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ERAWATCH Country Report 2009

Analysis of policy mixes to foster R&D investment and to contribute to the ERA

Denmark

Antje Klitkou

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ERAWATCH COUNTRY REPORT 2009:

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Analysis of policy mixes to foster R&D investment and to contribute to the ERA

ERAWATCH Network – NIFU STEP Norwegian research institute for studies in innovation, research, and education

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Executive Summary

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are thus at the heart of the Lisbon Strategy. This is reflected in guideline No. 7 of the Integrated Guidelines for Growth and Jobs. This advocates increasing and improving investment in research and development (R&D), with a particular focus on the private sector. This report aims at supporting the mutual learning process and the monitoring of Member States efforts. Its main objective is to characterise and assess the evolution of the national policy mixes in the perspective of the Lisbon goals, with a particular focus on the national R&D investments targets and on the realisation and better governance of the European Research Area. The report builds on the analytical country reports 2008 and on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

Denmark is a small but prosperous country with 1.1% of the total EU27 population. GDP per capita was 68% above EU27 average in 2007; the annual average growth rate of GDP for 2000–2005 was 3.7%, the same level as the EU27 (European Commission, 2008). The Danish research system is well funded compared with EU27. In 2006, Denmark's GERD was 2.43% of GDP, well above the average of the EU27 of 1.84% (Eurostat data from 2008). The estimate for 2007 is 2.55%. The absolute volume of GERD, however, has increased since 2003 at an average annual growth rate of 3.02The shares for gross domestic expenditure on R&D for the business sector are particularly high (€3.560b or 1.62% of GDP, 1.17% in EU27) and the higher education sector (0.63% in Denmark, 0.4% in EU27). The R&D expenditure of the public sector in total amounted to €1.756b, equivalent to 0.79% of the GDP in 2006 (Eurostat, 2008).

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Low level of public R&D infrastructure investments	Opportunity to modernise the public research infrastructure because of two new funds
Use of European funding and shared infrastructure facilities	European funding and shared infrastructure have attracted more attention
Lack of government incentives for private R&D	Targeted policy measures may provide framework conditions for more R&D in the business sector, but risk that economic crisis may endanger the output
Shortage of highly skilled labour	Lifelong learning strategy improves skills development of working force, but risk that increasing unemployment may have negative impact on education of scientists and engineers
Relatively weak science-industry linkages	Opportunities for firms to cooperate with strengthened public R&D sector

The Liberal–Conservative government has set as objective that Denmark is to become the most competitive economy in the world by 2015. To realize this objective the government has increased public funding of R&D, but also has increased the importance of competitive funding schemes and introduced performance based funding of universities. The *Globalisation Strategy* (Danish Government, 2006) set as a target that as much as one half of public R&D funding is to be competitive by 2010 (as opposed to one third in 2006). Since 2008, the basic funding of universities is

based on an evaluation of the institution's ability to reach the objectives given in the development contracts with the ministry. The National Reform Programme (NRP) (Danish Government, 2008) stresses the continuous implementation of the strengthened quality and scope of public research as a main task.

Public R&D expenditures are to reach 1% of GDP by 2010. This goal was formulated in NRP 2005 and has been repeated in the NRP 2008. Consequently, the government has increased the public R&D budget significantly, both for 2009 and 2010.

In the NRP 2005 it was also stated that the Danish government has set the goal that *business R&D expenditures* shall amount to 2% of GDP goal in 2010. According to the latest statistics this goal does not seem capable of being achieved. The NRP 2008 has not explicitly repeated or changed this goal, but government policy is working on a company-oriented innovation strategy with a "focus on improving framework conditions for enterprises' innovation policy" (NRP, 2008).

	Short assessment of its importance in the ERA policy mix	**Key characteristics of policies**
Labour market for researchers	• Important, with focus on improved international competitiveness of Danish research	• Policy focus on attracting the best foreign researchers and students • Danish researchers and students shall have the possibility to gain international experiences
Governance of research infrastructures	• Increasingly important	• Development of national strategy • National programme for research infrastructure is supporting national infrastructure and participation in European infrastructure
Autonomy of research institutions	• Important, with focus on improved research quality	• High degree of autonomy of universities is underpinned by high core funding, and high share of bottom-up research funding, but they are accountable to the Ministry of Science, Technology and Innovation (development contracts) • Introduction of performance indicators as basis for core funding in 2009-2010
Opening up of national research programmes	• Increasingly important, with focus on improved international competitiveness of Danish research	• Strategic research programmes have been opened up for foreign researchers and research organisations as far as the projects strengthen Danish research • "Money follows researcher initiative" is granted by the Danish Councils for Independent Research • Increased participation in ERA-NETs and JTIs

In recent years GDP has grown much faster than R&D expenditure. Consequently the share of GDP spent on R&D has declined from 2.58% in 2003 to 2.55% in 2007. It remains to be seen what the consequences of the ongoing *economic crisis* will be. Along with the majority of EU Member states, Denmark is experiencing a recession. That means that GDP is falling. It is unlikely that the increase of public R&D expenditure planned in the Globalisation Strategy and the NRP 2008 will be halted. However, the development of BERD is much more uncertain and currently we have no data permitting a proper assessment of this. However, a recently published study on the impact of the economic crisis on R&D and innovation in the business sector concluded that the share of BERD will probably decrease from 2008 to 2009 to between 1.81% and 1.88%, while it was at 1.91% in 2007 (DASTI, 2009b).

The policy mixes addressing science-industry linkages and commercialisation of public research results have been in the centre of policy development lasting recent years. There has been an increase of the number of Gazelle enterprises in the country, probably as a consequence of the respective policy measures, but this development was also supported by the favourable economic situation. Since the newly introduced policy measures are not supported by large budgets and the economic situation is now critical, it remains to be seen if the R&D intensity of SMEs and the R&D intensity of the business sector in general can be further improved.

The high policy focus on the development of the public research sector has resulted in a clear increase of public R&D funding, even the low level of infrastructure investments has been addressed by new policy measures. We assess that Denmark will reach the 1% target by 2010.

The Lifelong learning strategy improves skill development of the working force. However, the shortage of highly skilled labour has been identified as a major barrier for business R&D and innovation (DASTI, 2009b). The economic crisis will lead to increased unemployment also of engineers.

ERA and ERA-related policies have an increasing influence on Danish research policy. Since the development of the Globalisation Strategy in 2006 there is an increased international orientation of Danish research policy.

The main contributions of Danish policies to the ERA are the increased openness of Danish research programmes and the expressed interest in participating in new European research infrastructures. The main focus remains on the participation in FP7 and ERA-Nets.

The *openness of Danish national research programmes* to European and international researchers has been limited, but there are some differences and also some important changes. Recently there has been a new approach to promote international collaboration by opening up national research programmes for foreign research organisations, foreign researchers or Danish researchers employed abroad. The only requirement is that the funded research activities promote and strengthen Danish research. It remains to be seen whether Danish research programmes are attractive to foreign researchers and research organisations. The Danish Government has a focus on enhanced Danish participation in new *European research infrastructures* and has foreseen adequate funding for this purpose. DASTI has introduced several measures and organisational changes for improving Danish *participation in EUFP7,* but it remains a challenge to reverse the negative trend.

Concerning the opening up of the *labour market for researchers,* Danish policies aim to open up this market, but also look beyond Europe (e.g. Asia and the USA). The NRP 2008 highlights the need for free movement of knowledge in Europe, “where knowledge, ideas, researchers, and students can move about freely”.

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1 Introduction

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are thus at the heart of the Lisbon Strategy. This is reflected in guideline No. 7 of the Integrated Guidelines for Growth and Jobs.[1] This advocates increasing and improving investment in research and development (R&D), with a particular focus on the private sector. For the period 2008 to 2010, this focus is confirmed as main policy challenge and the need for more rapid progress towards establishing the European Research Area, including meeting the collective EU target of raising research investment to 3% of GDP, is emphasised.

A central task of ERAWATCH is the production of analytical country reports to support the mutual learning process and monitoring of Member States' efforts in the context of the Lisbon Strategy and the ambition to develop the ERA. The first series of these reports was produced in 2008 and focused on characterising and assessing the performance of national research systems and related policies in a comparable manner. In order to do so, the system analysis focused on key processes relevant to system performance. Four policy-relevant domains of the research system have been distinguished: resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The analysis within each domain has been guided by a set of generic "challenges", common to all research systems and which reflect possible bottlenecks, system failures and market failures which a research system has to cope with. The analysis of the ERA dimension still remains exploratory.

The country reports 2009 build and extend on this analysis by focusing on policy mixes. Research policies can be a lever for economic growth, if they are tailored to the needs of a knowledge-based economy suited to the country and appropriately co-ordinated with other knowledge triangle policies. The policy focus is threefold:

- An updated analysis and assessment of recent research policies.
- An analysis and assessment of the evolution of national policy mixes towards Lisbon R&D investment goals. Particular attention is paid to policies fostering private R&D and addressing its barriers.
- An analysis and assessment of the contribution of national policies to the realisation of the ERA. Beyond contributing to national policy goals, which remains an important policy context, ERA-related policies can contribute to a better European level performance by fostering, in various ways, efficient resource allocation in Europe.

[1] COM(2007) 803 final, "INTEGRATED GUIDELINES FOR GROWTH AND JOBS (2008-2010)", http://ec.europa.eu/growthandjobs/pdf/european-dimension-200712-annual-progress-report/200712-annual-report-integrated-guidelines_en.pdf

2 Characteristics of the national research system and assessment of recent policy changes

2.1 Structure of the national research system and its governance

Denmark is a small country with only 1.1% of the total EU27 population. GDP per capita is 68% above the EU27 average in 2007; the annual average growth rate of GDP for 2000–2005 is 3.7%, the same level as the EU27 (European Commission, 2008). The unemployment rate is low with only 4.8% in 2007 versus 7.1% for EU27 (Eurostat July 2008). The Danish research system receives a high level of funding compared to EU27. In 2006, Denmark's GERD was 2.43%, well above the average of the EU27 of 1.84%, but still considerably lower than the two other Nordic EU member states, Sweden (3.82% of GDP) and Finland (3.45%) (Eurostat, 2008). In recent years GDP has grown much faster than R&D expenditure, and consequently the percentage of GDP spent on R&D has declined from 2.58% in 2003 to 2.43% in 2006. The absolute volume of GERD, however, has increased since 2003 at an average annual growth rate of 3.02%. Especially high are the share of gross domestic expenditure on R&D for the business sector (€3.560b or 1.62% of GDP, 1.17% in EU27) and the higher education sector (0.63% in Denmark, 0.4% in EU27). R&D expenditure in the public sector in total amounted to €1.756b or a proportion of 0.79% of the GDP (Eurostat, 2008).

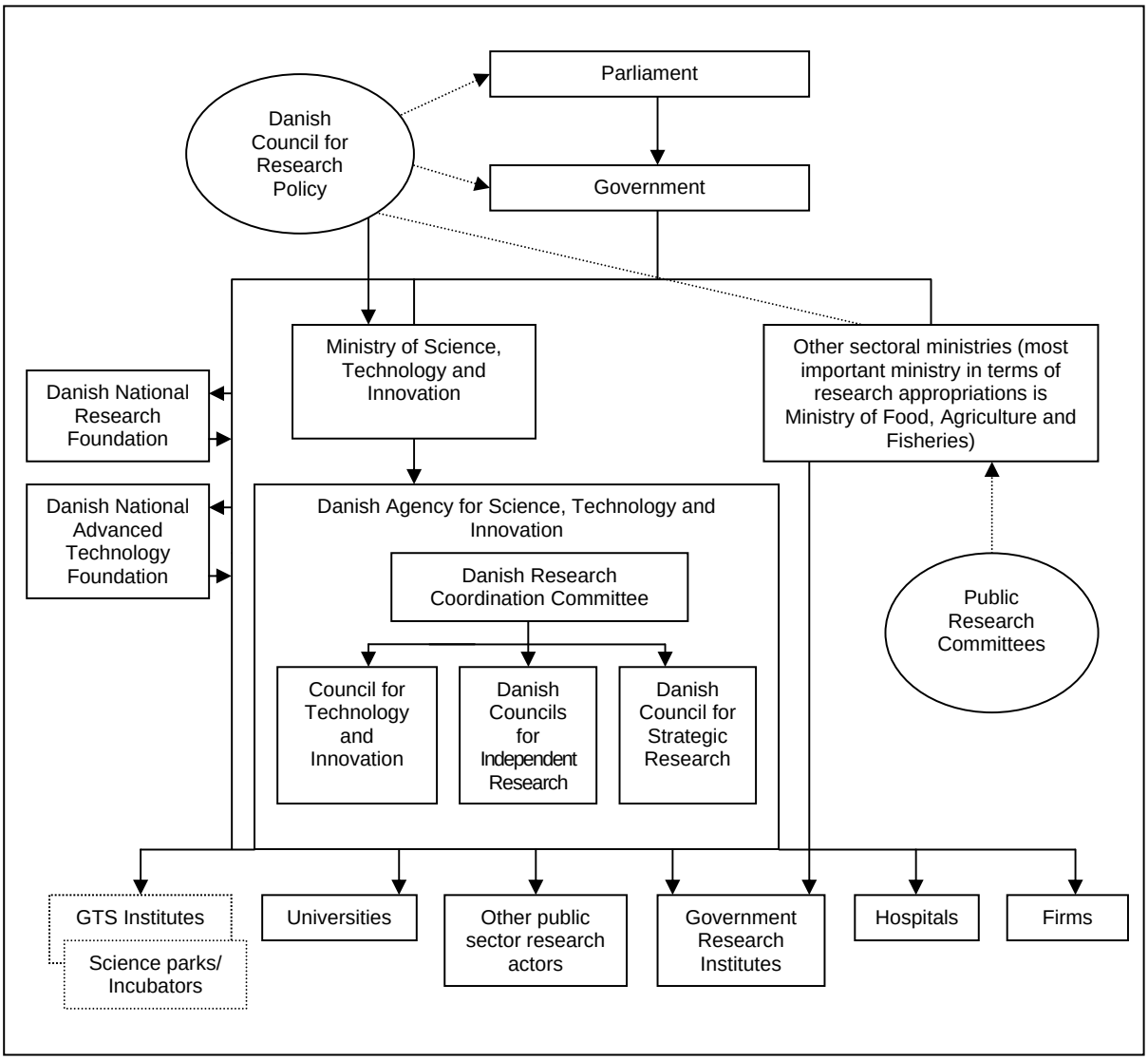
Main actors and institutions in research governance

Figure 1 portrays the Danish research system and its governance. Three levels are identified in the chart: policy level (parliament, government and ministry level); implementation of the policies in agencies, research councils, research foundations and other R&D policy bodies; and organisations engaged in R&D. An important issue is the coordination of the Ministry of Science, Technology and Innovation, the Danish Agency for Science, Technology and Innovation, the research councils, the two research foundations and the R&D instruments of the sectoral ministries, such as the R&D programme of the Ministry of Food, Agriculture and Fisheries, and the Energy Technology Development and Demonstration Programme under the Ministry of Climate and Energy. The main current research governance system is divided into two subsystems: the advisory part, the Danish Council for Research Policy, was established in 2004. The funding part consists of two research councils. The Council for Independent Research is the umbrella organisation for five research councils and supports research projects ideas based on researchers' initiatives and priorities. The other funding subsystem consists of the Council for Strategic Research which supports strategic and policy-oriented research. Other notable changes in the Danish research governance structure during recent years include the establishment of the Council for Technology and Innovation, and the Danish National Advanced Technology Foundation, oriented towards commercialisation of research results. In addition there is also the Danish National Research Foundation, specialised in funding basic science.

The institutional role of the regions in research governance

Research governance has not been an explicit responsibility of the regional authorities, except in the health sector.

Figure 1: Overview of the governance structure of Denmark's research system



Source: NIFU STEP

Main research performer groups

The *business enterprise sector* is the main R&D performer, funded mainly by the business sector and performing 68% of total R&D in 2005. In 2005, *Danish industry* invested 1.67% of GDP in R&D expenditure. This decreased slightly in 2006 to 1.62%. An analysis of the size distribution of Danish companies financing own R&D in 2006 reveals that R&D investments are still concentrated in the largest companies, as in most other European countries. One per cent of the firms account for almost half of all R&D expenditures. However, the share of R&D expenditures by SMEs is quite high: 29% of R&D expenditure in 2005 came from SMEs (1–249 employees) in Denmark. Manufacture of pharmaceuticals and medicinal chemistries, software consultancy and supply are the largest sectors regarding intramural R&D expenditures.

The main *public research performers* are now concentrated in the *university system,* performing 25% of the total R&D in 2005. More than 60% of publicly supported R&D takes place there. There are now mainly five universities: Copenhagen University, Aarhus University, the Technical University of Denmark, University of Southern

Denmark and Aalborg University. The universities are organised in an own stakeholder organisation, Universities Denmark.

The *government sector,* performing 6% of the total R&D in 2005, has been changed dramatically due to the merger of most research institutes with the universities in January 2007. Before 2007, there were 15 government research institutes, including institutes for food, the environment, space exploration and social research. In 2005, these institutes received €201m (DKK1.5b) in public funding, out of which €102.5m (DKK764m) was for research. The rationale of this restructuring of the Danish public research system was to strengthen the universities and research quality, and to reduce the fragmentation of the research system.

2.2 Summary of strengths and weaknesses of the research system

The analysis in this section is based on the ERAWATCH Analytical Country Reports 2008 which characterised and assessed the performance of the national research systems. In order to do so, the system analysis focused on key processes relevant to system performance. Four policy-relevant domains of the research system have been distinguished: resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The analysis within each domain has been guided by a set of generic "challenges", common to all research systems, which reflect possible bottlenecks, system failures and market failures a research system has to cope with. The Analytical Country Report for the specific country can be found on the ERAWATCH web site.

The strengths and weaknesses of the Danish research and governance system can be summarised as follows:

The Danish research governance system is characterised by *good horizontal policy coordination* between ministries and their agencies. The Ministry of Science, Technology and Innovation is responsible for *policies on research and innovation, which allows a high level of coordination,* in particular between national R&D and innovation policies. Important coordination channels in the Danish R&D governance system are the Research Coordination Committee and the Danish Council for Research Policy. In addition, there is a good coordination between the Ministry of Science, Technology and Innovation and other ministries with R&D portfolios. A multitude of research funding possibilities exist for researchers, but it is still difficult maintain an overview and to obtain long-term funding for larger projects.

Danish industry has a higher absorptive capacity and R&D intensity than average for Europe. However, the *linkages between industry and public research organisations need further strengthening.* More *formal knowledge channels,* such as the purchase of R&D results from universities and the licensing of university patents are limited and indicate a weakness in *knowledge circulation.* However, *informal knowledge channels* are better developed (Bekkers & Bodas Freitas, 2008). Denmark has long experiences with Industry PhDs and they facilitate circulation of knowledge quite well.

Table 1: Summary assessment of strengths and weaknesses of the national research system

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Broad policy consensus on the importance of research and development (R&D) for the future of Danish economy and society.
	Securing long term investment in research	Long-term planning for development of public R&D expenditure to meet the 1% Barcelona target in 2010
	Dealing with barriers to private R&D investment	Funding of higher education institutions (HEI) by industry is limited.
	Providing qualified human resources	Relatively low numbers of PhDs and engineers Increasing focus on the quality of PhD education
Knowledge demand	Identifying the drivers of knowledge demand	Common thematic orientation between public and private knowledge demand drivers Stakeholder involvement in public R&D priority settings and foresight exercises.
	Co-ordination and channelling knowledge demands	Research and Innovation policy under one ministry Danish Council for Research Policy is an adequate instrument for co-ordination of research policy Research Coordination Committee allows co-ordination between the main research funding organisations A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge.
	Monitoring of demand fulfilment	Broad and frequent use of international benchmarking and systemic evaluation
Knowledge production	Ensuring quality and excellence of knowledge production	Long experience with centres of excellence A well-performing technical university which has been further strengthened considerably the late years Good funding of interdisciplinary research
	Ensuring exploitability of knowledge	Increased focus on patenting. Coherence between R&D thematic focus in the public and private sector and economic specialisation – strengths in food, pharmaceuticals, instruments and energy sectors.
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Relatively low level of Higher Education R&D financed, by industry, but Industry PhDs facilitate circulation of knowledge. Modest rates of commercialisation of university research. National network for technology transfer strengthens professionalisation of technology transfer from public research to industry, but staffing of technology transfer offices (TTO) and qualification of TTOs not prioritised in all organisations.
	Profiting from international knowledge	Modest participation of HEIs in the EU Framework programmes. National research programmes with limited access (participation and funding) to foreign researchers. Agreements on research collaboration with China, India etc.
	Enhancing absorptive capacity of knowledge users	Small and medium sized enterprises (SME) have high absorptive capacity. High levels and well organised Lifelong learning Industry PhDs have successfully contributed to increased absorptive capacity in private firms.

2.3 Analysis of recent policy changes since 2008

The contribution of research and research policies to the Lisbon goals (as well as to other societal objectives) goes beyond the fostering of R&D investment. It is therefore important to also analyse how other remaining shortcomings or weaknesses of the research system are addressed by the research policy mix. The focus of the section is on the analysis of main recent policy changes which may have a relevant impact on the four policy-related domains.

2.3.1 Resource mobilisation

The European Commission has emphasised that Denmark's national reform programme identified developing the knowledge society as one of the key challenges. The Commission recommended a focus on increasing the labour supply and achieving the education targets (Council of the European Union, 2008).

According to the state budget for 2009, public sector R&D expenditure as share of GDP has increased to 0.89% in 2008 and will be 0.94% in 2009. The 1% target will be achieved in 2010 (Ministry of Science, Technology and Innovation, 2008).

The government has addressed decreasing venture capital by two new, competitive funding pools to which universities can apply for funding:

- The Infrastructure Pool, with a total of €80.4m for financing investment in large-scale, interdisciplinary research infrastructure in Denmark and abroad. A €26.8m share was put up for tender in spring 2007.
- UNIK (University Research Investment Capital) for large, long-term initiatives. €32.2m has been earmarked for 2008 and for 2009.

For improving PhD education and attracting foreign PhD students, in April 2008 the Minister for Science, Technology and Innovation approved 12 elite educational courses at Danish universities.

The government is planning to revise the researcher taxation scheme for attracting more foreign researchers. Foreign researchers will have the possibility of shorter stays in Denmark as guest teachers before applying for the special taxation scheme.

Changes in National Reform Programme regarding the role of research in the broader economic growth strategy

Denmark's NRP, published in October 2008, has a focus on public research: the *1 per cent goal* is to be reached by 2010, and the NRP gives a short outline of the policy measures that have been implemented in 2008 to achieve this goal, such as the research catalogue FORSK2015 or the University Research Investment Capital (UNIK).

In the field of research in the private sector, the NRP 2008 has not explicitly repeated or changed the 2 per cent goal, but emphasises that the government is working on a company-oriented innovation strategy with a "focus on improving framework conditions for enterprises' innovation policy".

Table 2: Main policy changes in the resource mobilisation domain

Challenges	Main Policy Changes
Justifying resource provision for research activities	• Increased public R&D expenditures in government budget • Distribution of increasing core funding to universities based on bibliometric research indicator after the Norwegian model (NRP 2008)
Securing long term investments in research	• Introduction of two new competitive funding pools for universities (Infrastructure Pool and UNIK)
Dealing with uncertain returns and other barriers	• Working on a company-oriented innovation strategy (NRP 2008)
Providing qualified human resources	• Introduction of 12 elite PhD courses at Danish universities • Plans to revise researcher taxation scheme

2.3.2 Knowledge demand

The Ministry of Science, Technology and Innovation organised a broad process that addressed the strategic knowledge demands for Danish society. The process resulted in a catalogue of priorities for strategic research – Forsk2015, published May 2008. All ministries and the research councils were included in this process and also a broad range of branch organisations. The expert panel consisted of experts from universities, and representatives from private think-tanks and industry stakeholder organisations. The involvement of the user-panel was based on a workshop with participants from industry stakeholder organisations, companies, representatives from regional authorities, public research organisations and others. In addition, several hundred persons submitted proposals for research fields.

Forsk2015 has identified 21 strategic research fields distributed over six key research areas. These six areas are: energy, climate and environment; production and technology; health and prevention; innovation and competitiveness; knowledge and education; and people and society. For each research field, the key challenges, knowledge demands and Danish research conditions and possibilities, and finally, national and international research perspectives, have been identified.

The identified strategic research fields will be used in the political prioritisation of strategic research areas in 2009. New calls for project proposals from the Strategic Research Council from March 2009 apply these priorities.

The evaluation and accountability culture of the Danish research policy system has been addressed in the Second Progress Report of the NRP 2005 (Danish Government, 2007) and further developed by new initiatives, such as the recent report of the Strategic Research Council on impact assessment of strategic research (2008) or the evaluation of the public service for inventors (2008), commissioned by the Danish Agency for Science, Technology and Innovation (DASTI). In January 2009, an action plan for the evaluation of research programmes and related policy measures was published, including guidelines for research evaluation.

Table 3: Main policy changes in the knowledge demand domain

Challenges	Main Policy Changes
Identifying the drivers of knowledge demand	• Involvement of stakeholders in the development of research priorities
Co-ordinating and channelling knowledge demands	• FORSK2015 catalogue to be used in the political prioritisation of strategic research areas in the 2009 government budget (NRP 2008) • Calls for project proposals from Strategic Research Council based on FORSK2015
Monitoring demand fulfilment	• New initiatives for impact assessment of strategic research • Evaluation of research programmes intensified

2.3.3 Knowledge production

In the NRP 2008, the Danish government has announced that it will develop a bibliometric research indicator based on the Norwegian model, and "which is to promote publishing in the most esteemed publication channels and strengthen the quality of Danish research" (2008; p. 12). The indicator will be utilised for the distribution of the increasing core funding that universities are to receive in the coming years. However, the research community has debated whether such a performance-based funding system may have a negative impact on academic freedom possibly resulting in an extra burden for researchers.

The further funding of the Danish National Research Foundation has been secured and thereby the continuation of the successful centres of excellence scheme.

Table 4: Main policy changes in the knowledge production domain

Challenges	Main Policy Changes
Improving quality and excellence of knowledge production	• Continuation of the Danish National Research Foundation and the Centres of Excellence scheme • Introduction of bibliometric research indicator planned (NRP, 2008)
Ensuring exploitability of knowledge production	• The Strategic Research Council invites SMEs for participating in shorter research projects which may have an impact on their innovativeness and strengthen their competence building

2.3.4 Knowledge circulation

Improved knowledge circulation has been addressed in the Second Progress Report of the NRP 2005 (2007) and NRP 2008. The following recent initiatives of the Danish Council for Technology and Innovation should be mentioned:

Knowledge Voucher for SMEs

The initiative to this commenced in 2008, and targets SMEs without previous experience in working with academic and research institutions. SMEs may apply for a knowledge voucher which can be used for the procurement of knowledge from academic and research institutions. The policy measure shall improve the collaboration between SMEs and academic and research institutions, contribute to increase the commercialisation of public research results, and reorient the attention of the academic and research institutions towards the needs of SMEs. It is planned to fund such vouchers with €5.36m in 2008 and again in 2009.

Research Voucher for SMEs

A similar initiative for facilitating research collaboration with academic and research institutions also commenced in 2008: this policy measure can annually fund up to €2m research collaboration with SMEs (in 2008 and 2009).

Proof of concept

The measure has the objective to facilitate the transfer of knowledge from research to business and the attraction of risk-willing investors, and to stimulate cooperation between public research institutions, innovation incubators and other partners.

The *scarcity of engineers* in the Danish labour market could threaten the absorptive capacity of Danish companies and has been addressed by a campaign which commenced in May 2007 and ended in 2008. The shortage of engineers is allegedly one of the main reasons why Danish companies move production out of Denmark: every fifth company that moved abroad has stated this as the main reason for the decision. The initiative is a collaborative effort of the Ministry of Science, Technology and Innovation, Danish Industry and the Danish Society of Engineers.

The decreasing number of S&T students has been addressed by a policy measure from the Ministry of Science, Technology and Innovation: the goal is to increase the subsidy to universities for experimental courses.

Table 5: Main policy changes in the knowledge circulation domain

Challenges	Main Policy Changes
Facilitating knowledge circulation between university, PRO and business sectors	• Introduction of Proof of concept scheme • Introduction of several new policy measures, such as Knowledge vouchers and Research vouchers for SMEs
Profiting from access to international knowledge	• New policy measures to reinforce Danish participation in EU Framework Programmes • Danish innovation centres in USA, China and Germany • Agreements on research collaboration with China, India etc.
Absorptive capacity of knowledge users	• Joint initiative of Ministry of Science, Technology and Innovation, Danish Industry and the Danish Society of Engineers • Introduction of subsidies for experimental courses for S&T students

2.4 Policy opportunities and risks related to knowledge demand and knowledge production: an assessment

This section assesses whether recent policy changes have responded to identified system weaknesses and take into account identified strengths.

The policy portfolio addresses research, innovation and education policy has been in the centre of attention of recent Danish policy. The Globalisation Strategy from 2006 combines a boost to R&D, innovation and education policy. However, it takes time to realise this range of envisioned policy measures.

Denmark has a clear commitment and a feasible roadmap for fulfilling the Barcelona target of public R&D expenditure equivalent to 1% of GDP by 2010. The GDP share of business R&D has, however, been stagnating since 2002 and it may be difficult to achieve the 2% target for this sector. In order to achieve the 2% target the Danish R&D policy ought to stimulate more R&D in the business sector, even though a broad

range of new policy measures with this goal have been introduced. The new policy measures provide rather limited funding and it remains to be seen whether this set of policy measures is powerful enough for achieving the 2% target. A further strengthening of the linkages between industry and universities will also contribute to a higher share of BERD.

Recently policy measures were introduced aimed at facilitating increased participation in the EUFP7, a strong focus on collaboration with countries outside the EU, and measures to attract a highly qualified labour force from abroad. These measures may all contribute to improved access to international knowledge.

The recent policy measures attempt to strengthen the identified strongholds of the Danish research system. A policy opportunity arises from policy measures that followed the restructuring of the Danish R&D system aiming at world-class universities: they have to become more competitive and entrepreneurial, and more responsive to the needs of industry. The knowledge production of universities is to be measured by bibliometric indicators and core funding given accordingly. This means a funding mechanism which will boost research quality. However, the distribution of core funding of universities based on bibliometric indicators may lead to unintended consequences such as changes of research priorities or even lower quality if they are not well communicated and fail to clearly distinguish between quality differences of different publishing channels, and are not aware of different publication patterns in the various science fields.

As a result of the restructuring of the public research sector, most of the applied research institutes have merged with universities. As for the risks, enhanced university IPR policies should not hinder university–industry collaboration, and experience with knowledge transfer from the former research institutes has to be acquired and activated. Technology transfer from universities to industry will be strengthened and possible conflicts of interest are to be addressed in standard agreements on IPR and strategic collaboration agreements between universities and industry partners.

Table 6: Summary of main policy related opportunities and risks

Domain	Main policy-related opportunities	Main policy-related risks
Resource mobilisation	• Publicly financed expenditure for research and development is to reach 1 per cent of GDP in 2010. • Long-term funding for universities, and introduction of new funds providing access to investment capital and improved infrastructure	• Increased competitive funding may have a negative impact on academic freedom and may lead to an extra burden for researchers who have to apply for competitive funding
Knowledge demand	• Broad stakeholder involvement ensures good match between research policy and user needs • Further strengthening evaluation, benchmarking and accountability culture • Application of strategic research priorities in strategic research programmes	• A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge. • The identified strategic research areas may be too diverse for a small country as Denmark.

Domain	Main policy opportunities	Main policy-related risks
Knowledge production	• Focus on world-class universities based on development contracts and bibliometric indicators as a basis for distribution of the increased university core funding	• Distribution of core funding of universities based on bibliometric indicators may lead to unintended effects, if they are not well well-communicated and not combined with other output indicators.
Knowledge circulation	• New policy measures to support participation in EUFP7 • Strong recent policy focus on collaboration with China and other countries outside Europe • New policy instruments in place targeting university-industry collaboration	• Policy efforts insufficient to counter decreasing numbers of S&T students and engineers

3 National policy mixes towards R&D investment goals

The aim of this chapter is to deepen the analysis of national policy mixes with a focus on public and in particular *private R&D investment*. The Lisbon strategy emphasises an EU overall *resource mobilisation objective* for 2010 of 3% of GDP of which two thirds should come from private investment. R&D investment is seen as important yardstick of the capacity of an economy to turn the results of science and research into the commercially viable production of goods and services and hence knowledge into growth. Corresponding investment policies are mainly pursued at national level and determined with a national focus.

This chapter is structured around five questions:

1. What are the specific barriers in the country that prevent reaching the Lisbon goal? What barriers exist in the country to prevent reaching the specific targets, particularly related to the private sector R&D investments?
2. Given the above, what are the policy objectives and goals of the government that aim to tackle these barriers?
3. What Policy Mix routes are chosen to address the barriers and which specific instruments and programmes are in operation to implement these policies?
4. What have been the achievements in reaching the above mentioned R&D investment objectives and goals?
5. What are the reasons for not reaching the objectives, adaptation of the goals?

The chapter aims to capture the main dimensions of the national policies with an emphasis on private R&D investment. The chosen perspective of looking at investments in R&D is the concept of Policy Mixes. The analysis and assessment follows a stepwise approach following the five questions above.

3.1 Barriers in the research system for the achievement of R&D investment objectives

Low level of infrastructure investments

The low level of infrastructure investments, both for HEIs and PROs, can be seen as critical and has therefore been addressed in several policy measures in recent years (see section 4.2 for further details).

Use of European funding and shared infrastructure facilities

Only €89.95m, or 2% of Gross Domestic Expenditure on R&D (GERD), was funded by the EU in 2003. The funding of Danish R&D by EU Framework Programmes nevertheless decreased and in 2006 amounted to just €73.78m. In the same year, the share of EU funding of R&D expenditure in the Business Enterprise sector (BERD) was 0.7%, and 3.5% of R&D expenditure in the Higher Education Sector (HERD). The share of EU funding of the Government Intramural Expenditure on R&D (GOVERD) was 5.2%. As has been emphasised in the Globalisation Strategy (2006), business participation in EU Framework programmes is to be improved.

When analysing the financial contribution of the EUFP6 to research infrastructures Denmark received a much lower share than the EUFP6 in total (DASTI, 2009).

Government incentives for private R&D

The share of R&D performed in the business sector directly financed by government sources is quite low: in 2005 6% (€84.2m) of the total government funding went to the business sector, while 2% of the R&D performed in the business sector was funded by the government. The share of the total government funding to the business sector has even decreased since 2001 (7% or €89.6m). As in many other OECD countries the government is addressing this challenge by particularly focussing on R&D collaboration between universities and business enterprises (see for example projects funded by the Danish National Advanced Technology Foundation).

As regards R&D tax incentives schemes, in 2005 Denmark had R&D allowances (deduction of expenses from taxable income) between 100 and 150% (CREST, 2006). The tax scheme of 150% Tax Deduction on Certain Research Expenditures focused on SMEs which in addition to the deduction of costs that the SMEs paid to the public research institutions in a collaborative research project could also apply for a deduction of own labour costs related to collaborative projects. Annually, only €3.35m were foregone in tax revenues. This experimental tax scheme was, however, terminated at the end of 2006. It may thus be concluded that Denmark is one of the Member States in EU with few and decreasing in importance government incentives (in particular tax incentives) for private R&D, but there are new policy measures that are intended to stimulate collaborative R&D between SMEs and public research institutions.

Shortage of highly skilled labour

The main risk for Denmark's innovation system is labour shortage in general and the shortage of highly skilled labour in particular. This has been addressed by several

initiatives by the Danish government and stakeholder organisations for Danish industry such as the Confederation of Danish Industries.[2]

Statistics on the aggregate level imply that Danish industry has a high knowledge absorption capacity. However, Denmark is suffering under a lack of engineers, which may have a negative impact on SMEs' R&D intensity.

Attractiveness for foreign researchers

The recent OECD Survey on Denmark emphasized that high-skilled migration patterns may be problematic. "Even if small in size, there is a clear brain drain with high-skilled Danes moving abroad while, on the other hand, Denmark attracts relatively few high-skilled immigrants compared with English speaking countries. Moreover, the high-skilled immigrants who come have considerably lower employment rates than their native peers. This could reflect that language barriers matter more in high-skilled jobs... The fact that underemployment is so clear for immigrants across all skill levels could also indicate that discrimination plays a role" (OECD, 2008; p. 40). Permanent residence permits are difficult to obtain and a number of restrictions pose growing barriers for highly skilled workers from outside the EU.

Mechanisms for strengthening university- and PRO-industry links in knowledge transfer

Private enterprises finance Danish public R&D to only a minor degree. The shares of HERD and GOVERD financed by business R&D expenditures in 2005 were 2.4% and 2.1% respectively. GOVERD industry funding has diminished since 1991 and the share for GOVERD is probably much lower today because of the structural reform of the Danish research system in 2007. The EU15 shares of HERD (6.3%) and GOVERD (8.1%) financed by private enterprises are much higher. It seems that Danish business R&D expenditures are kept inside the business sector: in 2005 this amounted to 86% of Danish business R&D expenditure. Private enterprises purchased R&D from Danish HEIs and PROs for €66m in 2006.

While the number of patents is comparable with other European countries, the commercialisation of these patents is not so successful. Research organisations in Belgium, Netherlands, Switzerland and Germany produced between four and fifteen times as many license agreements than the Danish institutions (Inside Consulting, 2004).

3.2 Policy objectives addressing R&D investment and barriers

The Danish Government has a high focus on improving the competitiveness of the Danish R&D system. The Liberal–Conservative government has the objective that Denmark is to become the most competitive society in the world by 2015. In order to realise this objective the government has increased public funding of R&D, but also has increased the importance of competitive funding schemes and introduced performance based funding of universities. The Globalisation Strategy (2006) set as a target that as much as 50% of public R&D funding is to be competitive by 2010 (as opposed to one third in 2006). Since 2008, the basic funding of universities has been

[2] In 2007, the Confederation analysed the Danish perspectives in the global economy and explored the brain drain of highly qualified Danish workers, and criticised the limited accessibility of Danish research programmes to foreign researchers.

based on an evaluation of the institution's ability to reach the objectives given in the development contracts with the ministry. The NRP 2008 stresses the continuous implementation of the strengthened quality and scope of public research as a main task. The development of bibliometric indicators highlighted in the NRP 2008 will further strengthen the performance-based funding of universities.

Public R&D expenditure is to reach 1% of GDP by 2010. This goal was formulated in NRP 2005 and has been repeated in the NRP 2008. Consequently the government has increased the public R&D budget significantly, both for 2009 and 2010. New policy initiatives help to use this increased funding for strengthening the Danish research base, such as the introduction of the University Research Investment Capital (UNIK) initiative which will be distributed in competition between the universities and the securing of the long-term financial basis of the Danish National Research Foundation.

In the NRP 2005, it was also stated that the Danish government has the goal whereby business R&D expenditure shall reach the 2% of GDP goal in 2010 (see also section 3.4). However, the NRP 2008 has not explicitly repeated or changed this goal, but government policy involves a company-oriented innovation strategy with a "focus on improving framework conditions for enterprises' innovation policy" (NRP 2008). Innovation environments have been selected which will help to attract private capital to R&D groups. The trade of IPR has been improved through the introduction of an electronic marketplace of knowledge. The establishment of new university spin-off companies is also envisioned and supported. The NRP 2008 has also pointed to collaboration between the business sector and public research as an important task. The government has the goal of stimulating SMEs to invest in R&D and to collaborate with the public R&D organisations.

3.3 Characteristics of the policy mix to foster R&D investment

This section concerns the characterisation and governance of the national policy and instrument mix chosen to foster public and private R&D investment. While policy goals are often stated at a general level, the policy mix has a focus on how these policy goals are implemented in practice. The question is what tools and instruments have been set up and are in operation to achieve the policy goals? The following sections will each try to tackle a number of these dimensions.

3.3.1 Overall funding mechanisms

Denmark has a clear demarcation between bottom-up research funded by the Council for Independent Research and the Danish National Research Foundation, on the one hand and strategic or programme research funded by the Council for Strategic Research on the other.

Total governmental R&D expenditure amounted to €1.878b (DKK14.09b) in 2007. According to the latest state budget for 2009, public sector R&D expenditure as share of GDP has increased to 0.89% in 2008 and will be at 0.94% in 2009. The 1% target will be achieved in 2010.

Since 2002, 85-87% of the public funding is allocated in the state budget. The regional and local authorities account for 6–7% of public funding, the Danish National Research Foundation 1–2% of the public funding; 6% of the public funding comes from international sources, EU and Nordic Council of Ministers (Danmarks statistik, 2008). These are not included in Eurostat data. The ministry with the highest share of

R&D funding is the Ministry for Science, Technology and Innovation. The share of funding provided by this ministry has increased from about 60% in 2000 to about 80% in 2009 (Mejlgaard & Siune, 2009). The higher concentration is due to the transfer of some of the sectoral funding to the ministry.

The universities receive 55% of the government research funding, and 87% of the university funding is basic funding, while the research councils get all programme funding. The research councils receive 17% of the government research funding, and the research institutes 4%.

The ratio of basic funding to programme funding is 60% to 40% (Danmarks statistik, 2009). Programme funding is mainly provided by the Danish Council for Strategic Research (DCSR) and the Danish Advanced Technology Foundation (DATF). In 2007, the DATF allotted €34.55m, and the CSR €100.26m. In addition to the programme funding by these two organisations come two sectoral R&D programmes, the R&D programme 'The future food sector' of the Ministry of Food, Agriculture and Fisheries and the 'Programme for Energy Technology Development and Demonstration' of the Energy Authority.

The DCSR has identified 10 Innovation Accelerating Research Platforms, i.e. areas where Denmark has internationally recognised researchers, competitive business clusters and/or a need for research-based solutions. Areas of priority are food, health, renewable energy (areas of traditional strength) and the use of nano-, bio- and information technologies – i.e. a combination of 'new' activities and research for existing industries. The DATF has the goal of stimulating advanced technologies such a nanotechnology, biotechnology and ICT, including the interface between these areas. Public–private collaboration is required.

BERD accounted for 1.65% of the Danish GDP in 2006. However, the business sector gives very little funding to Danish public research institutions, including universities and other public research organisations. The higher education sector received just €29.5m and the government sector €6.7m from the business enterprise sector in 2005 (Eurostat). That means that only 2.4% of the R&D performed in the higher education sector was funded by the business sector, and 2.1% of the R&D performed in the government sector was financed by the business sector.

An experimental, indirect funding scheme for business R&D was abandoned in 2006.

3.3.2 Policy Mix Routes

The "Policy Mix Project" identified the following six 'routes' to stimulate R&D investment:

1. promoting the establishment of new indigenous R&D performing firms;
2. stimulating greater R&D investment in R&D performing firms;
3. stimulating firms that do not perform R&D yet;
4. attracting R&D-performing firms from abroad;
5. increasing extramural R&D carried out in cooperation with the public sector or other firms;
6. increasing R&D in the public sector.

These routes cover the major ways of increasing public and private R&D expenditure in a country. Each route is associated with a different target group, although the

routes overlap. Neither are they mutually exclusive as, for example, competitiveness poles of cluster strategies aiming to act on several routes at a time. Within one 'route', the policy portfolio varies between countries and between regions depending to policy traditions, specific needs of the system etc.

Route 1: Promoting the establishment of new indigenous R&D performing firms

Commercialisation of public research results in new R&D-intensive firms has been a target of Danish innovation policy lasting recent years. In 2004, DASTI established an inventor service counselling office, and after 2004, commercialisation of public research results has been assessed annually. The national network for technology transfer (see techtrans.dk) aims to provide a national forum for public researchers and staff from companies involved in commercialisation of public research. It contributes to developing skills, increasing professionalization and sharing experience regarding the patenting process and in dealing with intellectual property rights. In 2004, the Act on Technology Transfer at Public Research Institutions was passed, addressing the transfer of knowledge from public science to industry and the establishment of research-based enterprises by public research institutions. This has also been highlighted in the NRP (2005), and the progress reports in 2006 and 2007. Besides technology transfer institutions, the innovation incubators which invest capital in entirely new, high-tech enterprises, should also be mentioned.

The NRP 2005 pointed out that the systems and procedures in connection with business start-ups are to be less bureaucratic, and the first progress report was able to mention that a reduction of the audit obligation for SMEs had been implemented. The Globalisation Strategy (2006) highlights that "new forms of financing for entrepreneurs are to improve the financing of the initial development of ideas, market tests as well as coaching by experienced business people".

Denmark is on a par with the leading countries in the world in respect of start-up of new companies, but the progression of these new enterprises into growth companies was traditionally less developed. However, as the TrendChart Report for Denmark (INNO-Policy TrendChart, 2008) highlights, this is no longer the case. Improved framework conditions and a generally improved economic situation have contributed to a clear increase of the number of gazelles. In 2007 the Danish Council for Technology and Innovation (DCTI) formulated the Innovation Action Plan which contained a number of start-up measures including gazelles, incubators and coaching activities. A *Proof of Concept* scheme was recommended in the Globalisation Strategy and highlighted in the First Progress Report (2006), and was introduced in 2008 by the Danish Council for Technology and Innovation. The policy scheme is to enable public research organisations to finance testing and documentation of the commercial potential of an invention. In 2007, Innovation Denmark implemented the *Gazelle Growth programme*, with the aim of strengthening innovation and growth in knowledge-intensive SMEs through advisory and educational activities and aiming to strengthen innovation and value growth in SMEs with global potential. Another relevant programme is the *AcceleRace programme* which was launched in 2008 with the goal: "to increase their commercialisation success by providing them with insight into customers, market and competitors and helping them develop a concrete and realistic go-to-market strategy". (TrendChart Report, 2008; p. 25)

The Second Progress Report (Danish Government, 2007) of NRP (2005) showed a clear increase in the number of spinout enterprises from research institutions since

2002. The new National Reform Programme (2008) highlights, that "six innovation environments have been selected for the 2009–2011 period". The innovation environments aim at attracting more private capital market. The NRP 2008 points out that since 1998 the innovation environments have contributed to the establishment of more than 600 knowledge-based enterprises, with an average survival rate of approximately 45 per cent.

Route 2: Stimulating greater R&D investment in R&D performing firms

The NRP 2005 and the Globalisation Strategy (2006) highlight R&D collaboration between public research organisations and business enterprises as an important route to stimulate the Danish business sector to greater R&D investments (see Route 5). Direct funding to firms only is not prioritised in Denmark.

In 2008, DCTI implemented several smaller policy measures aiming at the enhancement of R&D intensity of Danish firms, such as the *Knowledge Voucher for SMEs* (also Route 3), the *Research Voucher for SMEs* and the *Knowledge Pilot Initiative*.

In the field of tax incentives for stimulating more R&D investments, Denmark currently has at the moment only one scheme, the *25% Tax Scheme*, addressing the taxation of the salaries of well-paid foreigners and foreign researchers, employed in the business sector or in public research organisations. From 2004 to 2006, there was also in place another tax incentive, the *150% Tax Deduction on Certain Research Expenditures*, which aimed to increase co-operation of private firms with public research institutions. However, this scheme was experimental and discontinued after 2006.

Route 3: Stimulating firms that do not yet perform R&D

Some of the policy measures described under Routes 1 and 2 are also relevant under Route 3, especially the simplification of bureaucratic procedures and the *Knowledge Vouchers for SMEs*. However, main focus here is the improvement of human capital in the Danish enterprises, i.e. vocational and further education and lifelong learning. The Second Progress report of NRP 2005 highlights that a new apprenticeship scheme has been introduced in the area of vocational education. Also in higher education there is a stronger focus on new professions and practice-oriented education programmes. A key element of the Welfare Agreement from 2006 is the strengthening of adult and vocational education and training.[3] In the new NRP (2008) several initiatives in the field of lifelong learning are highlighted, such as making labour market-related programmes more attractive, flexible, and oriented towards a specific purpose, providing better competence development programmes for adults in the special continuing training system for adults, and higher public grants for an increased number of adult apprentices who can acquire a vocational education and training qualification.

Route 4: Attracting R&D-performing firms from abroad

In general terms, it can be said that the Danish government does not sufficiently prioritise inward R&D foreign direct investments (FDI). Laws and regulations are characterised by openness and non-discrimination, but the volume of FDI is quite

[3] For further information on the initiatives under the Welfare agreement from 2006, consult http://uk.fm.dk/Publications/2006/Denmarks%20Convergence%20Programme%202006/Appendix%201%20The%20Welfare%20Agreement%20Overview%20of%20initiatives.aspx

small: in 2004, €68b as FDI came into Denmark and in 2007 €90b (data provided by Statistics Denmark). The balance of outward and inward direct investments is increasingly negative meaning that there are more outward-going investments than inward. The only sectors where the balance is somewhat positive are less R&D intensive, such as trade, hotels and restaurants, wholesale trade, and financial intermediation.

Route 5: Increasing extramural R&D carried out in cooperation with the public sector

The NRP 2005 and the Globalisation Strategy (2006) highlight policy schemes that emphasise the importance of R&D collaboration between public research organisations and business enterprises. Several policy schemes support this objective.

In 2007 DCTI published an action plan for more innovation entitled 'Innovation Denmark 2007-2010' (DASTI, 2007). The action plan highlighted following policy tools for implementing the goals of the plan, which are relevant for this policy mix route:

- Innovation consortia and ICT interaction projects;
- Networks among one or several public research institutions and many enterprises, such as high-technology networks, regional technology centres and ICT competence centres;
- GTS Advanced Technology Group.

The establishment of *High-tech networks* in 2004 aimed at creating stable collaboration patterns between companies and knowledge institutions so as to increase the utilisation of research based knowledge in private industry. A high-tech network is a frame for cooperation in a lasting and binding partnership between private companies and knowledge institutions.

In 2005, the DCSR introduced *Innovation Accelerating Research Platforms* (IARP) as a tool to pinpoint research areas in which it makes sense to invest. These platforms are based on collaboration between companies and public research organisations. The platforms are also oriented towards strengthening existing knowledge intensive SMEs.

GTS Advanced Technology Group: The GTS is a group of independent Danish research and technology organisations. The GTS institutes develop and offer state-of-the-art services within respective research and technology fields. Customers are private businesses as well as public authorities.

The *Danish Advanced-Technology Foundation* is another organisation which contributes to increased R&D cooperation between the private and the public sector. The foundation shall make a special effort to promote R&D and innovation in small and medium-sized enterprises.

In 2008, DCTI implemented several smaller policy measures such as the *Knowledge Voucher for SMEs* and the *Research Voucher for SMEs* with the goal of encouraging Danish SMEs to purchase more R&D from public research organisations.

Between 2004 and 2006, another tax incentive was put into place – the *150% Tax Deduction on Certain Research Expenditures*, which aimed to increase co-operation

of private firms with public research institutions. However, this scheme was only experimental and discontinued at the end of 2006.

Route 6: Increasing R&D in the public sector

Danish policy is strongly concentrated on improving the framework conditions for R&D in the public sector. The National Reform Programmes (2005 and 2008) have a focus on increased funding of R&D in this sector. The NRP 2005 emphasises the aim for public sector investment to be equivalent to 1% of GDP by 2010. The NRP outlines that the government will assign €1.34b (DKK10b) for increased effort in research, innovation, entrepreneurship and education until 2010. According to the government budget for 2009, public sector R&D expenditure as share of GDP has increased to 0.89% in 2008 and will rise to 0.94% in 2009 (Ministry of Science, Technology and Innovation, 2008). The Second Progress report for the implementation of the NRP 2005 highlighted the establishment of an Infrastructure Pool for financing investments in large scale, interdisciplinary research infrastructure in Denmark and abroad (NRP, 2007). The National Reform Programme 2008 pointed out that public expenditure on R&D is still highly prioritised by the Danish Government. The NRP 2008 confirms that the 1 per cent goal is to be reached by 2010, and the NRP highlights policy measures that have been implemented in 2008 to achieve this goal, such as the research catalogue FORSK2015 and the University Research Investment Capital (UNIK).

The development in the state budget from 2007 to 2009 (Danish Ministry of Finance, 2006, 2007, 2008) shows a clear increase in the budget of the Ministry of Science, Technology and Innovation (Table 6). Total expenses increased by 8% from €2593m in 2007 to €2812m in 2009. Especially notable was the 31% increase for the research council system, from €254m in 2007 to €331m in 2009.

Table 7: Development of State budget for the Ministry of Science, Technology and Innovation: Expenses 2007-2009, in million €.

	2007	2008	2009
Research and university education	1 773	1 689	1 823
Research councils	254	292	331
New research programmes	32	21	37
Ministry of Science, Technology and Innovation in total	2 593	2 544	2 812

The *Danish National Research Foundation* has supported a large number of Centres of Excellence at universities, oriented towards basic science. Today, more than 30 Centres of Excellence are funded; in February 2009, nine new centres were established. The continuation of the foundation will strengthen this policy instrument. In 2005, the foundation initiated the Niels Bohr Visiting Professorship as a supplement to the Centres of Excellence in order to further the internationalisation of Danish research. The foundation invites top foreign researchers to Denmark.

The DCSR has established several strategic research programmes, covering research fields such as sustainable energy, food and the correlation between food, nutrition and health, nano-science and technology, and the interdisciplinary application of nanotechnology, biotechnology and information and communications technology. Funding goes mainly to the public research organisations, but also to collaborating firms.

The importance of education and innovation policies

The Ministry of Science, Technology and Innovation is responsible for policies on research, higher education and innovation, which allows a high level of coordination, in particular between national R&D and innovation policies. The ministry is responsible for the university education, while the other levels of education, such as pre-primary education, primary and lower and upper secondary education, adult education and continuing training, are under the responsibility of the Ministry of Education. The Ministry of Education is also responsible for higher education of short- and medium term. The ministries are coordinating their activities as shown by Denmark's Strategy for Lifelong Learning (Danish Ministry of Education, 2007).

In the cross field of research and innovation, the Ministry of Science, Technology and Innovation has introduced several measures targeting at the commercialisation of public research results in new R&D intensive firms and at R&D collaboration between public research organisations and business enterprises for stimulating greater R&D investments in the private sector.

There is good coordination between the Ministry of Science, Technology and Innovation and sectoral ministries with R&D portfolios such as the Ministry of Food, Agriculture and Fisheries and the Ministry of Climate and Energy. The ministries have their own R&D programmes which are coordinated with the DCSR: the Energy Technology, Development and Demonstration Programme and the Future food sector programme. The recent policy debate about climate change has had an impact on the priorities of strategic research funding, as the FORSK2015 process and the allocation of funding to related research areas demonstrate.

Assessment of the importance of policy mix routes and their balance

Table 8: Importance of routes in the national policy and recent changes

Route	Short assessment of the importance of the route in the national policy	Main policy changes since 2008
1	Commercialisation of public research results in new R&D intensive firms has been a target of Danish innovation policy. The framework conditions of new R&D intensive firms have been addressed systematically.	Several new policy schemes for improved framework conditions have been implemented in 2008, such as Proof of concept, the AcceleRace programme and the Gazelle Growth programme.
2	Direct funding of firms only is not prioritised, but R&D collaboration between PROs and business enterprises for stimulating greater R&D investments in the private sector has been more in the focus of Danish innovation and research policy.	Several smaller policy measures have been implemented aiming at the enhancement of R&D intensity of Danish firms, such as the Knowledge Voucher for SMEs, the Research Voucher for SMEs and the Knowledge Pilot Initiative.
3	Main focus is the improvement of human capital in Danish enterprises, i.e. vocational and further education and lifelong learning.	In the new NRP (2008) several initiatives in the field of lifelong learning are highlighted.
4	Policies towards increased FDI inflow are not prioritised.	No policy changes are registered.
5	Science-industry linkages are addressed by many policy schemes that support R&D collaboration between public R&D organisations and business enterprises.	Several smaller policy measures have been implemented aiming at the procurement of R&D by Danish firms from public R&D organisations, such as the Knowledge Voucher for SMEs, the Research Voucher for SMEs and the Knowledge Pilot Initiative.

Route	Short assessment of the importance of the route in the national policy	Main policy changes since 2008
6	Further development of the research capacity and capability of the public research organisations, and here especially the universities, is a long-term R&D policy goal.	Several new policy measures were launched in 2008, such as the Research catalogue FORSK2015, the University Research Investment Capital (UNIK), the Energy Technology, Development and Demonstration Programme. The further work of the Danish National Research Foundation has been secured in 2008.

3.4 Progress towards national R&D investment targets

The NRP 2005 highlighted the aim that public sector investment will comprise 1 per cent of GDP by 2010. The NRP lined out that the government will appropriate €1.34b (DKK10b) for an increased effort in research, innovation, entrepreneurship and education until 2010. According to the government budget for 2009, public sector R&D expenditure as share of GDP has increased to 0.89% in 2008 and will be at 0.94% in 2009 (Ministry of Science, Technology and Innovation, 2008). The 1% target will be reached in 2010. The share of the total government budget appropriations or outlays on R&D (GBAORD) of the total government expenditure has increased from 1.35% in 2005 to 1.41% in 2006 and 1.55% in 2007, while the share for EU27 still has been higher with 1.62% in 2006 (Eurostat). In the NRP 2005 it was stated that business R&D expenditures shall reach the 2% of GDP goal in 2010 (see also section 3.2). According to the latest statistics (May 2008), this goal will not be easy to reach. After a peak of 1.78% in 2003 the proportion declined continuously: 2004, 1.69%; 2005, 1.67%; and 2006, 1.65% (Eurostat).

In recent years GDP has grown much faster than the R&D expenditure – the average growth rate of GDP for 2000–2005 was 3.7% and of GERD 3.02%. Consequently the share of GDP spent on R&D has declined from 2.58% in 2003 to 2.43% in 2006. The estimate for 2007 was 2.55%. It remains to be seen what the consequences of the ongoing financial crisis will be. Denmark has entered a state of recession with a declining GDP. The increase of public R&D expenditure is planned in the Globalisation Strategy 2006 and the NRP 2008, and will probably not be reduced. However, the development of BERD is much more risky and we have no data to assess recent development. However, a recently published study on the impact of the economic crisis on R&D and innovation in the business sector concluded that the share of BERD will probably decrease from 2008 to 2009 to between 1.81% and 1.88%, while it was at 1.91% in 2007 (DASTI, 2009b).

The policy portfolio addressing science–industry linkages and commercialisation of public research results have been at the centre of policy development over the last years. Progress has been made in the development of Gazelle enterprises (TrendChart report, 2008), but this development was also supported by the favourable economic situation. Since the recently introduced policy measures are not that large and the economic situation is now critical, it remains to be seen whether the R&D intensity of SMEs and the R&D intensity of the business sector in general can be further improved. The high policy focus on the development of the public research sector has resulted in a clear increase of public R&D funding, even the mentioned low level of infrastructure investments has been addressed by new policy measures. We estimate that Denmark will reach the 1% target by 2010.

The Lifelong learning strategy improves skill development of the working force. However, the shortage of highly skilled labour has been identified as a major barrier for business R&D and innovation (DASTI, 2009b). The Minister of Science, Technology and Innovation has therefore recently introduced a financial incentive for universities to get their candidates employed (Sander, 2009a). The economic crisis will lead to increased unemployment also of new engineers and scientists as the report has pointed out.

Table 9: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Low level of public infrastructure investments	Opportunity to modernise the public research infrastructure because of two new funds
Use of European funding and shared infrastructure facilities	European funding and shared infrastructure have attracted more attention
Government incentives for private R&D	Targeted policy measures may framework conditions for more R&D in the business sector, but risk that economic crisis may endanger the output
Shortage of highly skilled labour	Lifelong learning strategy improves competence development of working force, but risk that increasing unemployment may have negative impact on education of scientists and engineers
Science-industry linkages	Opportunities for firms to cooperate with strengthened public R&D sector

4 Contributions of national policies to the European Research Area

ERAWATCH country reports for 2008 provide a succinct and concise analysis of the ERA dimension in the national R&D system of the country. This chapter further develops this analysis and provides a more thorough discussion of the national contributions to the realisation of the European Research Area (ERA). An important background policy document for the definition of ERA policies is the Green Paper on ERA[4] which comprises six policy dimensions, the so-called six pillars of ERA. Based on the Green Paper and complementing other ongoing studies and activities, this chapter investigates the main national policy activities contributing to the following four dimensions/pillars of ERA:

- Developing a European labour market of researchers facilitating mobility and promoting researcher careers;
- Building world-class infrastructures accessible to research teams from across Europe and the world;
- Modernising research organisations, in particular universities, with the aim to promote scientific excellence and effective knowledge sharing ;
- Opening up and co-ordination of national research programmes.

[4] Commission of the European Communities: Green paper: The European Research Area: New perspectives. Brussels 4.4.2007, COM(2007) 161final
(See http://ec.europa.eu/research/era/pdf/era_gp_final_en.pdf).

In the ERA dimension, the *wider context of internationalization of R&D policies* is also an issue related to all ERA policy pillars and is normally present in the dynamics of national ERA-relevant policies in many countries.

4.1 Towards a European labour market for researchers

There is a persistent *high demand* for highly skilled researchers, both in the public and the private sectors. However, demand pressures are mostly felt within natural sciences, engineering and technology, ICT and medical sciences (Danish Government, 2007).

The *supply side* has been analysed in several reports. The incentives given for starting up a research career have been addressed in a report commissioned by the Ministry of Science, Technology and Innovation. The report pointed out the *main barriers* for the recruitment and retaining of researchers for a research career at universities (Ministeriet for Videnskab, Teknologi og Udvikling, 2006). The report identified the following barriers:

- Too late start of PhD education
- Varying quality of PhD education
- Lack of PostDoc positions and continuous employment of younger researchers
- Limited inter-sectoral mobility of researchers
- Bureaucratic and time consuming employment procedures at universities
- Limited career development possibilities
- Non-competitive salaries for young researchers
- Poor working environment.

The Danish Government has designated several policy measures aimed at improving the attractiveness of a research career.

One route is the *improvement of PhD education.* Since 1996, the number of PhD graduates has increased by almost 50%, from 720 in 1996 to 1072 in 2007 (Statistics Denmark). However, there is an imbalance between the various scientific fields: the number of PhD graduates doubled in agricultural and veterinary sciences (in 2007, 90 PhDs) and in social sciences (in 2007, 140 PhDs), while it is at the same level as in 1996 in natural sciences (187). The number of graduates in engineering and technology science (243), humanities (137) and medical science (270) increased by more than 50%.

PhD training has been addressed by the Danish government: in 2004 it was decided to increase funding for PhD training in order to increase the annual intake from 1000 to 1500 PhD students by 2006. In 2006, 1500 PhD students were admitted. The number of PhD-students is to be increased gradually and about 2400 PhD candidates are to be admitted in 2010.

Another route is the *improved internationalisation of higher education* which had been addressed in a joint report of the Ministry of Education and the Ministry of Science, Technology and Innovation for the Danish parliament in 2004: "*Styrket internationalisering af uddannelserne*" [Intensified internationalisation of education]. Among other things, the report highlighted the following:

- English has been introduced in a large number of education programmes and this will be continued,
- In 2000, the Ministry of Education established the Centre for Information and Counselling regarding International Education and Collaboration Activities (CIRUS), now an authority under the Ministry of Science, Technology and Innovation,
- The Government is going to support strategic partnerships, especially targeting joint degrees,
- Danish students should study more abroad and more talented foreign students should be attracted to studying in Denmark.

For increased internationalisation of higher education different scholarships have been implemented. A scholarship scheme has been introduced under which students can utilise the public grant to study in a recognised foreign educational institution (NRP 2008). Such a scholarship to study abroad can be used to fully or partially finance study fees. Students on university education programmes can receive the grant for a maximum of two years. The Ministry of Education has introduced a scholarship scheme for attracting foreign students to study in Denmark in selected academic profession degrees or professional bachelor programmes. In 2009, the Danish Government is to launch a sponsorship for foreign master students specialising in *sustainable climate solutions*.

There are certain differences in the level of *salary* between the private sector, the universities and other public organisations (Langberg, Ladefoged & Krogh Graversen, 2007). The private sector can provide the highest salaries in almost all science fields. Only in medicine are the salaries higher than in the other public organisations, i.e. public hospitals. As pointed out above, the salaries for young researchers in the public sector are non-competitive and may endanger recruitment and make it more difficult to retain young researchers.

4.1.1 Policies for opening up the national labour market for researchers

The evaluation report on Danish PhD education pointed out that foreign applicants are under-represented among the PhD students admitted (Ministry of Science, Technology and Innovation, 2006). The evaluation panel “encountered milieus where routines and admission procedures have been undertaken that disfavour foreign applicants”. The panel recommended that the general level of admission to Danish PhD education is to be increased so as to include around an average of 25% foreign students.

The NRP 2008 highlights the internationalisation of education programmes: €12.1m (DKK90m) have been allocated for 2007–2009 for the purpose of funding Danish students abroad and to finance highly-qualified foreign students and teachers to come to Denmark. An example for very strong cross-border collaboration in the field of PhD courses and research is the Öresund University, a consortium of eleven universities and university colleges on both sides of the Danish–Swedish region of Öresund. The number of foreign PhD students at Danish universities has almost doubled from 2000 (870 or 17% of all PhD students) to 2007 (1.631 or 25% of all PhD students) (Ministry of Science, Technology and Innovation, 2009).

According to the NRP 2008, “the number of employees in the researcher taxation scheme has risen in a stable manner since the scheme was introduced in 1992. As

per 1 January 2008, 2474 researchers and key employees were attached to the scheme". The researcher taxation scheme is to be revised so as to provide the possibility to choose between 25% gross taxation for three years, and 33% gross taxation for five years. Foreign researchers will also have the possibility of shorter research stays in Denmark as guest teachers before an appointment under the special researcher taxation scheme.

For all foreign researchers, payments are also made to national pension funds in addition to salaries. The terms of employment of foreign researchers will be in accordance with those of the scientific staff at universities in general.

4.1.2 Policies enhancing the attractiveness of research careers in Europe

Charter of Researchers

The Danish Rector's Conference (2009) has recently declared the commitment of the Danish universities to the Charter of Researchers. Since Danish universities in general live up to the recommendations of the charter, the Rector's Conference does not see the need for immediate action at the present time.

Remuneration policies

When considering the cost-of-living, the level of remuneration for researchers in Denmark is high, but still below remuneration levels in the U.S. (European Commission, 2007a; p. 20). The comparison of the remuneration level for the different levels of education in the public and the private business sector reveals that there is a huge difference between both sectors, both for employees with long-cycle higher education and for employees with PhDs. However, the field of education matters: in the humanities and arts the remuneration level is about the same in both sectors for employees with a PhD, while a *PhD in technical sciences, social sciences, natural science and health care results in a 20% higher remuneration in the private sector compared to the public sector* (Statistics Denmark, 2009). The *increase of remuneration throughout the career is lower* than in many other countries: Employees with a PhD in both sectors earn just 22-23% more than employees with a medium-cycle higher education (Statistics Denmark, 2009). The remuneration level for employees with long-cycle higher education is just 11-16% higher than for employees with a medium-cycle higher education. The question is if the remuneration level for researchers is high enough to be an incentive for young people to consider a researcher career.

The remuneration gap between men and women is very small compared to other countries (below 5% after 15 years of career). The difference in the annual average salary between men and women is 6 per cent. However, there are differences between the scientific domains regarding remuneration gaps. The remuneration level is the same for both genders in the life sciences, but much broader in social sciences and economics (20%) or also in chemistry, physics, mathematics, ICT, engineering sciences and environment and geosciences (about 11%) (European Commission, 2007a; table 65, based on Eurostat data).

Promotion of Women

According to the European study of remuneration of researchers (European Commission, 2007a), 29% of all researchers in Denmark are women (2003 data).

However, there are differences between the various sectors: the highest proportion of female researchers is found in the government sector (35%), followed by the higher education sector (31%) and the business sector (25%). This is changing: the highest growth rate for female researchers from 1999 to 2003 was in the business sector. The latest available data for 2006 show that 37% of all researchers in the public sector are female, although this varies between the sciences: the highest is in medicine with 48%, followed by agriculture and veterinary (44%) and the social sciences (41%). Engineering has the lowest proportion of female researchers (20%), slight less than the natural sciences (25%). The high proportion of women in medicine is consistent with the level of remuneration in life sciences. Most of the employed researchers specialised in medicine are employed in government hospitals which accounts for this high proportion.

It appears that recruitment of new female PhD students is addressing the gender gap in some of the science fields. The share of female PhD graduates was 41% in 2003 (European Commission, 2006). There are clear differences between sciences where the highest proportions of women are in health and welfare (54%), agriculture and veterinary science (52.4%), the humanities and arts (46.9%), while engineering (23.8%) and natural sciences, mathematics and computing (33.6%) have somewhat lower proportions of female PhD graduates, although still higher than the proportion of female researchers.

Today, 12% of all professors are women (Sander, 2009). This has been assessed by the Danish Minister for Science, Technology and Innovation as far too low in an international perspective. The government will renew the policy focus on this issue. In 2004, the government established a think-tank for more women in science, which came with a range of policy recommendations in 2005. As a follow-up, a programme for younger female researchers was established. The government will discuss new policy measures at a round table. However, the minister excluded recruitment of female professors based on quota. A question remains how the recruitment of women for engineering and natural sciences, mathematics and computing can be targeted more efficiently.

4.2 Governing research infrastructures

In November 2008, the political agreement on the distribution of the globalisation pool for R&D included the increase of investment in research infrastructure in the period 2010–2012. Therefore, the National Programme for Research Infrastructure has been continued also for 2009 where €26.8m (DKK200m) is to be allocated in this year. The programme will provide funding for establishing major national research infrastructures and Danish membership or participation in major international research infrastructures (DASTI, 2009a).

According to the recently published report *Improving research capabilities: An evaluation of the possibilities for increased Nordic cooperation on research infrastructures*, “Denmark is currently developing a strategy based on the results of a survey conducted in 2005 by the Danish Council for Strategic Research. The strategy is being developed by the Danish Agency for Science, Technology and Innovation. Considerable external consultations are foreseen. The strategy is not expected to be a roadmap but more ... a policy document identifying the problems related to funding large infrastructures” (Slipesæter et al., 2008). The DCSR published the report “Future research infrastructures – needs survey and strategy proposal” (2005), summing up the results of the survey, and with the following conclusions:

- There is an *immediate need* for investment in the upgrading of existing research infrastructures of €40.3m (DKK300m);
- There is a need for investment in new national research infrastructures of at least €268.5m (DKK2b) over the *next 8-10 years;*
- Participation in new international infrastructures over the next 8-10 years requires annually €13.4m (DKK100m).

The following *national* projects have been mentioned as being highly relevant within a short timeframe:

- Establishment of synchrotron radiation facility ASTRID 2000;
- Investment in supercomputing and grid computing (Danish Centre for Grid Computing, DCGC), and expansion of the research network;
- Establishment of a particle therapy facility for cancer research;
- Investigations on registers and databases.

The report pointed out following *international* projects as relevant for Denmark:

- European Research Observatory for the Humanities and Social Sciences (EROHS);
- European X-ray Free Electron Laser (XFEL);
- European Spallation Source (ESS).

The needs identified led to the establishment of a national programme for investment in research infrastructure. As part of the political welfare agreement of November 2006, a decision was made to establish the programme for the period 2007–2009. The idea of a special programme for research infrastructures was also an element of the Globalisation Strategy 2006. The total funds allocated to the programme are €80.5m (DKK600m). Highest priority is given to investments that are of national strategic importance and which are utilised by several institutions jointly. The programme has an annual budget of €27m (DKK200m) for the period 2007–2009 for establishing national research infrastructures and funding Danish participation in international research facilities. Subsequently, the programme is fully in line with the DCSR report.

With regard to European Strategy Forum on Research Infrastructures (ESFRI), “13 out of the 35 projects have so far officially been identified as interesting for the Danish research community. This does however not exclude universities from taking part in other ESFRI projects on their own initiative. The national research infrastructure programme has so far been funding one ESFRI project in the social science field… Denmark is currently negotiating membership in XFEL in Hamburg and for ILL [Institut Laue-Langevin] in Grenoble” (Slipesæter et al., 2008; p. 21). Denmark is supporting the Swedish candidacy to become the host for the ESS, and there are ongoing negotiations to determine the Danish role in the case where ESS will be located in Lund. Denmark has expressed an interest in co-hosting ESS.

4.3 Research organisations

The reform of the university system in Denmark was prepared following an evaluation of the university sector by an OECD panel in 2002. In accordance with the recommendations of the panel, there have been several new government and university initiatives, including the University Act of 2003 which gave the universities

more autonomy and self-governance. Furthermore, the allocation of funds to universities is to be changed.

The reform of the university sector consists mainly of the following processes:

- Re-organisation of the landscape of 12 universities and 13 public research institutes resulting in eight universities and three national research institutes in just one year (2007). The mergers have increased and diversified the economic base of the universities, and have created the potential for synergy effects.
- University autonomy is framed by strategic government contracts between the Ministry of Science, Technology and Innovation and the individual universities concerning how the university should develop in the future
- The role of the university collegiate body has changed formally from decision-making to a more advisory role. Until 2003 university governance was based on the internal election of collegiate bodies at all levels, and all managers, including the rector, continued to be elected. This governance system was replaced by the formation of university boards comprising a majority of members external to the university, and in addition representatives for both the academic and the non-academic staff, and two seats for students. The external members of the university boards come from industry, cultural institutions, the public sector, the media world etc. (Oddershede, 2009).
- The university boards are responsible for the university's development agenda, for appointing the rector and for the formal development contracts with the government. The university rector (vice-chancellor) and the senior management team have increased power to steer their own university. Deans as well as department heads are appointed and no longer elected.
- We can distinguish between core funding and competitive funding of universities, both of which will be strengthened. The distribution of both types of university funding is largely based on performance indicators. The NRP 2008 points out that a bibliometric research indicator based on the Norwegian model will be implemented for the distribution of core funding (see section 2.3.3.). However, there is still some debate in the research community. The share of competitive funding is to constitute 50% of the total public research funding, latest in 2010.

4.4 Opening up national research programmes

Opening up of national research programmes

The openness of Danish national research programmes to European and international researchers has been limited, but there are some differences and also some important changes. Some research programmes already have the possibility also to fund foreign research groups, but according to Danish law concerning research counselling, it has to be documented that funded foreign research activities clearly strengthen Danish research groups. Foreign research groups can apply for funding also within the *Strategic Network Project* scheme. Recently there has been a new approach to promoting international collaboration also by opening up national research programmes to foreign research organisations, foreign researchers and Danish researchers employed abroad: “It will be possible to apply for funding for international participation, e.g. towards the costs associated with collaborative research, for the procurement of research from foreign research environments and

towards the cost of bringing visiting researchers to Denmark" (Danish Council for Strategic Research, 2009; p. 8). The only requirement is that the funded research activities promote and strengthen Danish research.

A specific instrument which is targeting this new approach is the *Strategic Research Alliance.* "Strategic research alliances are a form of focused research initiative established in response to a pressing need in the future for research in a particular area, or where research in the given area is spread geographically across small-scale research environments, and where there is therefore a need to create alliances between existing Danish research environments or between Danish and international research environments in order to achieve greater capability at a high scientific level" (Danish Council for Strategic Research, 2009a). All the strategic research programmes with recent calls promote this openness. They include strategic research alliances as an instrument.

Joint programming initiatives

Regarding participation in joint programming initiatives, according to the ERA-NET Review 2006, Denmark is participating in 28 full ERA-Nets or 39% of all ERA-Nets (Guy et al., 2006). DASTI has participated in 2008 in the following ERA-Nets:

- BONUS for the Baltic Sea Science
- ECORD-NET European Consortium for Ocean Research Drilling
- ERA-IB Industrial Biotechnology
- ERA-PG European Research Area Plant Genomics
- HERA Humanities in the European Research Area
- NORFACE New Opportunities for Research Funding Cooperation in Europe
- WoodWisdom Net Networking and integration of national programmes in the area of wood material science and engineering.

Denmark is also represented in the new ERA-NET Plus actions under the FP7, such as iMERA+, a metrology network, and BONUS+, a Baltic Sea research network.

Danish researchers have been quite successful in the first round of the European Research Council (ERC). The ERC is rather similar to the DCIR in its focus on basic science. The DCIR is going for a better cooperation with the European Research Council: researcher should be able to combine national and ECR funding.

Denmark is represented in the European Union Research Organisations Heads of Research Councils (EUROHORCs) by the Strategic Research Council and the Danish Councils of Independent Research. The *Money-follows-researcher initiative* is granted by the Danish Councils for Independent Research.

A new type of instrument targeting collaboration between industry and science at European level is the *Joint Technology Initiatives (JTI).* Currently there are five such initiatives, and Denmark is participating in all of them, although in different degrees: Artemis (Embedded Computing Systems), IMI (Innovative Medicines Initiative), Clean Sky (Aeronautics and Air Transport), Fuel Cells and Hydrogen, and ENIAC (Nanoelectronics Technologies 2020).

Nordic collaboration

As a Nordic country, Denmark participates in the Nordic research cooperation coordinated by NordForsk, the Nordic research board under the Nordic Council of Ministers for Education and Research. Several instruments have been used to enhance Nordic R&D collaboration: *Nordic Centres of Excellence (NCoE)* have been established to increase the quality and competitiveness of Nordic research through enhanced collaboration. Basic funding of the NCoEs is expected to come from national sources while Nordic support supplements national funding. Several *research programmes* have been established, such as the Epidemiology Research Programme 2003–2007; Nordunet3, a four-year thematic Internet research programme; Nordic Energy Research; and the NordBib Programme (2006–2009).

The research collaboration between Denmark and Sweden in the cross-border Öresund Science Region is another example of successful Nordic collaboration where four innovative platforms bring together regional authorities, businesses and eleven universities from both sides of the border in the region, specialised in ICT, food, environment and logistics. A network specialised in health is associated to Öresund Science Region.

4.5 National ERA-related policies - a summary

ERA and ERA-related policies have increasing influence on Danish research policy. Since the development of the Globalisation Strategy in 2006 there has been increased international orientation of Danish research policy. The Globalisation Strategy highlighted that Danish participation in the EU framework programmes is declining and therefore proposed several actions to improve Danish access to the European knowledge networks. The analysis of the Danish participation in EUFP6 suggests that the share of funding from the EU Framework programmes for Danish project participation is decreasing compared to former FPs (DASTI, 2008). However, the absolute EU contribution has increased and is higher compared to many other Member States.

Danish policies aim to *open up the labour market for researchers*, but also look beyond Europe (e.g. Asia and the USA). The new NRP 2008 highlights the need for free movement of knowledge in Europe, “where knowledge, ideas, researchers, and students can move about freely” (Danish Government, 2008; p. 14). The latest calls (March 2009) for strategic research programmes launched by the Strategic Research Council, are open to foreign researchers and research groups, which is a large step forward towards enhanced international collaboration.

DASTI has introduced several measures and organisational changes for improving *Danish participation in EUFP7,* for example a new Pre-project grant for the 7th EU framework programme. The Danish Councils for Independent Research give also support to developing FP7 proposals (DCIR, 2009). Strengths and weaknesses of Danish R&D organisations’ participation under the FP7 have been analysed for selected R&D fields: Food, Agriculture, Fisheries and Biotechnology, Information and Communication Technologies, and Socioeconomic Sciences and Humanities (DASTI, 2009a). The report made field-specific recommendations and concluded that international networking activities have to be strengthened for increasing the success rate of FP7 project proposals.

The establishment of science and technology attachés in leading international knowledge environments – in 2006 in Silicon Valley (USA), in 2007 in Shanghai

(China) and latest in 2008 in Munich (Germany) – and bilateral agreements with leading knowledge-based economies exemplify the increased focus on international collaboration.

Table 10: Importance of the ERA pillars in the ERA policy mix and key characteristics

	Short assessment of its importance in the ERA policy mix	Key characteristics of policies
Labour market for researchers	• Important, with focus on improved international competitiveness of Danish research	• Policy focus on attracting the best foreign researchers and students • Danish researchers and students shall have the possibility to gain international experiences
Governance of research infrastructures	• Increasingly important	• Development of national strategy • National programme for research infrastructure is supporting national infrastructure and participation in European infrastructure
Autonomy of research institutions	• Important, with focus on improved research quality	• High autonomy of universities is underpinned by high core funding, and high share of bottom-up research funding, but development contracts with Ministry of Science, Technology and Innovation • Introduction of performance indicators as basis for core funding
Opening up of national research programmes	• Increasingly important, with focus on improved international competitiveness of Danish research	• Strategic research programmes have been opened up for foreign researchers and research organisations as far as the projects strengthen Danish research • "Money follows researcher initiative" is granted by the Danish Councils for Independent Research • More collaboration in ERA-NETs and JTIs

5 Conclusions and open questions

5.1 Policy mix towards national R&D investment goals

In recent years GDP has grown much faster than R&D expenditure. Consequently the proportion of GDP spent on R&D has declined from 2.58% in 2003 to 2.55% in 2007. It remains to be seen what the consequences of the ongoing financial crisis will be. Denmark, along with the majority of EU Member states, has entered the state of recession. That means that GDP is falling. It is unlikely that the increase of public R&D expenditures planned in the Globalisation Strategy 2006 and the NRP 2008 will be halted. However, the development of BERD is much more uncertain and we have no data permitting a proper assessment of that at the moment.

The policy mixes addressing science–industry linkages and commercialisation of public research results have been in the centre of policy development over the last years. There has been an increase of the number of Gazelle enterprises in the country, probably as a consequence of the respective policy measures, but this development was also supported by the favourable economic situation. Since the newly introduced policy measures are not supported by large budgets and the

economic situation is now critical, it remains to be seen if the R&D intensity of SMEs and the R&D intensity of the business sector in general can be further improved.

The high policy focus on the development of the public research sector has resulted in a clear increase of public R&D funding, even the low level of infrastructure investments has been addressed by new policy measures. We estimate that Denmark will reach the 1% target by 2010.

The Lifelong learning strategy improves skills development of the working force. However, the shortage of highly skilled labour and especially the scarcity of engineers are difficult to address. The remuneration level for employees with PhDs is just 22-23% higher than for employees with medium-cycle higher education, and for long-cycle higher education the difference is just 11-16%. This may be a barrier for convincing more young people to choose a research career or at least to select a long-cycle higher education. The economic crisis will most probably lead to increased unemployment among engineers and scientists, and may have a negative impact on the willingness of the younger generation to study science and technology.

5.2 ERA-related policies

Danish research policy is increasingly influenced by ERA-related policies. The Globalisation Strategy from 2006 provided a forceful impulse for an increased international orientation of Danish policy which, however, is not restricted just to Europe.

What are the main contributions to the ERA? Danish policies aim to *open up the labour market for researchers*, but also look beyond Europe, and here especially to Asia and USA. The 25 per cent researcher taxation scheme has been used to attract more foreign researchers. The number of employees covered by the 25 per cent researcher taxation scheme has risen continuously since the scheme was introduced in 1992. However, the taxation scheme is to be revised to provide the possibility to choose between 25 per cent gross taxation for 3 years and 33 per cent gross taxation for 5 years. Foreign researchers will also have the possibility of shorter research stays in Denmark as guest teachers before an appointment under the special researcher taxation scheme. For all foreign researchers, payments are also made to national pension funds in addition to salaries, and the terms of employment of foreign researchers are in accordance with those of the scientific staff at universities in general.

The NRP 2008 highlights the need for *free movement of knowledge in Europe.* However, foreign applicants are still under-represented among the PhD candidates. The NRP 2008 has highlighted the internationalisation of education programmes as one way to attract foreign PhD students. An example for strong regional cross-border collaboration in the field of PhD courses and research is the Öresund University, a consortium of HEIs on both sides of the Danish-Swedish region of Öresund.

In November 2008, the political agreement on the distribution of the globalisation pool for R&D included the increase of investments in research infrastructure in the period 2010–2012. Therefore, the National Programme for Research Infrastructure will give funding for establishing major national research infrastructures and Danish *membership or participation in major international research infrastructures.*

The main contribution of Danish policies to the ERA is the increased openness of Danish research programmes and the expressed interest in participating in new

European research infrastructures. The main focus remains on the participation in FP7 and ERA-Nets.

The *openness of Danish national research programmes* to European and international researchers has been limited, but there are some differences and also some important changes. Recently, there has been a new approach to promote international collaboration also by opening up national research programmes for foreign research organisations, foreign researchers or Danish researchers employed abroad. The only requirement is that the funded research activities promote and strengthen Danish research. It remains to be seen if Danish research programmes are attractive for foreign researchers and research organisations.

The Danish Government has a focus on enhanced Danish participation in new *European research infrastructures* and has foreseen adequate funding for this purpose. Denmark is willing to co-host the European Spallation Source together with Sweden.

What are the main challenges for the Danish R&D system in relation to the development of the ERA? The absolute amount of EU contribution to Danish FP projects has increased from FP5 to FP6, but the Danish proportion of the total EU contribution in FP6 has decreased compared to FP5. An explanation for that could be that new Member States entered in the FP6. DASTI has introduced several measures and organisational changes for improving Danish *participation in EUFP7,* but it remains a challenge to increase further the proportion of Danish projects funded by the EUFP7. Another challenge is the stronger involvement of Danish R&D organisations in the co-ordination of EUFP7 projects and an increase of the number of Danish proposals to the calls of the *European Research Council* (ERC) and a still higher success rate of Danish candidates.

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List of Abbreviations

ASTRID	Aarhus STorage RIng in Denmark
DASTI	Danish Agency for Science, Technology and Innovation (Forsknings- og Innovationsstyrelsen)
DCGC	Danish Centre for Grid Computing
DCIR	Danish Councils for Independent Research (Det Frie Forskningsråd)
DCSR	Danish Council for Strategic Research
DCTI	Danish Council for Technology and Innovation

ERA	European Research Area
ERC	European Research Council
EROHS	European Research Observatory for the Humanities and Social Sciences
ESFRI	European Strategy Forum on Research Infrastructures
ESS	European Spallation Source
EUFP	European Framework Programme
EUROHORCs	European Union Research Organisations Heads Of Research Councils
FP	European Framework Programme for Research and Technology Development
GBAORD	Government budget appropriations or outlays on R&D
GDP	Gross Domestic Product
GERD	Total intramural R&D expenditure
GEUS	Geological Survey of Denmark and Greenland (De Nationale Geologiske Undersøgelser for Danmark og Grønland – GEUS)
GOVERD	Government Intramural Expenditure on R&D
GTS-net	Network of accredited technological service institutes (Godkjente Teknologiske Serviceinstitutter)
HEI	Higher education institutions
HERD	R&D expenditure in the Higher Education Sector
ICT	Information and Communication Technology
IGL	Integrated Guidelines for Growth and Jobs
ILL	Institut Laue-Langevin
IPR	Intellectual property rights
JTI	Joint Technology Initiatives
NCoE	Nordic Centres of Excellence
NordForsk	Nordic Research Board
NORIA	Nordic Research and Innovation Area
NRP	National Reform Programme
PRO	Public research organisations
R&D	Research and development
S&T	Science and technology
SF	Structural Funds
SME	Small and medium enterprises
TTO	Technology transfer office
UNIK	University Research Investment Capital (UNiversitetsforskningens InvesteringsKapital)
XFEL	European X-Ray Laser Project

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Abstract

The main objective of the ERAWATCH Policy Mix Country reports 2009 is to characterise and assess in a structured manner the evolution of the national policy mixes in the perspective of the Lisbon goals, with a particular focus on the national R&D investments targets and on the realisation and better governance of the European Research Area. The reports were produced for all EU Member State and six Associated States to support the mutual learning process and the monitoring of Member and Associated States' efforts by DG-RTD in the context of the Lisbon Strategy and the European Research Area. The country reports 2009 build and extend on the analysis provided by analytical country reports 2008 and on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

This report encompasses an analysis of the research system and policies in Denmark.

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