in place supporting entrepreneurship, the latter focusing mostly on actors more than on investors in such activities (e.g. simple new business registration, e-taxation, liberal employment laws, and particularly taxation policies). Existing policy efforts, currently being expanded in the field, are mainly dedicated to promoting general entrepreneurship and developing entrepreneurial culture, the exception being public seed-capital investment funds into high-growth, technology-intensive, early-stage firms.
Innovation-oriented procurement policies are at an initial development phase and, mostly, take the form of one-off initiatives or focus on specific elements of regular procurement procedures. There is no visible political or organisational leadership in place to define a more systematic, comprehensive approach. A recently-issued, procurement-related law also regulates 'competitions on ideas' but there is no reliable data on how often and in which fields such competitions occur. However, a few, one-off examples include procurement in the defence sector, e.g., having a tech transfer and innovation component within, as well as e-government policies leading to systematic, large-scale procurement from ICT providers (e.g. creating novel technology platforms for e-voting, e-health, e-customs and e-taxation).

2.4.8 *Intra-group similarities and differences*

- Regulatory changes to R&D's financial framework conditions are generally not undertaken, while public or public-private guarantees or capital funds are becoming more commonplace, often with a focus on high-growth actors and/or in high-tech or high-priority fields. A notable, unfortunately negative exception within the group is Latvia.

- In general, instruments seem to have flourished in the specific context of the recent crisis, making governments more prone to share risk within the private sector.
- In most countries such policies aim at either existing SMEs and/or entrepreneurs. In addition, some entrepreneurial policy mixes target entrepreneurs as well as their financers. In any case, the evidence on countries suggests that coherent approaches are more effective than other, singular ones.
- Innovation procurement is not in place (Latvia and Greece) or at very preliminary stages across most other countries, often initial development triggered by EU level initiatives. Only collecting and diffusing information on best practices is being performed.
- If any are implemented, they are initiatives one-off and marginal in nature, having a thematic focus, e.g., green procurement or e-government, or have co-existing technology transfer policy objectives, e.g., initiatives in the defence sector.

Appendix 6

Country Group 6 - Challenges and policy responses

Cyprus

1.0 Main challenges confronting the national R&I system

- Ratio of GERD to GDP is 0.46% (2009)[36], being among the lowest in the EU and predominantly financed by the public sector. In addition, the R&D budget was negatively affected by the crisis, showing a decrease from 2007 to 2008;
- Lack of clear strategic research priorities resulting in allocation of funds being too broad among different research themes;
- Frequent delays in launching and implementing policy measures;
- RTDI governance is weak but improving with modern structure creation;
- Inadequate science-industry dialogue. Lack of university-industry cooperation tradition and culture;
- Persistent low knowledge demand from business sector, mainly due to its structural composition;
- The business sector has not developed an innovation culture and is only very slowly adapting to knowledge-based competition;
- System is unable to provide an adequate knowledge exploitation.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

Despite the impressive recent growth of research, focused strategic approach is still lacking, resulting in fund allocation being too broad among different research themes. Research is financed mainly through the multi-annual National Framework Programme for Research and Technological Development (DESMI) which targets a broad spectrum of multi-thematic research projects in pre-selected fields (manufacturing technologies, ICT, sustainable development, health and bio-sciences, and social sciences and humanities).

Research in the formal grand societal challenges is supported through the Sustainable Development programme (EUR1.73m) which allocates funds to projects on sustainable urban development, recycling, urban waste management, pollution control and protection. Some other relevant topics such as health and environment are also addressed under the Health and Biological Sciences programme funded with EUR2.5m. Environment and Public Health is also supported through the joint venture with Harvard, the Cyprus International Institute (CII) for the Environment and Public Health. Another top class venture is the Cyprus Institute (CyI) operating three Research Centres[37] in research fields considered top priority by the Cypriot society.

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[36] EUROSTAT (provisional data)

[37] The Energy, Environment and Water Research Centre (EEWRC), the Science and Technology in Archaeology Research Centre (STARC) and the Computation-based Science and Technology Research Centre (CSTRC).

2.2 Smart fiscal consolidation

A positive trend of the public R&D expenditure is observed over recent years, attributed mainly to a considerable expansion of research activities in the public sector. However, despite significant efforts, Cyprus remains among EU countries with the lowest R&D expenditure levels and even lower BERD levels.

Exhibit 1 Cyprus – Basic statistics

	2006	2007	2008	2009	EU average (2008)
GDP growth rate	4.1%	5.1%	3.6%		0.5%
R&D intensity (GERD as % of GDP)	0.43%	0.44%	0.42%	0.46	1.9%
GERD per capita	81.4	90.4	100.5	97.8	479.2
GBAORD as % of GDP	0.32%	0.42%	0.42%		0.71%
Business sector R&D intensity	0.1%	0.1%	0.1%	-	1.21%

The main instrument, through which the national policy is applied, is the multi-annual National Framework Programme for Research and Technological Development (DESMI) for 2009-2010. In 2008, due to the economic crisis and internal organisational delays this faced a budget cut of about 35%. Although RTDI is among the eight key priorities of the National Strategic Development Plan (NSDP) 2007-2013, the strategy is not accompanied by any Action Plan. The positive sign is that the first steps towards the adoption of a coherent research and innovation strategy were already made: a draft of the first long-term National RTDI was elaborated. Upon the approval of the Strategy, the Action Plan towards the ERA 2020 vision will be prepared.

2.3 Efficiency of public support

RTDI governance is weak but improving with modern structure creation. The RTDI system in Cyprus developed in the mid 1990s partly following pressure for adapting to the '*acquis communautaire*'. The governance of the system is still in a transition period, the restructuring being aimed to increase efficiency and modernise cooperation between different actors. The new governance system allows (if operating correctly) for better coordination and a more focused approach. The education and research policies and systems compared to innovation are significantly better developed and have achieved more progress. Nevertheless, the new long-term strategic approach should consolidate the knowledge triangle coordination under the single policy framework.

The Cypriot higher education system is very young with its first (and only until 2006) university being established in 1992. The public core funding is the main financial source in Cypriot public universities, reaching 78% of the total budget in 2008. There are no funding formulas or specific criteria used to define the levels of block funding for universities. However, the research undertaken in universities is financed mainly via competitive bidding procedures for specific research programmes. Given the size and the short term history of the national HE sector, there may not be rationale for shifting the funding balance towards more competitive funding.

The research performance is rather low. In terms of EPO patenting, Cyprus ranks only at about 21% of the European average. The low rate in patenting is part of the general 'picture' of the local R&D system characterised by extremely limited levels of exploitation of research results. The system's performance is deteriorating instead of improving, while the lack of evaluation culture creates unfavourable framework for evidence-based policy making.

Links between public and private R&D sectors are almost non-existent. The 0.2% contribution of the industry and non-governmental sector to the R&D performed by the HEIs is a good indication of this situation. The government has recognised the problem and the importance of such links. Consequently the topic has recently become a priority in the policy agenda. There are several measures under the national R&D plan supporting public-private collaboration. For example, two new measures were introduced for 2009-2010, the 'Mediation Centres for Research and Innovation' and the 'Innovation Clusters', however they were never announced due to budget cuts. The development and operation of Liaison Offices in universities is also aimed to improve the collaboration with firms. Four business incubators have been developed to spin-out knowledge to the market.

Although there is strong willingness of the government to bridge the gap between academia and industry, the enterprises' interest in research and innovation remains very weak. This situation is mainly generated by industry structure. However another important reason is that the business culture has not changed regardless of policy efforts: companies do not apply for grants and under-exploit the incentives offered.

Taking into consideration that the education and research policies were developed later in Cyprus (only in the last two decades), as well as the constraints concerning size and the island's peripheral location, progress is important, yet far from having achieved a satisfactory level.

2.4 Framework conditions for business R&D and innovation

BERD levels are very low, businesses contributing to only 17.8% of overall GERD (EUROSTAT, 2008).

As mentioned before the education system has progressed and political interest in education is evident: 1.61% of GDP public expenditure on tertiary education is well above the EU average (1.12%). HRST share aged 25-64 reaches 43%. However, the low S&E graduate rates in combination with low life-long learning levels (88% of the EU average, EIS 2009) creates unfavourable frameworks for development of highly-skilled human resources in research. On the other side, the national public system in comparison with the private one offers very attractive conditions for researchers: high salaries, coupled with other incentives, making research in the public system a highly attractive career in Cyprus.[38] While this situation is positive, meant to reverse brain drain, the downside is that the private R&D performing sector cannot compete with the public R&D system. The lack of adequate national RIs may further impede the business sector to perform R&D activities in Cyprus.

The Cypriot research system relies almost exclusively on direct support. Venture capital is almost non-existent. Introducing tax allowances was studied and rejected, as corporate tax is already so low that it would not be a credible incentive to make R&D investment tax free. However, tax exemptions are offered to academic institutions operating under a 'non-profit' status as well as reductions for acquiring research-related equipment. There is a serious lack or even absence of the lead market initiatives. Regarding the public procurement for innovation some progress was made with the approval of the National Action Plan for Green

[38] The annual average salary of a researcher is slightly more than EUR45,000, a figure well above the EU-25

Public Procurement in 2007. Innovation support in the form of innovation vouchers has been in place since 2008 with business enterprises being the main funding recipients.

Another challenge of the system is that there has historically been limited demand for IPR protection. The new ‘Patents’ action aims at motivating individuals, research organisations and enterprises to file patent applications.

This overall negative situation is very much linked to the limited business response: companies are not requesting the public sector to take such initiatives. There is very low knowledge demand from the business sector, mainly due to its structural composition: the service sector is the most dynamic economic sector (tourism, followed by financial services and real estate). Most enterprises tend to concentrate on low added-value activities, the role of the business community remaining marginal. The financial crisis has further deteriorated an already unfavourable context: contraction of revenues, reduced bank liquidity and negative business expectations discourage firms from risky investments. No matter how effective the knowledge production will become it risks becoming irrelevant for national well being, if demand and exploitation do not increase. This situation is difficult to tackle at the level of research and innovation policy: the absorptive capacity of the business sector is limited due to the economy structure.

Appendix 7

Country Group 7 - Challenges and policy responses

Czech Republic, Slovenia, Slovakia, Hungary and Italy

1.0 Main challenges confronting national R&I systems

At the turn of the century all countries in the group "medium-low knowledge capacity with an important industrial base", started off on levels significantly below EU average in terms of R&D expenditure (GERD) per GDP. However, the Czech Republic, Slovenia and Hungary were successfully catching-up having well-above EU-average GERD growth. Slovakia and Italy did not, Slovakia being an exception among the group's 2004 accession states. Despite most recent developments (2008-2009) in the context of the financial and economic crisis, weakly increasing GERD ratios are observed within the subset of catching-up countries.

Exhibit 1 Trends in GERD

	2000	2008	2009	Variation of nominal GERD 2000-2008	Variation of nominal GERD 2008-2009
EU-27	1.86	1.92	2.01	38%	-1%
Czech Republic	1.21	1.47	1.53	104%	2%
Slovenia	1.39	1.65	1.86	140%	6%
Slovakia	0.65	0.47	0.48	56%	-4%
Hungary	0.79	1	1.15	153%	12%
Italy	1.05	1.23	1.27	55%	+/-0%

1.1 Czech Republic

- Fragmentation of the public funding landscape, even though some progress has been made by consolidating project-based funding efforts;
- Insufficient horizontal coordination between research and innovation policies as well as limited coherence with sectoral policy approaches;
- Global economic crisis triggered budget cuts in public and private R&D spending;
- Insufficient concentration of financial and human resources for excellence, HEI reform underway but not implemented yet. In addition, a strive towards excellence is hindered by limited advancement in evaluation practices;
- There is a significant lack of R&D personnel and graduates in S&T fields, both in the public and private sectors;
- Lack of international mobility, e.g., low national participation in international schemes due to limited researcher awareness;
- Low output productivity of public and private R&D;
- Low levels of business R&D expenditures and a low share of high-tech industry and services, often favouring purchase of external know-how over own R&D investments;
- Weak R&D links between universities and companies as evidenced by a low proportion of R&D performed by universities and funded by business sector. In

addition, missing intermediary services and unfavourable conditions for academic spin-offs, and a limited support to inter-sectoral researcher mobility, restrict technology and knowledge transferred;
- Support to commercial financing sources, such as private equity and venture capital, is underdeveloped.

1.2 Slovenia

- Low absorption capacity of SMEs while unfavourable economic climate may deter further SMEs risk-taking and investing in R&D;
- Lack of coordination and transparency of the STI governance, in particular with respect to knowledge and technology transfer policies;
- Thematic priority setting (including societal challenges) and public R&D allocation is undergoing a process of restructuring; however the implementation suffers from limited integration and translation mechanisms of business and public stakeholders' needs as well as general society opinion;
- Limited openness and attractiveness of research labour market, in particular HEI working conditions;
- Planned HEI reforms are perceived as having a lack of financial sustainability: some PROs are especially being reluctant to increasing business sector funding (and associated dependency);
- Emerging evaluation system causes controversy among stakeholders, e.g., lobbying on favourable evaluation criteria and methodological concerns arising due to small business and academic communities.

1.3 Slovakia

- Slovakia has a dual economy: on the one hand, multinational companies with world-class technology developed abroad and high productivity manufacturing; and on the other hand, domestic SMEs with low productivity levels and low R&D intensity;
- Domestic SMEs have limited absorption capacity and partly neglect cooperation with multinationals;
- Low focus on thematic priorities on the STI agenda leading to further fragmentation of limited public R&D resources;
- Misconduct in STI governance such as corruption and misallocation of public resources, public R&D resources being largely dependent on EU structural funding;
- Very little public R&D resources provided for international co-operation in science and technology and low national participation to EU R&D programmes;
- Quality of scientific output is low and is not leveraged by its underdeveloped evaluation culture; HEI reforms lags behind growth in student numbers and widespread misconduct in science system such as plagiarism;
- Unattractive working conditions for researchers leading to researcher and student brain drain; however the low wages potentially attracted multinationals in the first place;
- Defunct capital market discourages venture capital activities.

1.4 Hungary

- GDP contracted by almost 7% in 2009, leaving Hungary heavily indebted. The government launched a one-year 'crisis management' programme, aimed at restoring market stability and reducing the budget deficit; structural reform initiatives were put on halt. Without these reforms, framework conditions for RTDI activities cannot be improved, nor can the impacts of public support be enhanced;

- STI policy-makers cannot influence the policy agenda, as indicated by the unexpected action to block HUF16bn from the Research and Technological Innovation Fund in June 2010;
- Currently, the macroeconomic situation, the structure of the economy, the overall framework conditions for R&D have very unfavourable impacts on RTDI activities of firms. The STI policy cannot counterbalance these effects and it is unlikely that R&D investment targets can be achieved simply by providing more public funding;
- The bulk of BERD is performed by foreign-owned firms and their RTDI activities are largely determined by their parents' strategies, while domestic STI policies can play a relatively minor role. Therefore, structural reasons, that are difficult to address even by overall economic policies, let alone STI policies, can be regarded as obstacles;
- STI policy evaluation culture is weakly developed in Hungary;
- STI policy governance structures have been frequently reorganised. The highest coordination body has only worked intermittently. A related risk is the lack of an overall, strong consensus among stakeholders and policy-makers on the desired objectives and instruments, leading to an unpredictable policy environment;
- In the same context of governance instability, various plans have not been efficiently put into practice or remained largely on paper. Given the large number of STI policy measures, well-targeted efforts are needed, streamlining the portfolio of measures to avoid overlaps and make it more transparent;
- Volatile macroeconomic environment for businesses. High interest rates and crowding out effect of the mounting fiscal deficit. Market conditions are not conducive to RTDI activities.

1.5 Italy

- Coordination between the two research governing ministries, Ministry of Education, University and Research, and the Ministry of Economic Development has been weak, which created the traditional separation of the national system between research and innovation;
- The system has been lacking efficient implementation of the measures, continuity of policy and revision based on a systemic evaluation;
- Italy has the lowest number of researchers per unit of GDP among industrialised countries and the lowest percentage of researchers in the active population;
- Fragmentation and dispersion have characterised the national public incentive system for a long time, based on many small measures (launch of several calls with relatively small budgets). This trend is now changing and efforts are directed to concentrate the resources to finance large projects on specific key strategic areas/sectors (e.g. industrial innovation projects).

1.6 Intra-group similarities and differences

- Insufficient horizontal coordination among policies in the STI domain, lack of coherence with industrial policies and general weak institutional efforts on implementation, e.g., including misconduct of agencies, limited transparency and strong fragmentation of public funding.

- In half of the countries, establishing thematic priorities is still under intense general public and academic debate or is currently undergoing restructuring, since it has been accused of not sufficiently involving stakeholders and/or hindering implementation.
- As systemic evaluation schemes and HEI reforms have only recently started being developed, fostering quality and productivity of scientific activities has not been very successful; HEI and PRO performance remaining relatively low.
- In addition, R&D labour markets have limited openness and attractiveness, in particular for HEI employment. High brain drains are therefore reported in almost all countries, accompanied by limited national participation in international R&D schemes.
- Structural features of most economies favour low R&D intensity of SMEs and limited cooperation activities with foreign multinationals active in home markets as well as with national academia.
- Unfavourable conditions for spin-offs and generally for start-ups in some countries as well as a lack of private equity and venture capital for financing the former.

2.0 Policy Responses

2.1 Grand challenges and thematic priorities

2.1.1 *Czech Republic*
A strategic framework for defining priorities in research and innovation including societal challenges is in place, mostly reflecting the orientation of national science and industry systems. Related thematic R&D funding schemes are based on the following priorities: sustainable prosperity, healthy and quality of life, IT for a knowledge-based society, socio-economic development of the Czech society, and three cross-cutting programmes, on human resources, international cooperation, support for preparing and implementing a national policy including technical assistance. However, in some fields/activities of the framework, implementation is in progress and further fine-tuning with industrial policy measures will be required. On-going institutional reforms starting in 2009 are an attempt of establishing two national one-shop funding agencies, one for basic research and the other for applied/industrial research.
In the Czech R&D system, three main modes of public funding are applied, institutional funding, project-based funding and fiscal incentives, whereas institutional and project-based funding is almost balanced in scope. Again, as with implementation of national thematic R&D priorities, public support is to some extent disregarding excellence in disciplines, institutes, teams.

2.1.2 *Slovenia*
A national strategic framework is only emerging focusing on the period 2011-2020. In this way, thematic priorities are yet to be established. In opposition, there is even countervailing evidence from the report suggesting an enforced bottom-up trend in STI governance, e.g., a gradual shift in the financing structure was planned with a relative reduction of programme financing in favour of a project-based one, although it has yet been implemented.

To improve knowledge demand identification, as well as business opportunities, the government has established a council whose objective is to bring the actors in public research organisations and the business community together in ‘development groups’ of 10. These aim to give recommendations on future public R&D funding allocation, but under the aegis of industrial policy. Yet, as the first review suggests, the impact of their work has yet to be translated in the stakeholders' main funding priorities.

In addition, no structured effort to focus the research towards major societal challenges has been initiated with the exception of a few funded projects where results were directly fed into policy-making processes. There are also a few minor scope support programmes with thematic drive in place, directed at specific themes such as technology for security and peace. Within the planned strategic framework the government also proposes a shift from individual programme funding to higher shares of institutional funding, both for public R&D institutions as for HEIs, but at the same time it expects more ambitious institute involvement in engaging with business sector to finance more of their research activity.

2.1.3 *Slovakia*

The strategic STI framework launched in 2007 contains a number of thematic priorities including health, new materials and technologies, biotechnologies, ICT, social infrastructure, energy, civilisation challenges, culture and art heritage, defence and security, biological resources, environment and efficient use of domestic raw materials. In this way, priorities have been rather broadly defined, potentially being misaligned or not being very focused on the small research system and limited public resources available. In addition, the framework (and related documents) mentions several important societal challenges to be addressed by research such as energy/climate change, health, ageing and sustainable development, but no budgets for specific priorities/challenges have been specified. However, the framework seems to contribute to a better integration of policies related to the knowledge triangle improving policy coordination.

In fact, over 80% of public support is channelled to non-oriented research and institutional funding, partly accounting for the fact that Slovak research lacks a strong thematic focus. Top-down, thematic programme funding is, therefore, rather the exception, e.g. specific programmes targeting healthy lifestyles and culture heritage (ending soon). In general, Slovak research funding almost exclusively relies on grants, indirect funding such as tax incentives being introduced more recently. However, public research system funding increasingly relies on European resources.

2.1.4 *Hungary*

The government's mid-term STI policy strategy explicitly determines several priorities for R&D activities. The strategy determines first 'Key technology areas' such as ICT, life sciences and biotechnology; materials science and nanotechnology; technologies of renewable energy resources; environmental technologies. Second, these S&T opportunities are supposed to be translated into economic success in 'knowledge-based industries': IT and electronics industry; engineering and vehicle manufacturing; pharmaceutical industry; chemical industry; food manufacturing industry; innovative service industry. Furthermore, besides Budapest, six so-called 'development poles' have been defined with specific priority fields of science and industry sectors.
Biotechnology, ICT and nanotechnology have been prioritised as specific research fields for cross-border knowledge circulation.

2.1.5 *Italy*

The National Research Programme 2010-2012 identifies six R&D thematic priorities in the following fields: genetics; energy; materials; technologies linked to the working of the brain; information technologies; environment. Particular attention is devoted to corresponding enabling technologies and their diffusion within industrial innovation programmes. The *Industria 2015 programme* of the Ministry of Economic Development is going to include some of these technological areas.

Public demand expressed by GBAORD is mainly concentrated in research financed by general university funds (GUF), industrial production and technology, and protection, improving human health, and exploration/exploitation of space (respectively 37.7%, 12.8%, 9.3% and 7.5%, respectively). A significant quota is also devoted to non-oriented research (9.7%). The relevant concentration of government funding on aerospace, health and industry is also reflected in government funding of business R&D expenditure, which represents more than 12% of BERD. Among the sectors, aerospace attracts the highest share amounting to 29% of the total government funding, while pharmaceuticals is at the sixth position with 4.3%.

2.1.6 *Intra-group similarities and differences*

- National strategic frameworks currently existent in most countries. However, implementation is only partially completed or has yet to start, often missing out budgets specifications in new or existing funding schemes.
- Countries that are yet to have such frameworks in place are either following a bottom-up, indirect mechanism track of STI policy-making (Slovenia) or heavily rely on non-orientated and institutional funding (Slovakia).
- If in place, thematic priority frameworks focus on ICT, renewable energy, health and biotechnology sectors (among other fields, mostly depending on industrial specialisation). Reliance on EU public funding is likely to have originally affected priority setting outcomes (at least, as far as inclusion of societal challenges are concerned).
- Interestingly, in some countries framework setting exercises have triggered institutional change in STI governance, likely to heal funding fragmentation to a certain degree (Czech Republic), leading to better coordination across STI policies (Slovakia) or enhancing articulation of STI stakeholder opinions in future exercises (Slovenia).

2.2 *Smart fiscal consolidation*

2.2.1 *Czech Republic*

Since national R&D framework strategy was designed before the crisis it does not fully reflect the current environment of recent implementation efforts, i.e. strict budget constraints put on public spending, however, public R&D and education systems' budgets are left uncut and are stagnating. Furthermore, since it is a small country, national SMEs primarily focusing on exporting activities suffer from global stagnation, also having a negative impact on their R&D investments. The report does not attempt to assess the crisis' impact on overall, public and private R&D spending, nor does it explain in greater detail how public R&D budgets were preserved.

However, fortunately, political will seems to be reinforced in order to challenge ongoing reforms of the research, development, and innovation governance system as well as modernisation and reform of tertiary education and education systems in general.

2.2.2 *Slovenia*

For 2009, the business sector's share dropped from 63% to 58% in total R&D funding while the government's share increased from 31% to 36%, compared to 2008, partly due to the government's crisis package. At the same time, R&D from abroad, including the EU's structural funds, increased, being an important source of funding. Interestingly, R&D policy makers were swift in suggesting new measures to prevent a potential stronger decrease of business sector R&D investment such as new, dedicated support scheme to SMEs' R&D activities. In this way, they were able to mobilise additional resources within the R&D crisis package as well as redirect some funds within the European Regional Development Fund for R&D (competence centres in 2010), i.e. a reallocation from infrastructure projects to the R&D sector.

This as well as the overall increase in GBOARD would suggest that the role of R&D has strengthened during the crisis. However, as pointed out by the country correspondent, this may change in the near future as most of resources earmarked for R&D in structural funds have now been distributed (not paid, but allocated through the various measures) and there is potential danger that the next financial perspective issued on EU levels will be less favourable to overall Slovenian R&D budget.

2.2.3 *Slovakia*

Heavy cuts in public sector spending are underway in 2011, including R&D expenditures. As such, significant decreases in numbers of research staff and volume of bonuses are expected. Salaries for Universities and the Slovak Academy of Sciences may drop by 8%-12%. Again, this may point to abundant resources provided by structural funds and European funding. However, the report does not state policy responses related to consolidation efforts, either as they are not in place, delayed or as still under public debate.

2.2.4 *Hungary*

Exhibit 2 Hungary – Basic statistics

Hungary	2006	2007	2008	2009	EU average 2008
GDP growth rate	5.3	5.6	-3.5	-7.6	0.5
R&D intensity (GERD as % of GDP)	1	0.97	1	1.15	1.92
GERD per capita	89.4	97.1	105.4	106.4	476.2
GBAORD as % of GDP	0.45	0.49	0.52	0.57	0.71
BERD (BERD as % of GDP)	0.48	0.49	0.52	0.66	1.21

Hungary is a medium-sized EU Member state. As for economic development, measured by GDP per capita (in PPS), the country ranked 21-22 in the EU-27 in 2009 (with Estonia), with 62.7% of the EU-27 average. The Hungarian GERD steadily increased from 2004 in nominal values (EUROSTAT) and the increase continued during the crisis. The latter is a combined effect of two factors: given the global financial and economic crisis, the Hungarian GDP significantly shrank (-7.6%), while GERD continued to rise in nominal terms. In spite of this, the Hungarian R&D intensity trails behind the EU-27 average and is well below the Lisbon target.

The Government's mid-term STI policy strategy (2007-2013) stipulates that GERD should increase to 1.8% of GDP (up from 1.0% in 2006), while BERD should reach 0.9% by 2013. However, in order to keep the budget deficit at the target level of 3.8%, the new government decided to cut several types of expenditures in June 2010. As a part of this broader measure, almost 37% of the Research and Technological Innovation Fund was blocked. The R&D goals seem to be overly optimistic and serious doubts concerning the feasibility of these targets were raised even before the global financial crisis.

2.2.5 *Italy*

Exhibit 3 Italy – Basic statistics

	2006	2007	2008	2009	EU average 2008
GDP growth rate	2	1.5	-1.3	-5.2	0.5
R&D intensity	1.13	1.18	1.23	1.27	1.92
GERD per capita	286.5	308.3	323.8	321	481.7
GBAORD as % of GDP	0.61	0.64	0.63	-	0.71
Business sector R&D intensity	0.55	0.61	0.65	-	1.21

The country has an underdeveloped R&D intensity when compared with its economic profile: 1.23% of GDP (2008) compared to 1.85% for the EU-27. The recession (-5.2 growth rate in 2009) has also worsened the public finances. Total revenue slowed sharply, while indirect tax receipts diminished. BERD intensity of 0.65 (2008) is well below the EU-27 average (1.21).

The 2010-2012 NPR plans to concentrate resources on a small number of large interventions, where public and private actors could operate with shared objectives. The document of economic and financial policy (DPEF) establishes strategic direction and priorities for scientific and technological research, financial resources and coordination among different public administrations, PROs and HEIs. It includes the economic and financial measures for the following year, and is submitted by the Ministers' Cabinet to the Parliament each year.

2.2.6 *Intra-group similarities and differences*

- Due to the crisis impact the relative importance of public funds on national as well as EU levels has increased in most countries. Crisis cuts are likely to result in public salary cuts including HEI and PRO R&D staff.
- However, only Slovenia has launched an explicit, anti-cyclical recovery package with additional R&D expenditure. In addition, swift STI policy responses and reallocation of EU funds in this country have enhanced the overall role of STI in government.
- Increased dependence on EU funding raises concerns for long-term stability of overall public funding on national level in all countries
- Positive side-effects of budget cuts on STI governance are seemingly more coherent funding efforts (less fragmentation) as well as reinforcement of political will for on-going HEI reforms, in the Italian and Czech case, respectively.

2.3 Efficiency of public support

2.3.1 *Czech Republic*

There is a number of policy instruments in STI, focusing on knowledge and technology transfer, the issue being high on the political agenda, e.g., as evidenced by a 10% allocation of overall budget in operational programmes. These measures include:

- Direct funding through industrial R&D programmes also supporting private-public R&D collaboration;
- Funding schemes for science and technology parks, incubators, and centres of technology transfer at HEIs or at specialised intermediary organisations. In addition, cluster programmes aim to create formalised, long-term alliances among enterprises, HEIs/PROs and other entities (e.g. regional authorities).
- Most recently, support has been expanded to joint public-private spin-offs and creating instruments funding the proof of concept stages for technologically-based projects.

Even though the economic structure may suggest, there is no programme designed specifically for SMEs. To some extent, effectiveness of existing instruments is put at risk due to the low absorption capacity of the business sector.

In evaluation terms, the allocation of institutional funding is not sufficiently tied to the evaluation of research work yet, negatively affecting scientific productivity with respect to publications, patenting or new technologies, products and services but also lower motivation of researchers to carry out high-quality research. Methodological controversies and applicability across all disciplines on the establishment of a full-fledged evaluation system on national levels have postponed compromise, reform and implementation among the research community and other stakeholders. The EU's structural funding has fostered the establishment of centres of excellence. However, national policy efforts on excellence in science (e.g., funding allocation tasks within) will require further advancements in national evaluation practices, which are not currently in place.

2.3.2 *Slovenia*

A wide variety of support institutions and measures have been set-up in order to promote the cooperation between the public R&D sphere and the business sector. These include:

- Recently expanded and prolonged support to joint R&D projects;
- Specific mobility support for young industrial researchers providing a communication link between their employer – the business firm and their educator – HEI, proving to be a rather successful funding scheme;
- Support for development and investment projects where resources are not only available for the research part of projects, but also its developmental and investment component in initial production capacities.

However, effectiveness of such policies is limited as HEIs and PROs suffer/are reluctant as insufficient infrastructure and institutional funding prevail which to some extent hinders engagement in collaborative schemes. Individual researcher's incentives are limited as public-private collaboration has only limited relevance for promotion and careers as well as there is an enhanced emphasis on scientific excellence. In addition, there is a low relevance of public research units for innovation activities of enterprises relative to other sources of knowledge and limited visibility of public funding schemes.

With respect to HEI or PRO spin-offs, current legislation is hindering establishment of the latter as it requires a special permission to be issued by the government, however, this being under revision. The new NRIS suggests amendment to this legal statute to allow for a more flexible approach. Up to now, such spin-offs are more of an exception and have had to completely cut ties with their 'mother' institution to avoid legal problems.

An independent, national evaluation agency for HEI was established in 2010 (substituting a less independent institution), but has not yet issued the guidelines for the accreditation of the HEI programmes or for evaluation criteria, in particular targeting future institutional funding. In terms of scientific output quality assurance, the national evaluation system is advancing. Most recently, evaluation practices will be expanded from those solely exercised at the level of research programmes to the level of institutions (HEIs and PROs). However, recent institutional change as well as further elaborating practices related to evaluation have yet to be implemented. Nevertheless, rather than programme-specific efforts, advancements in evaluation are perceived as the gateway towards scientific excellence in national STI governance.

2.3.3 *Slovakia*

As SMEs account for low levels of R&D expenditure and co-operation with research institutions, the government implemented several measures aimed at direct or indirect support to knowledge circulation. Most measures, however, are related to a variety of other policy goals. Measures include:

- Public support to collaborative research, i.e. allocating grants for reimbursement costs of partnership creation and operation, and costs of basic research in centres established under this scheme;
- R&D programmes open to participants from private and public sectors and being dedicated to applied R&D, and project funding on applied research, IPR and organisational innovations;
- Establishing a national information system facilitating technology transfer and improving collaboration networks between SMEs, large enterprises, HEIs, PROs and regional bodies. A similar programme/platform is in place enhancing cross-boarder transfer with EU MS and third countries.

Again, the bulk of funding of these measures is provided from the EU's structural funds.
In general, public funding schemes are regularly evaluated, but the evaluation is rather formal and descriptive. Evaluation and monitoring reports concentrate on reporting numbers of projects supported, but provide little analytical insight in efficiency of support. Evaluation culture is underdeveloped in Slovakia, having limited impact on fostering excellence in research at HEI and PROs, also because funding was not affected by evaluation practices in place, even when independent or foreign expertise was included in the processes.

2.3.4 *Hungary*

The STI policy governance structure has been in an almost permanent state of change since the 1990s, including the highest level policy-making bodies, as well as the implementing agencies. This lack of stability prevents organisational learning of policy design and implementation bodies, and hampers their efficient functioning. Moreover, a significant administrative burden is put on research performers.

No comprehensive analysis is publicly available to establish whether an adequate balance between institutional and project-based funding of research is provided. Competitive (especially “bottom-up”) funding for basic research is small. Several studies, however, have argued that a noteworthy share of competitive grants intended for application-oriented research is in essence financing basic research (Arnold et al., 2007; OECD, 2008a). HEIs are entitled to normative support from the central budget for education and training, scientific research and maintenance purposes. In addition to this, R&D budget is channelled through two main funding streams: block and competitive funding. Neither the R&D block funding nor the normative support includes performance criteria such as publication and citation and patent applications. The three-year ‘maintenance agreements’ and the ’research university’ label represent a step in the direction of applying performance-based criteria for determining state funding.

STI policy evaluation culture is weakly developed in Hungary. However, according to the law, publicly financed STI policy measures shall regularly be evaluated by independent experts.

Hungarian researchers are fairly productive in terms of scientific output, especially if their low number and the low level of research expenditures (compared to the EU averages) are taken into account. Output per researcher is close to the EU-15 average (85%), while funding is much lower: 40% of EU-15 R&D spending per researcher and 47% funding per publication. The quality of publications, as suggested by the citation-related indicators, is also much closer to the EU average than the level of funding. According to the publication, impact factor and citation data of the Web of Science database, Hungarian researchers have shown outstanding performance in three scientific fields in terms of the number of publications, namely chemistry, clinical medicine and physics, while no field of science has been labelled as moderate in this respect. Only a single field has achieved an outstanding performance in terms of citation rate, namely space science, whereas none in terms of impact factor. However, Hungarian researchers are far less successful in terms of producing directly exploitable knowledge; in fact, this particular aspect has been often identified as one of the major weaknesses of the research system. The number of triadic patents, community designs and trademarks per million population is a mere 11.9%-22.5% of the corresponding EU averages, but these indicators show a modest improvement (EIS 2009). It has been argued that this may not reflect the low capability of researchers to produce exploitable performance but it reflects the economy sectoral distribution and the specificity of its catching-up economy and its NIS. At this stage of development it may be more relevant to concentrate on fostering the diffusion of new technologies and other forms of innovation and enhancing learning capabilities for a more efficient absorption and exploitation of new knowledge.

Community Innovation Survey data indicate that industry-academia links are not particularly strong in Hungary. The frequency of innovative firms’ co-operation with higher education organisations initially declined significantly (from 21.6% in 1999-2001 to 14.6% in 2002-2004) and then improved (17.3% in 2004-2006, 18.7% in 2006-2008). As for their co-operation with public laboratories, it was originally at a lower level, and became even less frequent (8.6%, 6.4%, 6.5%, and again 6.5%, respectively).

Strengthening academia-industry co-operation has been one of the most prominent objectives of the Hungarian STI policies, served by several schemes, e.g. the 'Co-operative Research Centres' and the 'Regional Knowledge Centres at Universities' 'Developing and strengthening R&D centres'. A number of measures, such as 'Supporting innovation activities of businesses', or 'Supporting market-oriented research and development', 'Innocsekk' include provisions for purchasing extramural R&D services.

Attempts have also been made to create a more favourable regulatory environment and incentives for PROs to accelerate their IPR activities and produce exploitable knowledge. The Law on Research and Technological Innovation (2005) has introduced the notion of spin-offs into the regulatory framework. Since 2006, every publicly financed research institute is obliged to devise an IPR management strategy. There have been a number of policy measures in recent years providing public funding to promote knowledge transfer in general (partly through supporting TTO creation), and spin-offs in particular. However the TTO system seems quite fragmented and therefore inefficient, exacerbated by the lack of critical mass of inventions at most universities. Furthermore, the incentives provided by the internal regulations for researchers at PROs and HEIs are still not sufficient to achieve a fundamental transformation of prevailing attitudes. In fact, some experts even claim that the knowledge transfer and IP commercialisation activities of HEIs are driven by the availability of public funding, and not by market pressures and opportunities.

Some tax incentives also promote extramural R&D. For example, 200% of extramural R&D expenditures, if carried out by public or non-profit research organisations are deductible from the corporate tax base. Extramural R&D expenditures can also be deducted from the so-called innovation levy (a major source to finance the Research and Technological Innovation Fund).

2.3.5 *Italy*

The coordination between the Ministry of University and Research and the Ministry of Economic Development is weak and consequently so is the coordination between research and innovation policies. The 2010-2012 National Research Program (NRP) introduces the creation of a new structure, a technical secretary of governance (ACR), with the scope of enhancing the national research activity coordination. A simplification and a coordination of governance have been pursued through the unification of different funds and measures. The 2010-2012 NPR envisages concentrating resources on a small number of large interventions, where public and private actors could operate with shared objectives.

The impact of evaluation on policy formulation, implementation and structures is weak and has been heavily affected by delayed implementation. A National Agency for the Evaluation of the University and Research (ANVUR), established by the 2007 Financial Law has been eventually endorsed by the Parliament three years later (May 2010) and will evaluate the efficiency and efficacy of the education and research activity and institutions. Meantime, a national Decree launched the five-year evaluation exercise for assessing HEI and PRO research performance. The National Innovation Agency evaluates (ex ante and in itinere) the industrial innovation projects.

Italy has a dual university funding system. The share of core funding allocated on the basis of evaluation results recently increased, while the budget and types of research project funding have also increased and diversified. Recently a government decree reforming the PROs foresees a reform of the governance, a multiyear planning of the activities for pursuing scientific excellence and integration with the private research sector. The university system is characterised by good performance indicators and the presence of important isles of excellence, but it suffers for a low mobilisation of financial and human resources. Interesting changes are driven by the diffusion of an evaluation culture that however is constrained by the academic corporation resistance to a deeper change in the system governance.

Relevant indicators show that the scientific output versus input balance is rather positive (the lowest percentage of researchers in the active population and R&D intensity among the industrialised countries). One problem is represented by the low number of licenses or selling of publicly-owned patents, consequently having effect on effective valorisation and transfer of RD results. In terms of input the situation continues to deteriorate.

The need to increase private-public dialogue and partnership is indicated as strategic in many documents and declarations and has many instruments attached, from the Research Support Fund (FAR), and in particular to Strategic Projects, Technological Districts, Excellence Poles and Technological Platforms. The TTO manage IPRs (83% of TTOs), create spin-offs (80.9%) and less frequently manage RD collaborations with industry (57.4%).

2.3.6 *Intra-group similarities and differences*

- All countries within the sample have a set of instruments in the knowledge triangle. However, these sets vary in terms of elaboration and broadness.
- Some reports evidence knowledge transfer policies mostly in the context of other innovation or regional policies, e.g., openness of direct funding in R&D programmes to private as well as public actors, or as part of more general collaborative research schemes.
- Cluster and transfer intermediary policies such as the establishment of technology parks and TTOs at HEIs and PROs, respectively, can be found among most countries.
- However, there is a weak trend on getting ideas to the marketplace by supporting, e.g., proof of concept stages of innovation.
- Some of the instruments may suffer effectiveness due to limited absorptive capacities among businesses. However, not all countries have SME-specific support schemes in place to overcome structural features of their economies.
- In other situations, STI policies are less able to put an emphasis on knowledge transfer due to an institutional funding focus or researchers facing the trade-off with requirements of excellence-driven science.
- As evaluation culture is only starting to emerge in all countries, some countries have only recently established independent, evaluating agencies on national levels.
- However, practices are slowly expanding from a focus on R&D programme evaluation to evaluation of all public research institutions and feedback on institutional funding schemes.
- Similarly, practices are becoming more advanced (being more descriptive in nature in the first place) and continuous, notwithstanding significant methodological debates and lobbying efforts of interest groups.
- With the exception of EU level centres of excellence and national participation within them, striving towards excellence is not observed but will require further advancement in evaluation practices beforehand.

2.4 *Framework conditions for business R&D and innovation*

2.4.1 *Czech Republic*

Even though the need for financial R&D framework adjustments, such as enhanced venture capitalist incentives or attracting business angels, has been expressed in STI policy, there are solely measures in place supporting the company creation by granting credits and bank guarantees, with a focus on technology-based start-ups. In addition, with the exception of a few indirect mechanisms such as tax incentives, policies miss out financial tools facilitating SMEs access to pre-seed and seed capital.

The country report states indirect tools of public support for R&D and innovation to include furthermore public procurement. However, it does not specify in any detail on the latter.

2.4.2 *Slovenia*

Even though risk capital related framework conditions have not been adjusted recently there are several, advanced funding schemes for entrepreneurs as well as SMEs in place aiming in particular on their financial 'backbone' for R&D. One single exception of changed framework conditions is, however, a national fund providing indirect entrepreneurial support by providing equity finance to private venture capital firms. The general policy rationale in providing a wide ranging set of entrepreneurial instruments is based on entrepreneurs being perceived as major drivers of structural change and transformation of the overall economy.

In addition, a variety of consultancy services on both, national and regional levels, e.g., public support for business angels, which share their experiences with new start-ups and feed their business expertise to public start-up funding selection. National public funds enhance (sometimes focusing high-tech) start-ups in technology parks and university incubators through direct subsidies in the establishment of the company as well as in the first years of operation. In addition, these funds provide supplementary guarantees, which help SMEs in obtaining bank loans. Furthermore, additional formation of private-public partnerships to start venture capital funds were planned but have not been launched so far. Soft, non-financing policies including programmes in entrepreneurial training are planned paying special attention to employability, self-employment, life-long learning, entrepreneurial and management skills.

There is little evidence of any procurement-related innovation policies.

2.4.3 *Slovakia*

No information was available from country reports, neither on existing R&D finance framework conditions, nor on fitness of risk capital markets and entrepreneurship policies in general.

Given lack of strong domestic private R&D demands, public procurement of innovative technologies is expected to stimulate private investment in R&D. In this way, the government has made very few, one-off attempts of procuring innovative technologies, e.g., in field of e-government. However, no such policy was in force by 2010.

2.4.4 *Hungary*

The Hungarian BERD has been increasing since 2004 both in nominal terms and as a percentage of GERD. Yet, it is still much lower than the EU-27 average. However, the share of public funding in BERD increased significantly in the last few years: from 3.3% in 2004 to 10.8% in 2008, and further increased in 2009 (compared to EU-27 average 7.3% in 2008; Eurostat). The share of SMEs in the Hungarian economy has become fairly similar to that in the EEA (52.6% vs. 51%, respectively; 2003), while the share of medium-sized enterprises is higher (18.3% vs. 15.7%). The weight of small firms might suggest a high degree of entrepreneurship. Yet, the share of innovative Hungarian SMEs – especially that of small firms – is rather low in international comparison, and much lower than the share of innovative large Hungarian businesses. (CIS data)

In terms of science base, Hungary has a mixed landscape: very few large up-to-date and many outdated RIs, lacking a comprehensive RI investment strategy and uneven HEI performance. The research system had shrunk significantly in the early 1990s when industrial research facilities were hit especially hard by economic transition. Although it has increased from 31.7% in 2007 to 33.2% in 2009, the HRST share in the economically active population in the age group of 25-64 remains below the EU-27 average (40.1% in 2009). An important reason is because there are less S&E graduates (0.63% compared to 1.43% for the EU-27) and S&E PhD degree holders (0.02% vs. 0.06%). Another important threat is the brain drain: the highly qualified, young workers, especially those with S&E degrees are overrepresented within the group of Hungarians working abroad. The low share of S&E graduates is often mentioned in policy discussions as a major challenge. However, a wider policy perspective, as well as concerted public and private efforts is needed, sustained for a longer time-horizon, to deal with this complex challenge. This should involve good quality of pre-university education and improvement of the attractiveness of the research career.

A major driver of knowledge demand is the economic structure itself. The services sector has become the predominant one in Hungary. The Operational Programmes (OPs) of the New Hungary Development Plan are a key source for financing RTDI in the period 2007-2013 and is primarily aimed at boosting market-oriented RTDI activities of firms. The Social Infrastructure OP (SIOP) also contains research-related measures, e.g. for upgrading research infrastructure at higher education institutes (HEIs). Though the EDOP also supports research infrastructures, the focus is that OP are projects carried out by firms, whereas the SIOP is dedicated exclusively to HEIs.

The Investment and Trade Development Agency (ITDH) offers incentives for large-scale foreign R&D investments in the form of direct grants and tax holidays, partly based on individual government decisions. Direct funding may be obtained for employing new research personnel and training, while tax holidays may be awarded for up to 80% of corporate tax for ten years. Several multinational companies have participated in large co-operative projects, such as the Co-operative Research Centres.

As for the overall policy mix towards increased private R&D investment, professional associations, business interest organisations, as well as the State Audit Office have claimed that there are too many STI policy schemes, and that they are not well targeted and clearly differentiated. Given that there are so many schemes, firms have to shoulder a significant administrative burden, meaning that they are not easily accessible. A large number of SMEs, in particular, cannot afford to devote the required amount of time to identify the relevant schemes and develop applications. Further, the activities of implementation agencies also become unnecessarily complicated, and decision-making processes are too long, cumbersome, and insufficiently transparent.

Besides STI policies per se, several other policies affect private R&D investment by influencing its framework conditions. Macroeconomic policies have failed to create a stable, predictable environment for businesses. Economic growth has been volatile at least since the mid-1990s. Inflation has constantly been above the target. Government behaviour has also been unpredictable (e.g. the tax code has been rewritten frequently). Both the general government deficit and the general government debt have been rather high. Businesses, in turn, felt the crowding out effect of the mounting fiscal deficit. In sum, the macroeconomic environment has been unfavourable for firms' RTDI activities.

Administrative costs incurred by businesses are high by international standards, and that is especially unfavourable for SMEs. The tax system is also putting significantly higher administrative burden on companies, and the total tax rate is significantly higher than the OECD average.[39] The share of genuine entrepreneurial businesses is rather small in Hungary. As for competition legislation and oversight, Hungary has caught up with typical OECD practice, largely due to its entry to the EU. The Hungarian IPR legislation is in accordance with the EU legislation and international treaties. The respective industrial property acts are suitable to comply with the requirements of a market economy and offer an adequate protection for the innovators.

For a long time, the lack or insufficient level of available venture capital has been a serious challenge, hindering the emergence of innovative start-ups and spin-off companies. Therefore, in recent years more attention has been given to this challenge. The government launched the New Hungary Venture Capital Programme in 2009, establishing 8 private-public funds, allocating EUR166m venture capital until 2013.

2.4.5 *Italy*

In terms of innovation performance, Italy is below the EU average and its relative position has not significantly improved over the past five years. According to EIS, Italy positions itself in the group of 'moderate innovators', showing slow progress and registering a below-average annual growth rate (1.8 in 2008 versus 2.3 EU average). Within these 'moderate innovators', the growth performance of Italy and Spain is among the weakest of all countries.

The total number of researchers per thousand total employment points to the low values in Italy (3.4) compared to, for instance, Spain (5.5), France (8.0), or the EU-27 (5.8). These data show the low availability of research position in Italy, which affect the private sector more than the public one, given the low propensity of the business enterprise to hire graduates. The number of graduates in S&T is another weakness of Italy: in 2007 the number of S&T graduates was 8.2 as a % of 1000 persons aged 20-29 years (compared to 13.4% at EU-27 level). The situation regarding the PhD is also not favourable. The government encouraged the creation of doctoral schools within universities with special incentives, aimed at favouring a simplification of PhDs courses supply, the internationalising courses, and involving the private sector (PNR 2010-2012), but no specific incentives have been introduced. Brain drain is another problem. In response to this, the 'Brain-return' measure (November 2008) foresees a tax incentive (10% tax applied to personal income) during the first five years of fiscal residence in Italy in order to encourage the return of Italian researchers living abroad.

The lower level of business R&D intensity in Italy is partly linked to the structural composition of its economy: the share of high-tech industry in total manufacturing value-added is low. Italy remains non-specialised in all high-technology sectors (except chemicals), although in some cases it shows a scientific specialisation (such as in pharmaceuticals) or a high concentration of patents (such as in other machinery and electrical equipment). The Italian industrial structure is largely composed of small and medium sized firms, which

[39] For details, see http://www.doingbusiness.org/economyrankings

represent over 95% of the total number of enterprises. Special attention has therefore always been devoted to the enhancement of their R&D activities.

The current mix of policy measures is highly concentrated on providing direct funding (mostly grants) to firms engaged in applied industrial research, product development and prototype creation as well as on measures to improve R&D cooperation between public/academic/sectoral research institutions and enterprises. The number of policy measures addressing SMEs' specific needs is still low as well as the number of measures to improve education and skills and to promote entrepreneurship and the creation and growth of new firms (financial support for the creation and early development phase of innovative enterprises, service provision to spin-offs, gazelles, support to risk capital, etc.).

National Fund for Innovation (EUR60m) has the main goal to support SMEs and to reinforce Italian patents. The Ministry for public administration and innovation has launched the fund for risk capital for the SMEs located in the south of Italy (Risk capital fund for SMEs (EUR160m)). The Funds for innovation projects in start-ups measure the Ministry for Economic Development finances innovation projects proposed by start-up firms operating in medium and medium-high sectors in the following areas: biotech, ICT, materials, robotics and energy.

In recent years, the system has witnessed a shift from direct support mechanisms based on grants and loans to indirect support based on tax incentives. One of the most important research policy measures is tax credit for R&D: firms are given a 10% tax credit on the total expenses for R&D. A risk capital fund for SMEs has been launched and fiscal incentives in the form of tax credits are foreseen for capital gain from start-ups. Fiscal incentives have been introduced to encourage firms to recruit researchers. Recent (2008-2009) policy changes deal with a higher attention to supporting the high tech start-ups and to improve the national patent system, through the establishment of a fund for public participation in risk capital of enterprises operating in high technology sectors (information technology, electronics, nanotechnologies and micro technologies, electro-medical instruments, high technology mechanics for industrial automation). Since the summer of 2008, when the crisis triggered the first negative signals on the world economy, the government announced several measures that would be adopted to sustain the national economy. One of the measures is the introduction of an anti-crisis export promotion plan with an overall allocation of EUR185m in 2009. New tax benefits have been granted to enterprises, with an allocation amounting to about EUR2,900m for 2009-2011. In a national context characterised by scarce funds for innovative SMEs the tax exemption on capital gains from start-ups is an incentive to attract funds to finance new entrepreneurial initiatives. In January 2009 a refinancing of the Central Guarantee Fund for SMEs was put in place (EUR1.6bn) and a State guarantee as a last-resort guarantee has been provided for this Fund.

The most important non-financial innovation policy measures relate to intellectual property. A first attempt to reinforce the patent and IP systems started with the launch of the new Industrial Property code. The Italian Patents and Trademarks Office coordinates a project which requalifies national patents, thanks to the introduction of the anteriority search (in vigour since 1 July 2008) being the responsibility of the European Patent Office (EPO).

2.4.6 *Intra-group similarities and differences*

- With the exception of Czech Republic and Slovakia, all countries have launched public or private-public risk capital funds in the context of entrepreneurial and SME policies. These funds often focus on medium- and high-tech industries, this being accompanied by 'soft' measures such as entrepreneurial training as well as consultancy services for founders in a few countries.

- A notable case in this respect is Slovenia having a comprehensive set of instruments in place and an explicit entrepreneurial strategy on national level, e.g., funds being associated with technology park engagement, ideally, fostering structural change in the economy (i.e. main policy rationale).
- Other means of public support to entrepreneurial and SME finance include bank guarantees (to become eligible for loans) or direct granting of credits, mostly arising in the recent crisis context.
- Again, with the exception of Slovakia, all countries have established tax incentive systems for innovation. However, as most of them are still experimenting with such policies, tax codes are being rewritten frequently and, thus, having limited predictability, sometimes even worsening the business environment.
- In addition, tax incentive schemes target different levels of innovation activity such as attraction of multinationals by giving tax holidays or income tax incentives for individual researchers in order to foster brain-return initiatives.
- In most countries, framework conditions are not touching risk capitalists. However, Slovenia is directly providing equity capital to venture capital firms, and fiscal incentive reform in Italy has only recently started, but foresees tax credit for capital gains from start-ups.
- Given the information from country reports, innovation-orientated public procurement is not part of national STI policies (with very few, one-off exceptions), nor are explicit coherent strategies under development.

Appendix 8

Country Group 8 - Challenges and policy responses

Bulgaria, Poland, Romania

1.0 Main challenges confronting national R&I systems

While specific country R&D features exist, particularly in terms of policy response, common patterns are evident, mainly related to the national R&D context strongly affected by the past common communist history.

The most important common country cluster challenges are:

- National R&D systems remain fragmented, dominated by public research organisations lacking regular evaluations.
- Chronic shortage of public resources for R&D, stretched across an oversized public institutional structure inherited from central planning. In addition, the economic crisis triggered R&D budget cuts.
- The prevailing public funding of research activities is indicative of problems related to the efficiency of research in stimulating economic growth.
- Lack of tradition of public-private R&D collaboration. Low innovation culture. The national industry structure reflects the prevalence of traditional industrial sectors, which use relatively low technologies and show a weak demand for knowledge.
- Business R&D is largely dependent on public funding, mainly Structural Funds dispersed through Operational Programmes. The private sector has shown low absorbance capacity.
- The implementation of policy is supported by a complex administrative system which has not been reformed, sometimes preserving unfavourable institutional habits. The progress of reform is slow, the implementation often being delayed, lacking transparency and consistency.
- Low salaries, slow career progression in the S&T/RDI system that generate brain drain and /or migration to other more attractive national sectors.
- Modest national research output.

2.0 Policy responses

2.1 Grand challenges and thematic priorities

2.1.1 *Bulgaria*

The main Bulgarian R&D strategic policy documents[40] show lack of coordination, consensus and clearly defined thematic priorities in research. Collaboration projects address either pre-determined or wide-ranging, generic topics, hence there is no evidence that specific research fields are prioritised for the inter-sectoral and cross-border knowledge circulation.

[40] Law on Scientific Research Promotion, the draft National Strategy for Scientific Research for the Period 2009-2019, the National Innovation Strategy, the Regional Plans for Development, the Regional Innovation Strategies, the Operational Programme Competitiveness, the Law on Higher Education, the Law for the Bulgarian Academy of Sciences, and the Strategy for Encouraging Investment in Bulgaria 2005-2010

As a recent change, the adoption of national targets regarding the Europe 2020 Strategy identified some grand challenges (e.g. reducing greenhouse gases, increasing of share of renewable energy sources and energy efficiency). Nevertheless, these documents have not set any mid- or long-term plans, relying first and foremost on EU funding (e.g. provided within the framework of the OPs).

2.1.2 *Romania*

The NSRDI 2007-2013 identifies nine S&T strategic priorities, with clear funds distribution among priorities (ICT, energy, environment, health, agriculture and food, biotechnologies, innovative materials, processes and goods, space and security, and socio-economic and humanistic research). Most (60%) of the NPRDI 2007-2013 funds for R&D activities are granted on the grounds of scientific and technological excellence, irrelevant to the S&T field. Public intervention in areas where long-term vision and systemic approach are required is drawn on thematic priorities. This is the case of Partnerships in priority S&T domains Programme (36% of NPRDI 2 funds) and National Roadmap for RIs. The funds administrated through the POS-IEC Programme (2007-2013) are dispersed to target groups on a competition basis, focusing on five thematic priorities: 1) Health; 2) Agriculture, food security and safety; 3) Energy; 4) Environment; 5) Advanced materials, products and processes. These priorities have been identified through broad consultation as having the potential to support the increase of economic productivity. The institutional funds directed to the network of research institutes coordinated by the Romanian Academy are mainly devoted to fundamental research. Signs that societal challenges resonate in the R&D projects exist, yet they remain modest. Analysis based on ISI publications reveals strengths in Romania's scientific output especially in Materials Sciences, Mathematics, Physics and Astronomy, Chemical Engineering and Chemistry. However, Romania does not seem scientifically strong in fields supported by the largest NPII grants such as Information and Communication Technology, Health, Earth Sciences, or humanistic.

2.1.3 *Poland*

The central National Scientific Research and Development Programme defines five research priority areas (society and security, accelerated and sustainable socio-economic development, health, energy and infrastructure, modern technologies for the economy, agriculture and environment). The programme, however, does not specify the financial allocation to individual research topics. In turn, it merely defines strategic research fields, which should give directions for public funding streams. As a recent change, the National Programme for the Development of Humanities announced in June 2010 would be the first long-term thematic funding in public research policy.

2.1.4 *Intra-group similarities and differences*

- The lack of concrete national research priority stands as one of the major challenges for the future development of the Bulgarian research system.
- Polish research policy defines a limited number of thematic priorities. However, given the lack of clear funds, distribution among these thematic priorities, they function rather as broad guidance than financing prioritisation.
- Romanian strategy has strategic and S&T thematic priorities, identified as such through national broad consultation. However, they do not match the fields where the Romanian research shows excellence. Current policy documents such as the 2007-2013 National RDI (NSRDI 2007-2013), the National Plan for R&D and Innovation 2007-2013 (NPRDI 2) have an overall emphasis similar to many of the main strands of EU policy in the research field. NPRDI 2 as the main instrument supporting the attainment of the strategic research objectives is structured around six specific themes, similarly to the EU FP7.[41] Under each

[41] People, Capacities, Ideas, Partnerships in priority domains, Innovation and institutional performance.

specific scheme, various programmes designed to address national specific challenges allot funds on a competition base to research topics identified in a bottom-up approach or identified as S&T strategic priorities.

2.2 Smart fiscal consolidation

2.2.1 Bulgaria

In Bulgaria, the public investments in R&D are not prioritised and budgeted in the framework of multi-annual plans. Bulgaria still lacks a national strategic framework for the promotion of R&D and innovation, showing an insufficient number of adequate funding instruments and weak coherence between innovation and research policies.

2.2.2 Romania

Public RDI investment in Romania is planned in a multi-annual framework, aiming for a gradual increase, in line with the government commitment to meet the Lisbon Strategy target. In terms of goal setting, Romania initially adopted the 3% GERD target (1% public and 2% private share) by 2013-2015. Although high R&D expenditure targets were set, the weak budgetary planning and execution, with frequent in-year rectifications accentuated by the world economic crisis jeopardised the targets. RDI policies are recognised as a priority of the 2009-2013 Government programme, but in reality they have little visibility and importance in the overall government policy, the RDI sector being subject to one of the sharpest funding cuts in 2009.

2.2.3 Poland

As in Bulgaria, the public investments in R&D are not prioritised and budgeted in the framework of multi-annual plans. The Building upon Knowledge research reform entered into force in October 2010, and is aimed to radically change the R&D landscape. The strategy defined very ambitious goals in terms of public and private R&D expenditures, aiming for a four times increase of GERD in absolute terms between 2007 and 2015.

Since 2009, Polish research and higher education systems have been undergoing significant governance changes,[42] the entire research system currently being in a transitory phase at the end of which the role of relevant actors will change significantly. In the current EU programming period 2007-2013, the role of regions as a source of funding increased significantly due to the EU Structural Funds.

2.2.4 Intra-group similarities and differences

- All the three countries are among those with the lowest R&D intensity in EU. Bulgaria and Poland had lower levels in 2008 than in 2000, after a period of fluctuating R&D intensity. Although, the Romanian GERD continuously increased during 2005-2008, it remained within a modest range. To objectively grasp the evolution of GERD, the evolution of nominal GERD values must also be observed. The strong economic growth in these countries prior to the global economic crisis explains the low variation of GERD to gross domestic product in spite of considerable increase of R&D expenditures in absolute terms. However, the catching-up effect has to be considered when assessing this positive evolution. Romania showed the highest growth over 2000-2008 period (+276%), the gradual progression dropping significantly in 2009 (-31% compared to 2008) as a result of sharp cuts in the public RDI funding. Although as for 2009, these countries show similar low

[42] Based on three reform packages: Building upon Knowledge, Partnership for Knowledge, and Long-term Strategy for science and higher education.

R&D intensities, the differences become more evident in terms of R&D expenditure per capita (BG 25.9, PL 47.9, RO 24.3 compared to the 473.9 of the EU-27).

Exhibit 1 Trends in GERD

	2000	2008	2009	Variation of nominal GERD 2000-2008	Variation of nominal GERD 2008-2009
EU-27	1.86	1.92	2.01	38%	-1%
Bulgaria	0.51	0.47	0.53	159%	11%
Poland	0.64	0.6	0.59	53%	-17%
Romania	0.37	0.58	0.48	276%	-31%

- In Bulgaria and Poland, the public investments in R&D are not prioritised and budgeted in the framework of multi-annual plans which hinders the predictability and long-term planning of research investments. The outdated legal and institutional frameworks add to the national conditions that hamper the achievements of the national R&D objectives. While in Bulgaria a coherent national R&D strategic and the revision of relevant legislation are mandatory, yet not planned, the recent Polish Building upon Knowledge reform addresses many system deficiencies and provide the legal framework for improvement. In both countries, although a clear trend towards increasing competitive funding exists (already visible in Bulgaria, but rather at the stage of planning in Poland) the institutional funding still prevails (BG 54%, PL 75%).
- In contrast, public RDI investment in Romania is planned in multi-annual framework and appears as a priority in the political speech. The 2009 severe R&D budget cuts generated an yearly unbalanced and unrealistic funds distribution within the multi-annual commitment and a shift of the steadily increasing trend towards competitive funding (in 2008, 82%). Although this remains dominant, it should be noticed that in 2009 the nominal institutional funds allocated to PROs increased to 30%.
- The governing and managing R&D structure in Bulgaria has not yet been reformed, while Polish R&D and HEIs systems are currently in a transitory phase, being heavily reformed. In Romania, the governing structure in place to design and implement RDI policies is relatively stable, with agencies designed to play specific responsibilities. However, its large size and multi-level structure often create gaps in the horizontal and vertical coordination and communication between the actors, as well as policy and implementation incoherencies. Also, serious concern exists at national level that all these organisms become more and more politically controlled.

2.3 *Efficiency of public support*

Cooperation between the private sector and public research institutions has long been identified as one of the main weaknesses of these national R&D systems.

2.3.1 *Bulgaria*

Bulgaria has the lowest levels of corporate research among the EU member states. According to the Fifth Community Innovation Survey in 2004-2006 innovative firms accounted for only 20% of all companies in Bulgaria, which is twice lower than the EU average (39%). The weak collaboration between publicly-funded organisations and the lack of national research strategy undermine the effects of increase in direct governmental aid.

Although the total number of Bulgarian ISI publications has risen to 120% between 2004 and 2008 compared to the preceding five-year period, it is still one of the EU countries with very low performance. There were only 15 Bulgarian patent applications with the European Patent Office in 2007, submitted mainly by large companies.

Quality control has been missing in the Bulgarian R&D system. Public research organisations are subject to only sporadic international evaluations.[43] The results of the recently implemented reform of the Bulgarian Academy of Sciences aimed to decrease the scientific and administrative staff and research units has not yet been evaluated. Although performance metrics are employed in the researcher evaluation, it does not effect scientists' remuneration. As a recent change, in October 2010, the Law on Scientific Research Promotion was amended in order to ensure accountability of public funds for R&D, requiring mandatory independent national and/or international assessment of research projects. The funding mechanism indicates a clear trend towards increasing competitive funding[44] (from 90:10 in 2004 to almost 50:50 in 2008); yet, the institutional funding still prevailed in 2009 (54%) which becomes a drawback for the efficiency of the public support given the lack of evaluation culture.

The flow of knowledge between public-private sectors in Bulgaria remains limited. In effect public research organisations lock in the biggest part of national financing without seeking links to the business sector. Allocation of resources is not market-driven and is not directed to the sectors with highest value added. Some policy efforts were made but no progress was registered at the implementation and monitoring stages. A number of limited instruments,[45] mainly using Structural Funds, have been developed since 2007 to encourage public-private research cooperation, the establishment of new indigenous R&D performing firms and greater R&D investment in R&D performing firms. The impact however remains low, the private sector showing low R&D capacity absorption. Innovation-oriented procurement policies are mainly absent.

2.3.2 *Romania*

While the GERD increased twofold in 2007 compared to 2003, the dynamics of business R&D investment was not positive: in the same period, BERD only slightly increased from 0.20% to 0.22%.

There are several actors that shape Romania's RD&I policy, including MERI-NASR and the line ministries, agencies and PROs and HEIs. There are three different relevant legislative frameworks. Given that the RDI activities involve policy fields belonging to different ministries, the complex institutional landscape seriously limits the effectiveness of the NASR in coordinating the RDI related agenda. A new ordinance on scientific research and technological development was enacted in January 2011 and attempts to reshape the Romanian RD&I system, including relations between MERI and NASR, evaluation rules of units and R&D institutions, rules of financing R&D institutions, programmes and research projects, development and innovation actions, and many others. However, the new law is unlikely to overcome the lack of horizontal coordination between bodies accrediting and certifying RDIs, making it impossible to have a single national system to assess the performance of the various research institutes. In practice each accrediting body will have its own accreditation system.

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[43] Although according to the Statute of the Bulgarian Academy of Sciences, all R&D institutes of the Academy are subject to periodic institutional evaluation, only two evaluations were performed between 1993 and 2009.

[44] The main competitive public R&D funding instruments are the National Innovation Fund (NIF) and the National Science Fund (NSF).

[45] The main policy instruments for increasing private R&D funding were the National Innovation Fund (NIF) and the National Science Fund (NSF) (until 2008), OP Human Resources Development and OP Competitiveness (since 2007). These have been recently (2010) complemented by the JEREMIE Fund.

Starting from 2007, competitive funding has become dominant. In 2008, public funding was allocated to different R&D actors predominantly on a competition basis (89.2%), the remaining part of the public funds being allocated to PROs. As a consequence of the serious budget cuts, an important policy change adopted in 2009 was an increased with 30% of the nominal block funding for the national R&D institutes.[46]

All projects funded through NRPDI 2 and SOP-IEC PA2 are monitored and evaluated on the basis of projects' activity reports produced by the project consortium and evaluation reports issued by independent evaluators. The overall concentration effect of the research potential is monitored in the framework of programme. The legal framework gives the provisions for a quality assurance system in education and for periodic accreditation of all RDI public or private organisations. However, there is no evidence of international evaluation of PROs and HEIs. Depending on the outcome of the evaluation, the R&D actors can be merely certified as having the capacity to carry out R&D activities financed with public funds. Public funding appropriations for universities are only for education activities. Although the financing formula quality quota increased in recent years, it still remains low (30% in 2008). While the basic salaries for academic staff and researchers from PROs remain constrained to rigid regulations, they have the right to withdraw funds from research projects as personal income. Specific schemes were designed to reward researchers who publish in ISI papers or are patents authors.

The NRDIS contains provisions for the revival of private R&D, the co-financing requirements under the NPRDI 2 being expected to stimulate the increase of the share of private funds for R&D. SOPIEC PA2 operations are specifically designed to support RD activities in enterprises, innovative SMEs, start-ups and spin-offs. The partnerships between public RDI organisation and enterprises in priority research fields and area of interventions are aimed to support the efficient channelling of the knowledge production. Despite these positive changes at policy level, progress is slow, and business sector participation in these calls remaining very low.

Romania has no specific innovation-oriented procurement policies. Public procurement operations for research and innovation follow the general national rules for public procurement that are regulated by a complex set of legislations and are made following public bids announced through the national Electronic System for Public Procurement.

Patenting activity, an indicator of Romania's innovative performance, is below that of countries with similar levels of development. In 2008, Romania had 0.23 patents (counted in triadic patent families) per million residents in comparison to 0.01 in 1998, where the EU average is 30 patents per million residents. Moreover, Romania is characterised by low levels of innovation efficiency given the value of GDP per capita and the number of triadic patents. Several efforts have been made recently to promote patenting and licensing, emergence of spin-off companies and the expansion of joint or contract research. Nonetheless, the results of public research remain essentially in academic domains with little impact on economic development. Comparing the considerable budgetary funds spent in the business sector with the decreasing participation of this sector to GERD leads to the conclusion that the public funds brought about a 'substitution effect' instead of the desired 'complementary-like effect'.

[46] This measure was seen as a solution for maintaining the research capacity of national R&D and helping them retain the R&D personnel.

2.3.3 *Poland*

The knowledge production in Poland has low quality and relatively low international importance given the size of the country. In 2007, Polish research organisations submitted only 3.82 patents per million inhabitants, with the EU-27 average of 116.54. The level of publications was also very low: the number of scientific publications per million inhabitants in 2008 was 552, compared to EU leaders Sweden with 2472 and Finland with 2337 (GUS, 2010) and other Central European countries, e.g. Czech Republic with 1016 scientific publications per million inhabitants.

In response to this weakness, in 2009, the Ministry of Science and Higher Education presented the second step of the science and higher education reform Partnership for Knowledge, aiming at increasing internationalisation of the scientific landscape and the quality of knowledge production.

Until the Building upon Knowledge is fully operational, the dominant R&D funding mechanism of R&D is based on non-competitive funding (around 75% in 2009). The new reform, which is becoming operational during 2010/11 aims at redirecting the funding streams towards competitive funding based on the principle of excellence and strongly output oriented scientific activities. All R&D institutes and universities will be evaluated by a newly established Committee of Evaluation of Scientific Units and classified in four different performance categories. According to the new system, the statutory funding will be replaced by a grant for maintaining research potential, which will be distributed only to the best research performers. Another aspect aiming at increasing the quality of knowledge production is the planned creation of National Leading Scientific Centres (KNOW), which will be university institutes or other research centres selected in a competition, and granted additional funding to conduct research at the highest European level.

In Poland, as in the other two countries, the main instruments aiming to have a leverage effect on business R&D expenditure are the OPs which disperse structural funds.

Although supported by various programmes within OPs, the innovation and technology transfer (ITT) infrastructure, namely the organisations specialised in the disseminating, transferring and assessing R&D results is still in its early development stages. Both Building upon Knowledge and Partnership for Knowledge introduce a series of actions to increase and strengthen collaborations between, universities, public research organisations and business sectors. The re-established National Centre will play the most prominent role in supporting public-private collaboration for Research and Development (NCNiR), which will specifically manage strategic programmes aiming at applied research and development projects.

2.3.4 *Intra-group similarities and differences*

- While, all countries follow the same procedures, complying to the EC regulations for monitoring and evaluation structural fund projects, these differ with regards projects funded by national public money. While evaluation/monitoring mechanisms are rather incipient in Bulgaria and Poland, in Romania, they are in theory well-designed, however, faulty and ineffective in implementation. In all of the countries, R&D institute and HEI evaluation exists to some extent or is planned to be further developed in the future. However, the reform is largely on paper in all the countries the scientific community showing reluctance to performance-based financing.
- Defective implementation of programmes and delayed payments. In short, there are distortions in public funding preventing full competition for resources and perhaps an unduly generous level of uncontested base level institutional funding.

- While R&D governance has not been restructured in Bulgaria and Poland, the implementation agencies were created with the aim of improving the implementation of Romania's RDI system, which has a complex structure, organised on several levels. There are three different legislative frameworks for the research institutes under MERI-NASR and the line ministries, RA, and universities.

2.4 Framework conditions for business R&D and innovation

2.4.1 Bulgaria

The Bulgarian BERD is among the lowest in Europe, showing, however, a low increase from 0.10% of GDP in 2002 to 0.15% in 2008. According to the World Bank's *Ease of Doing Business report* Bulgaria ranked as 51st out of 183 monitored countries in 2010, valued best for getting credit and worth for enforcing contracts. The latter has been particularly detrimental to R&D investment.

There are no legislative or fiscal mechanisms to promote business investments in R&D and existing guarantee schemes have still not produced any tangible increase in private sector R&D funding. Some tax incentives for R&D expenditures exist however the conditions limit the access of the business sector to them. The law allows tax reduction only if the R&D activity is carried out by an external contractor (research institute or HEI,) and only after the completion of the R&D activity even if it takes several years.

2.4.2 Romania

The evolution of Romanian BERD over the last 5 years shows a relatively stable share during 2005-2007, at around 0.20% of the GDP and about 18% of the EU-27 average – already a very low value. In 2008 and 2009, as a consequence of the economic crisis, Romanian BERD levels dropped even lower, to 0.17% and 0.15% of the GDP further increasing the gap to the EU-27 (14% and 11.7% of the EU-27 average, respectively). These low levels of the Romanian BERD reflect the poor R&D capacity of domestic firms, which, in turn, is due to several reasons: incomplete restructuring of the business sector, limited own financial resources and difficulty to access external funding sources (bank loans), virtual inexistence of private venture capital for R&D, poor motivation to invest in R&D and preference for external acquisition of technology instead of developing their own.

Framework conditions for private investment in R&D are underdeveloped, especially in terms of fiscal incentives and other financial instruments aiming to facilitate access to private finance. The general business environment is regulated by a variety of laws and legal provisions that are sometimes far from simple and transparent, and their enforcement is often poor. The World Bank's *Doing Business Report 2011* ranks Romania 56th among 183 countries in 2011, down from 54th in 2010. The insufficient and poorly diversified entrepreneurial base poses serious problems to the country's economic development, especially in certain regions and areas that are lagging behind in terms of economic development. While the impact of some efforts is visible,[47] Romania continues to operate one of the most burdensome tax administration systems in the world with companies paying 113 taxes per year (EC,2009). Although some steps have been made to address the persistent weak public administration, inefficient judiciary system and low access to public money, continue to be important drawbacks preventing the creation of an efficient business environment. The venture capital market is at an early stage, due to the unfavourable tax regime for private equity investments and underdeveloped domestic fund structure for private equity and venture capital. Although the creation of risk capital funds for innovation was foreseen in several policy documents such funds have yet to be created and the JEREMIE Fund for Romania is still not functioning The current tax

[47] For example, the process of setting up a new business is relatively straightforward (Romania ranks 44th in this regard), taking about 10 days to complete and relatively modest cost and minimum capital (2.6% and 0.9% of income per capita, respectively).

scheme only provides VAT exemption for RDI activities performed under NPII programmes, and within the frame of international, regional and bilateral partnership. There is no evidence that tax breaks or matching grants under the Innovation programme of the NPII have crowded-in private R&D investment. Romania has very low values for IP indicators compared to the EU-27 average (virtually zero), according to the EIS 2008. There is a law on IP that will be reviewed.

The innovation and technology transfer infrastructure, namely organisations specialised in the disseminating, transferring and evaluating R&D results, has been developed to some extent. The National Network of Innovation and Technological Transfer (ReNITT) consists of 46 specific entities as well as four scientific and technological parks located in different regions of the country. However, this technology transfer infrastructure is characterised by low commercialisation capacities.

There is no specific innovation promotion policy through public procurement.

2.4.3 *Poland*

The GERD share of BERD is historically very low in Poland. In 2008, BERD only amounted to 0.19%, which is particularly low as compared with the EU-27 average of 1.21%.

Polish companies' main challenge is not R&D itself but rather technological update in order to approach the Western European level of innovation, as well as infrastructural investments and expenditures aiming at meeting the environmental needs. Moreover, private demand for R&D is constrained by the sectoral structure of the Polish economy, which primarily focuses on low- and medium-low-tech activities, e.g. 11 out of 16 Polish regions are classified as low innovators by Regional Innovation Scoreboard (2009) and are in a group of EU regions with the lowest business R&D expenditures; the remaining five as medium-low innovators at the EU level.

The human resources in science and technology as a share of labour force (HRST) amounted to 33.4% in 2009, which is below the EU-27 average of 39.6%. The Partnership for Knowledge reform is expected to revolutionise researchers' situation, improve the quality of higher education and R&D activities and create strong ties between business and science to match better supply of highly qualified human resources with the market demand.

The *2008 New approach to public procurement report* underlined the importance and potential of public procurement, including green public procurement, as a successful policy instrument towards more R&D and innovation and identified existing obstacles and made recommendations for better use of public procurement. However, public procurement in R&D policy is still not widely used in Poland, mainly due to low recognition and awareness of its potential role.

2.4.4 *Intra-group similarities and differences*

- All of these countries have very low levels of BERD, despite the public push. Although the complexity, coherency and coordination of the schemes designed to support the private R&D differs from one country to another, the low capacity of private firms to absorb R&D funds is a common pattern. The main instruments aiming to have a leverage effect on business R&D expenditure build on structural funds and consequently follow EC recommendations regarding the evaluation and monitoring procedures. Yet, the results remain slow. There may be several reasons for this. On one hand, the private companies may be reluctant to participate in these schemes. This could be triggered by complex application procedures, high bureaucracy or fear of well-established and well-known defective routines and evaluations, often showing political or other sort of favouritism as is the case of Bulgaria and Romania. On the other hand, the enterprises may hesitate to increase their competitiveness based on RDI activities because of high market risks and technological uncertainties, particularly true in unstable economies and orientated towards low and medium technologies.

- Contrary to the other two countries, in Poland the publicly supported research and innovation policies are provided in a relatively simple and easy way to the potential beneficiaries. Further, the Building upon Knowledge reform created new organisations with clearly defined goals so that the politics and policy making will be separated, which should increase transparency and efficiency in distribution of public R&D funds. Some steps also have been made with regards public procurement.
- One of the main challenges of the private sectors in these countries is not R&D itself but rather the need of technological update in order to approach the Western European level of innovation. The low patenting activity is then rather a reflection of the economy sectoral distribution, low R&D input, the specificity of the catching-up economy and its NIS rather than of the capability of researchers to produce exploitable performance.
- Another main problem is the economic structure which is not favourable for the R&D investment and this cannot be solved by R&D policy itself. Also, macroeconomic policies have failed to create a stable, predictable environment for businesses.
- Administrative costs incurred by businesses are high by international standards, and that is especially unfavourable for SMEs.
- Often HEI and PRO knowledge transfer, collaborative projects and IP commercialisation activities are driven by public funding availability, and not by market pressures and opportunities.
- Overall the macroeconomic situation, the structure of the economy, the overall entrepreneurship culture together with the intensity and type of competition creates a context in which the STI policy schemes, however well designed and implemented, may not be able to offer strong enough incentives to overrule the unfavourable framework conditions.

Appendix 9

The origin of the country group classification: Extract from the Research, Innovation and Competitiveness Report

1. Diversity of European countries

Highlights

The design of innovation policies can not be homogeneous across countries. Research and innovation systems in Europe are diverse and face different challenges. Policy responses can be inspired by general guiding principles and knowledge, but should be tailored-made and take into account the economic structure of a country and its capacity to generate, diffuse and use specific knowledge to its economy. A close analysis of the European Research Area (ERA) reveals the heterogeneity of research systems. Country groupings can help designing policies and facilitating peer-learning by providing a framework of reference for closer comparison and benchmark between research systems. The analysis in this report identifies seven country groups with strong comparable characteristics.

1.1. Selected variables of the national research and innovation systems

Research and innovation (R&I) are key for the future economic competitiveness and social progress of Europe. Thus, R&I support policies have gained importance and are now placed at the heart of public intervention, including EU policies[48].

While general guiding principles for R&I policy are widely accepted and applicable, their definition and translation into specific policy measures, instruments and programmes need to be context-specific. R&I systems in Europe are diverse and face heterogeneous challenges. "One size-fits-all" strategies and policies cannot be applied across countries and tailor-made policies need to be adapted to the local conditions.

This section of the report analyses the heterogeneity of national R&I systems across Europe and identifies groups of countries with (relatively) similar features in their research conditions and innovation performance. These clusters can help improve policy learning and define better targeted policies.

It should be noted that the groupings accruing from this analysis are not meant to be prescriptive, but rather they constitute a framework for potential use of Member States in their policy analysis, learning and benchmarking exercises.

The European Research Area (ERA) is not a homogeneous research system and aggregate values mask large differences between individual countries.

As table XX shows, values in research intensity, the relative importance of the different research actors, their linkages, the innovation results, the economic structure, the framework conditions, or the openness of the system, vary largely across European countries.

Table: Key selected variables of the national research systems in Europe

[48] 'Europe 2020' places innovation at the heart of the next 10-year Strategy (http://ec.europa.eu/europe2020/index_en.htm)

	GERD	BERD	GOVERD	EPO patents	% population with tertiary education	Prim_employ	Industrial	Buss+Fin	MHiTech manuf	Emp KIS
Belgium	1.9	1.3	0.2	137.9	32.3	1.8	14.0	20.9	5.5	38.3
Bulgaria	0.5	0.2	0.3	3.5	22.8	19.3	21.5	7.1	3.9	18.3
Checz Republic	1.5	0.9	0.3	10.8	14.5	3.6	29.3	13.0	9.3	24.2
Denmark	2.7	1.9	0.1	207.8	33.7	2.9	14.3	15.9	4.8	42.9
Germany	2.6	1.8	0.4	290.9	25.3	2.1	19.9	17.4	8.8	34.0
Estonia	1.3	0.6	0.2	7.1	34.3	3.9	23.5	9.6	3.8	28.8
Ireland	1.4	0.9	0.1	65.3	32.7	5.8	13.6	14.0	2.7	36.3
Greece	0.6	0.2	0.1	10.9	22.6	11.5	11.6	8.9	1.8	24.9
Spain	1.4	0.7	0.3	33.4	29.2	4.3	15.5	12.2	4.3	28.5
France	2.0	1.3	0.3	134.7	27.3	3.3	13.2	18.6	5.0	37.3
Italy	1.2	0.6	0.2	85.2	14.4	3.9	20.5	15.0	5.6	28.7
Cyprus	0.5	0.1	0.1	25.0	34.5	4.3	10.4	11.1	0.8	28.2
Latvia	0.6	0.2	0.2	9.8	25.2	7.9	16.7	10.1	2.0	26.9
Lithuania	0.8	0.2	0.2	3.2	30.4	7.9	19.5	8.0	2.7	27.1
Luxembourg	1.6	1.3	0.3	231.8	27.7	1.4	10.9	28.9	0.3	26.1
Hungary	1.0	0.5	0.2	13.7	19.2	7.5	24.2	10.2	6.4	27.0
Malta	0.5	0.4	0.0	33.8	13.1	2.5	20.2	10.4	2.8	32.1
Netherlands	1.6	0.9	0.2	205.8	31.9	2.9	11.2	22.2	2.6	41.6
Austria	2.7	1.9	0.1	185.7	18.1	5.2	17.3	15.0	4.6	31.2
Poland	0.6	0.2	0.2	3.4	19.6	14.0	23.8	8.6	4.7	24.0
Portugal	1.5	0.8	0.1	13.2	14.3	11.6	17.9	8.5	2.9	23.6
Romania	0.6	0.2	0.2	1.6	12.8	30.2	23.7	4.1	5.1	14.8
Slovenia	1.7	1.1	0.4	57.6	22.6	8.6	25.5	14.2	7.8	26.0
Slovakia	0.5	0.2	0.2	6.1	14.8	3.6	26.2	10.3	9.4	26.9
Finland	3.7	2.8	0.3	247.3	36.6	4.8	18.0	13.3	5.0	41.0
Sweden	3.8	2.8	0.2	269.6	31.8	2.2	16.5	15.1	5.3	47.6
UK	1.9	1.2	0.2	85.9	31.8	0.7	12.6	31.9	4.0	42.5
Croatia	0.9	0.4	0.2	7.1	17.7	15.7	20.7	5.7	4.1	23.2
Turkey	0.7	0.3	0.1	2.7	11.4	8.5	18.0	21.1	3.6	13.6
Iceland	2.7	1.5	0.5	93.3	34.7	5.9	10.8	14.6	1.6	44.9
Norway	1.6	0.9	0.2	111.4	40.4	2.9	13.9	14.8	3.6	46.7
Switzerland	2.9	2.1	0.0	430.7	38.0	3.8	17.0	17.5	4.8	42.5

Source: DG Research and Innovation
Data: Eurostat 2009

This heterogeneity of research and innovation systems in Europe[49] demands an analysis which goes beyond a homogeneous and unique view and policy formulation

"One size fits all strategies" are then discouraged and targeted individual analysis and policies are needed to better understand the strength and weaknesses of specific systems and identify their threats and opportunities.

However, while each research and innovation system counts on specific characteristics that distinguish them from each other, some of them also share common features that allow them to be analysed together and differentiate them from the rest.

Country grouping of research and innovation systems in Europe can address the complexity related to the heterogeneity of systems in Europe, while limiting the analysis to a manageable set of reference groups

Any methodology aiming at reducing the complexity of a research and innovation system, and not taking into account all the specificities embedded in them, can only be a simplification and therefore, any results should be handled with caution. Other alternative and classifications taking more qualitative variables, e.g. cultural and historical elements, could also add new complementary insights on how to better classify Research and Innovation systems in Europe.

[49] The heterogeneity of the research systems in Europe can be even broaden as even within European countries, specific regions count on very different sets of conditions and therefore very different research systems. This is particularly true for countries like Italy, where the inter-regional differences are very large and it is possible to talk about two different Italian research and innovation systems, the North and the South.

In our analysis, in order to create groups of research and innovation systems in Europe, a large number of variables featuring their main characteristics, functioning and results are selected. In total, nineteen variables for which data were available were retained, and included the *total intramural expenditure in R&D* (*GERD*) as percentage of GDP, *the total intramural R&D expenditure performed by the private sector* (*BERD*), *the total intramural R&D expenditure performed by the public sector* (*GovERD*), *the total intramural R&D expenditure performed by the higher education sector* (*HERD*), the *Human Resources in Science and Technology aged between 25-64* ,and *the ratio in top-10% most highly cited publications*. These six variables covered the research intensity in the system, the relative importance of each performing sector and the research performance of the system.

The *patent applications per million of population* and the number of *patent applications in high-tech sectors* were introduced to proxy the innovation activity of the system. The variables of the *percentage of the population working on the primary sector, industry, business and financial services*, as well as the percentage of *population working on high-tech manufacturing sectors and knowledge intensive services* were also introduced to control for the economic structure of the country. Finally, in order to take account of the framework conditions existing in the system, the *population density* as a proxy for the establishment of the linkages between research actors, the *GDP per capita*, as a proxy of the technological development of the country, the *natural logarithm of the GDP* as a proxy for the size of the market, and last the percentage of the *population engaged in life-long-learning activities and with tertiary education* for the availability of the skills, were also selected.

1.2. Groups of countries based on knowledge capacity and economic structure

In order to reduce the complexity introduced by the use of such a large number of variables, a multiple multivariate econometric analysis based on a Principal Component Analysis was performed. The result of this analysis revealed that two key factors could summarise a large part of the information covered by the nineteen analysed variables. These factors were first, the knowledge capacity of the system[50], and second, the economic structure prevailing in the system, and more precisely, the importance of the manufacturing industry in the system[51].

After the Principal Component Analysis, a Cluster Analysis maximising the distance between groups and minimising this distance within groups was carried out in order to group the different research systems according to the values scored on the two key factors structuring the research and innovation systems.

European countries can be analysed in eight groups based on their knowledge capacity and economic structure

As figure XX shows, eight different research and innovation groups could be identified:

<u>Group 1: Very high knowledge intensity countries.</u>
This group would be composed of Finland, Sweden, Denmark and Switzerland.

<u>Group 2: High knowledge capacity systems with a specialisation in high-tech manufacturing</u>

[50] This factor accounted for almost 50% of the total variance.
[51] This factor accounted for more than 12% of the total variance in the model. As a result, the Principal Component Analysis accounted for more than 62% of the variance introduced by the nineteen individual variables.

Germany would be alone in this group as its characteristics would differentiate it from all other research systems.

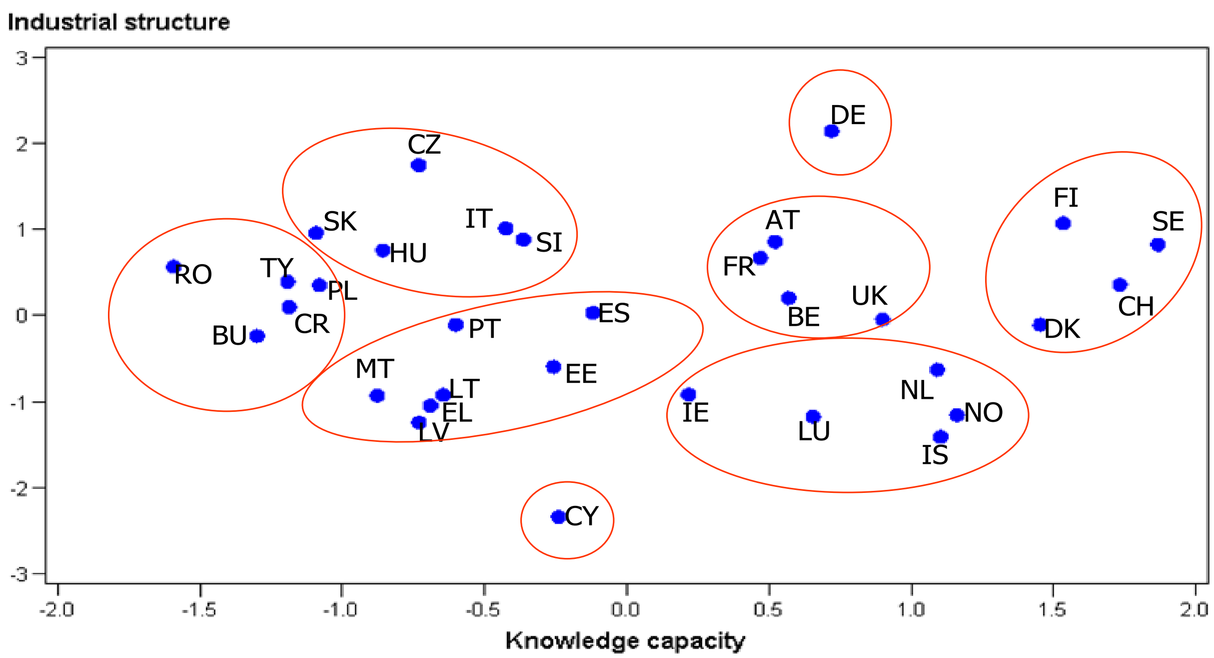
Group 3: High knowledge capacity systems with a mixed economic structure
This group would be composed of Belgium, the United Kingdom, France and Austria.

Group 4: Medium-high knowledge capacity systems with an economic specialisation in knowledge intensive services
This group would be composed of Ireland, Luxembourg, the Netherlands, Norway and Iceland
Group 5: Medium knowledge capacity systems with an economic specialisation in low knowledge sectors.
This group would be composed of Spain, Portugal, Greece, Estonia, Latvia, Lithuania and Malta

Group 6: Medium-low knowledge capacity system with a strong service-based economy
Cyprus, as Germany, would be alone as its characteristics would differentiate it from all other research systems
Group 7: Medium-low knowledge capacity with an important industrial base
This group would be composed of the Czech Republic, Slovenia, Slovakia, Hungary and Italy

Group 8: Low knowledge capacity systems with a specialisation in low knowledge intensive sector.
This group would be composed of Bulgaria, Romania, Poland, Turkey and Croatia.

Figure XX: Groups of research and innovation systems in Europe



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Source: DG Research and Innovation
Data: Eurostat and OECD, 2009

Table XX: Key selected variables of the national research systems of the different groups

	GERD	BERD	Hi-tech Patents	Employment in KIS	Research excellence	GERD growth 2000-2008	BERD growth 2000-2008
Group 1	3.3	2.4	36.5	43.5	1.3	6.6	6.9
Group 2	2.6	1.8	28.4	34.0	1.1	7.3	6.4
Group 3	2.1	1.4	19.0	37.3	1.1	7.9	5.8
Group 4	1.8	1.1	15.5	39.1	1.1	1.1	-6.7
Group 5	1.0	0.4	2.0	27.4	0.6	61.4	112.4
Group 6	0.5	0.1	0.4	28.2	0.7	95.8	120.0
Group 7	1.2	0.7	2.5	26.5	0.6	13.6	17.8
Group 8	0.7	0.3	0.6	18.8	0.4	11.4	7.8

Source: DG Research
Data: Eurostat

The results also allow for intra-group comparisons

This group classification can help identifying how similar countries, i.e. countries belonging to a group, react in terms of research and innovation policies. In many cases, countries with similar research and innovations systems follow different paths when it comes to defining their investment strategies. As table X shows, in the last decade, countries with well-developed research and innovation systems benefiting from high R&D investments and scientific and technological outputs have performed differently in terms of research and innovation.

Sweden, on the one hand, the world leader in terms of R&D investment, decreased its overall percentage and private R&D investments by more than 10, while Finland, a close follower, increased these investments by more than 10%. While this analysis does not allow accounting for the reasons of these trends, it allows identifying some interesting features of the research and innovation systems worth exploring further.

Table XX: Key selected variables of the national research systems for very high knowledge intensive countries

	GERD	BERD	Hi-tech Patents	Employment in KIS	Research excellence	GERD growth 2000-2008	BERD growth 2000-2008
Sweden	3.8	2.8	38.8	47.6	1.2	-10.1	-13.9
Finland	3.7	2.8	53.8	41.0	1.1	11.0	16.5
Denmark	2.7	1.9	20.5	42.9	1.1	21.9	27.3
Switzerland	2.9	2.1	32.8	42.5	1.5	14.6	14.4

Source: DG Research and Innovation
Data:Eurostat

Perhaps, more interesting is the situation for countries with weaker research and innovation systems, where the differences in performance are more remarkable, mainly due to the higher effect caused by smaller variations. For example, since the year 2000, Romania has benefited from a sharp increase in overall R&D investment, although this increase has been fuelled by the public sector, while the private sector decreased its R&D investment. On the contrary, for the same period Bulgaria decreased its R&D investment, mainly due to a decrease in the research intensity of public investment, while private R&D increased. Once again, these data do not allow understanding the reasons for these different behaviours but they point out to interesting areas for further research.

Table XX: Key selected variables of the national research systems for low knowledge intensive countries with a specialisation in low knowledge intensive sectors

	GERD	BERD	Hi-tech Patents	Employment in KIS	Research excellence	GERD growth 2000-2008	BERD growth 2000-2008
Romania	0.6	0.2	1.6	14.8	0.4	59.5	-28.0
Bulgaria	0.5	0.2	3.5	18.3	0.4	-5.8	36.4
Poland	0.6	0.2	3.4	24.0	0.5	-4.7	-17.4
Turkey	0.7	0.3	2.7	13.6	0.4	50.0	106.3
Croatia	0.9	0.4	7.1	23.2	0.4	-6.2	-2.4

Source: DG Research and Innovation
Data: Eurostat

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Abstract

Research and innovation policies are not formulated in a vacuum. They are shaped and influenced by myriad factors both internal and external to the realm of science and technology. In the context of a period of reflection on future support policies in Europe, this policy brief reviews the main drivers of change affecting the research and innovation landscape and their implications for EU policy. It observes that different drivers of change imply the need for similar sets of policy responses and concludes that wholesale changes are needed across a broad front, with a particular focus on eight distinct policy thrusts geared, inter alia, towards strengthening key elements of research and innovation systems, confronting major societal challenges, improving governance systems and enhancing international cooperation.

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