ERAWATCH COUNTRY REPORT 2010: Denmark

ERAWATCH Network – NIFU STEP

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Acknowledgements and further information:

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Executive Summary

Denmark is a small country – covering 43,098.31 km^2 – with only 5.5 million inhabitants or 1.1% of the total EU27 population. Denmark's Gross Domestic Product (GDP) reached €223,250.5m in 2009. That equates to €40,400 per inhabitant compared to an average of €23,600 per inhabitant for the EU27 overall (Eurostat October 2010). The real average growth rate of GDP for 2005–2009 was 0.5%: at a lower rate than the 0.9% average across the EU27. In 2008, Denmark's gross domestic expenditure on R&D (GERD) was 2.72% of GDP (estimated value provided by Eurostat October 2010), well above the EU27 average of 1.9%. The public budget for R&D increased in nominal value from €2.242b in 2008 to €2.375b in 2009; this reached in 2009 the target for these budgets to receive funding equivalent to 1% of GDP. The business enterprise sector is the main R&D performer, funded mainly by the business sector and providing 70% of total R&D funding in 2008. In 2008, Danish industry invested 1.91% of GDP in R&D expenditure.

The Danish research system is dominated by eight universities, some of which achieve high rankings on international ranking lists. The majority of governmental research institutes have merged with these universities. The majority of the universities have a broad range of faculties. However three of these universities are more specialised in technology, ICT or business and management.

The policy mix in place for promoting private investments in R&D has been further developed during the course of 2009 and 2010. New initiatives that target private R&D investments include increased public procurement of eco-innovations, support for large demonstration facilities, the launch of the Renewal Fund and the launch of a risk capital fund. These last two initiatives will improve access to capital. The main barriers for private R&D investments are shortages of capital and increased unemployment, both of which are consequences of the financial crisis. Danish unemployment increased significantly from 3.3% in 2008 to 6.0% in 2009, in comparison to average rates across the EU27 of 7.0% in 2008 and 8.9% in 2009.

Knowledge triangle

The following table gives a short assessment of the interaction between different policies relevant for the knowledge triangle.

Effectiveness of knowledge triangle policies

	Recent policy changes	Assessment of strengths and weaknesses
Research policy	The Ministry of Food, Agriculture and Fisheries and the Ministry of Climate and Energy have their own R&D programmes which are coordinated with the DCSR: the Energy Development and Demonstration Programme (EDDP, launched in 2008) under the Ministry of Climate and Energy, and the Green Development and Demonstration Programme under the Ministry of Food, Agriculture and Fisheries (GDDP, launched in December 2009).	The coordination between the Ministry of Science, Technology and Innovation and those sectoral ministries with R&D portfolios is strengthening research policy. The policy portfolio addressing science-industry linkages and commercialisation of public research results have been at the centre of policy development over the last few years. Policy measures are not that large in terms of budget, and the economic situation is now challenging. It remains to be seen whether the R&D intensity of SMEs and of the business sector in general can be further improved.

	Recent policy changes	Assessment of strengths and weaknesses
Innovation policy	The Ministry for Economic and Business Affairs revised the financial support for enterprises in 2011: this financial support amounts to €2.9b. There are 'green' measures, research and globalisation measures, cultural measures, and other types of measures. The main part of this financial support will be provided via tax measures – about €1.7b – while the rest will come from specific policy measures. The 2011 Budget Proposal includes the Renewal Fund, support for the DNATF and the DCSR and the start of Green Labs DK subsidy programme by the Ministry of Climate and Energy.	R&D collaboration between PROs and business enterprises has been more in the centre of Danish innovation and research policy, with the aim of stimulating greater R&D investments in the private sector. Clear strengths are the focus on user-driven innovation, open innovation, design innovation, employee-driven innovation and innovation in the public sector. The shortage of highly skilled labour is critical for growth in high-tech sectors.
Education policy	A report published in 2010 highlights goals for increased employment of R&D personnel in the Danish business sector, including the goals that 12% of small enterprises and 70% of medium sized enterprises should employ R&D personnel. The level of interest in higher education can be measured via the number of newly-enrolled students. From this perspective developments during 2010 show a positive trend: in 2010, the number of new enrolled students increased by 12%. In 2010, the Strategy for Education and Training in Entrepreneurship was introduced.	Growing unemployment is one of the societal challenges emphasised by the European Commission in its recommen-dations for Denmark. The rate of unemployment has increased from 3.3% in 2008 to 7.3% in the second quarter of 2010 (compared to 9.7% in the EU27 in 2010). This may endanger the goals of increased employment of R&D personnel in SMEs. The increased number of students overall can be seen as a strength.
Other policies	An action plan implemented by the Danish Government in spring 2010 aims to promote eco-efficient technologies. This plan foresees environmentally-conscious public procurement being used to promote development and demonstration of new environmental technology. Strengthening private investment in R&D is the aim of the Danish government's proposal for the establishment of a risk-capital fund by pension funds and the state. This will allocate about €670m to give start-ups and SMEs access to early risk-capital.	Sustainable development is key target, but also a key driver for Danish policy, covering a broad range of interacting policy fields. The Danish experience of the development of wind energy technology – from a renewable source of energy for Danish peasants, to dominating the global world market – shows that this kind of development can have a major impact on R&D capacity, employment and science-industry linkages, as well as sustainability.

European Research Area

ERA and ERA-related policies have attracted greater attention over recent years. This becomes clear when considering a number of mapping and evaluation reports for Denmark's participation in European FPs, ERA-NETS and other instruments for improved collaboration. Even more important is the introduction of different types of support measures from the Danish EU Research Office in Brussels, the EuroCenter under the Danish Agency for Science, Technology and Innovation administrating the

agency's EU pilot project scheme and the EU coordinator pool to different financial support measures for writing proposals.

Turning to the policy domain, the improved coordination of initiatives has proved to be important, as can be seen in the activities of the Danish Research Coordination Committee (to be finalised in December 2010) and the FACIT-committee (Funding Agency Coordination of International Tasks). Such coordination is important for avoiding a multitude of minor initiatives, which may compete with each other and endanger their intended impacts. An important barrier for participation in certain ERA initiatives, such as Article 169 initiatives, is the requirement for national co-funding. The development of the ERA has been addressed in several initiatives, an important example being the thematic priorities of future Joint Programming Initiatives.

The following table gives a short assessment of the national policies or measures that support the strategic ERA objectives.

Assessment of the national policies/measures supporting the strategic ERA objectives (derived from ERA 2020 Vision)

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive single European labour market for male and female researchers	2009 the Ministry of Science, Technology and Innovation conducted a mapping study of best practice for recruitment and retention of female talents.	A high supply of human capital for science & engineering is in place, which is matching the labour market demand to a great extent, but a lack of engineers and loss of female research talents have been a problem. The economic crisis has contributed to increased unemployment. The working conditions for researchers are attractive: a flexible labour market and a small remuneration gap between men and women. Danish researchers are less mobile than EU27 researchers, which may have negative repercussions for international cooperation.
2	Increase public support for research	The public budget for R&D increased in nominal value from €2.242b in 2008 to €2.375b in 2009; and, as percentage of GDP, reached the 2009 target of 1%, during 2009.	Overall high level of public R&D expenditure, which is minimally affected by the crisis due to long-term planning.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
3	Increase European coordination and integration of research funding	In 2009 and 2010 several evaluations and reports covered Danish participation in the 6th and 7th EU Framework Programmes and other instruments for cooperation and coordination. Danish representatives participated in the Joint Programming Initiatives (JPI). The DCSR decided following thematic priorities for JPIs based on a hearing process: food, climate and health issues. In May 2010 the first wave of JPIs was launched. All the strategic research programmes with 2010 calls promote increased openness to European and international researchers.	Strong engagement of Danish research funding bodies in European research initiatives. Denmark is represented in the European Union Research Organisations Heads of Research Councils by the DCIR. The 'Money-follows-researcher initiative' is granted by the DCIR. Danish R&D programmes are open to foreign researchers, but require that the funded research activities promote and strengthen Danish research. Danish research environments may be reluctant to share their resources with foreign colleagues as long as the research programmes in other countries are not open to them.
4	Enhance research capacity across Europe	Several governmental strategies strengthen the R&D specialisation in food, biotechnology and energy, such as the Climate Adaptation Strategy and the Green Growth Strategy.	Increased funding of energy and food related RD&D will strengthen Denmark's position in the ERA and will have an impact also on other ERA-countries.
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	The Action plan for research infrastructure (March 2010) gives an overview over 12 projects listed by the ESFRI, which are officially supported, and highlights that national framework conditions for research have to be improved across individual research organisations. A 'road map for the further development of research infrastructure' is to be developed based on short-term and long-term needs for such infrastructure.	There are still great needs for the improvement of research infrastructure. Denmark spends not enough in research infrastructure. A further weakness is that the list of prioritised areas for the development of research infrastructure still seems very diverse and difficult to accomplish. A strength is that these needs are addressed by policy actions.
6	Strengthen research institutions, including notably universities	In June 2009 a political agreement was reached on a new distribution model of core funding to universities. The model is a modification of the former model, which covered indicators for education, external funding and PhD graduates. The new model also includes bibliometric indicators and will be introduced stepwise over the period 2010–2012.	The new distribution model shows a stronger focus on performance measures for the Danish universities. This development has been led to some dispute amongst academics on academic freedom.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
7	Improve framework conditions for private investment in R&D	The EDDP launched in 2008, and the GDDP launched in December 2009; aiming at stronger linkages between research, development and demonstration. The Budget Proposal for 2011 covers a range of measures, such as the start of the Renewal Fund and the Green Labs DK subsidy programme. The promotion of eco-efficient technologies through public procurement is the aim of an action plan implemented by the government in 2010. The strengthening of private investment in R&D is the target of the establishment of a risk-capital fund by the pension funds and the state.	The financial crisis has had a negative impact on private R&D investments. Energy and food related RD&D are target areas for private investments. The co-funding provided by the two programmes will further facilitate private investments in these areas. The start of Green Labs DK will facilitate the establishment of larger test facilities in Denmark. The establishment of a risk capital fund is a vital step and will help new start-ups to get access to early risk capital.
8	Promote public-private cooperation and knowledge transfer	In 2010, the DCSR and the DCTI launched an initiative for Strategic Platforms for Innovation and Research. This initiative covered two sectors for initial pilot projects: the energy and food sectors. A large number of innovation policy measures have been restructured into just a few programmes, which will reduce complexity.	Commercialisation of public research is facing problems because of the financial crisis: private investors are reluctant to invest in university start-ups. New policy measures may strengthen inter-sectoral R&D co-operation and improved linkages between research and innovation.
9	Enhance knowledge circulation across Europe and beyond	The latest evaluation report on participation under FP7 shows a slight increase after a declining trend: the Danish share of FP7 funding (2007 –November 2009) reached 2.49%, while the share for FP6 was 2.38%.	Danish research environments are fairly successful in participating in FP7 projects, but they take less responsibility for the leadership of such projects. Low mobility of Danish researchers might reduce knowledge exchange in ERA.
10	Strengthen international cooperation in science and technology and the role and attractiveness of European research in the world	Several new initiatives for the coordination of international activities were set up in 2009, such as the FACIT committee (Funding Agency Coordination of International Tasks), and the pool for research collaboration. The DNRF will establish virtual centres of excellence with Danish and Chinese researchers.	The need for international cooperation, both regarding funding and policy coordination, is receiving more attention. Denmark's strong position in some fields of energy and biotechnology and life sciences may attract foreign researchers and facilitate research cooperation. Other science fields may benefit less from international cooperation.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	Other ministries contribute to innovation and research in Denmark, such as the Ministry of Climate and Energy (with the new Green Labs DK programme), and the Ministry of Food, Agriculture and Fisheries (with the Green Development and Demonstration Programme). The Renewal Fund and the Risk capital fund were established in 2010.	Research, higher education and innovation policy is fairly well coordinated, within one ministry. In addition, this ministry is coordinating action in the field of innovation and entrepreneurship, along with other ministries. Political coordination on entrepreneurial education is a strength. Access to more capital will provide better framework conditions for knowledge based start-up companies.
12	Develop and sustain excellence and overall quality of European research	In 2010 the model for the distribution of basic funding to the universities was based on various performance measures for the first time, one of them being the 'bibliometric research indicator'. Danish universities are placed in good positions in the Shanghai ranking list of leading universities in Europe.	The introduction of the new bibliometric performance indicator may boost high quality research publishing, as the Norwegian case has shown. However, the system has to be developed continuously, because interdisciplinary fields or new, still small science fields need special attention.
13	Promote structural change and specialisation towards a more knowledge-intensive economy	The development of public procurement for eco-innovations, the introduction of Green Labs DK, the new Green Development and Demonstration Programme in 2010.	Specialisation in ecology, climate and energy technology and food and agriculture RD&D will be strengthened. The focus on user-driven innovation, open innovation, design innovation, employee-driven innovation and innovation in the public sector will strengthen knowledge intensive services.
14	Mobilise research to address major societal challenges and contribute to sustainable development	The Energy Policy Agreement covers the period 2008–2011 and foresees new funding for R&D: on electric cars, solar and wave power. Important are increased public procurement for eco-innovations, Strategic Platforms for Innovation and Research, Green Labs DK and the GDDP.	Sustainable development is a core target for Danish policy, and the new policy measures introduced should support that further. Energy and climate challenges are addressed by the Energy Policy Agreement and the Climate Adaptation Agreement.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	An action plan for research evaluation for 2008–2010 was formulated by the Ministry of Science, Technology and Innovation and has been realised over the last few years.	There are two bodies which have been tasked with building mutual trust between science and society and giving advice to the government and the parliament: the Danish Council for Research Policy and the Danish Board of Technology. The systematic evaluation policy has contributed to a more systematic policy and may facilitate further policy learning.

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1 Introduction

The main objective of the ERAWATCH Analytical Country Reports 2010 is to characterise and assess the evolution of the national policy mixes in the perspective of the Lisbon goals and of the 2020, post-Lisbon Strategy. The assessment will focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments into R&D, the articulation between research, education and innovation, and on the realisation and better governance of ERA. In doing this, the 15 objectives of the ERA 2020 are articulated.

The report builds on the 2009 report streamlining the structure and updating the 2009 policy assessment in the domains of human resource mobilisation, knowledge demand, knowledge production and science-industry knowledge circulation. The information related to the four ERA pillars covered in the 2009 report is also updated and it is extended in order to cover all six ERA pillars and address the corresponding objectives derived from ERA 2020 Vision.

Given the latest developments, the 2010 Country Report has a stronger focus on the link between research and innovation, reflecting the increased focus of innovation in the policy agenda. The report is not aimed to cover innovation per se, but rather the '**interlinkage**' between research and innovation, in terms of their wider governance and policy mix.

2 Performance of the national research and innovation system and assessment of recent policy changes

The aim of this chapter is to assess the performance of the national research system, the **'interlinkages'** between research and innovation systems, in terms of their wider governance and policy and the changes that have occurred in 2009 and 2010 in national policy mixes in the perspective of the Lisbon goals. The analysis builds upon elements in the ERAWATCH Country Report 2009, by updating and extending the 2009 policy assessment in the domains of resource mobilisation, knowledge demand, knowledge production and science-industry knowledge circulation. Each section identifies the main societal challenges addressed by the national research and innovation system and assesses the policy measures that address these challenges. The relevant objectives derived from ERA 2020 Vision are articulated in the assessment.

2.1 Structure of the national research system and its governance

This section gives the main characteristics of the structure of the national research and innovation systems, in terms of their wider governance.

Denmark is a small country – covering 43,098.31 km^2 – with only 5.5 million inhabitants or 1.1% of the total EU27 population. Denmark's Gross Domestic Product (GDP) reached €223,250.5m in 2009. That equates to €40,400 per inhabitant compared to an average of €23,600 per inhabitant for the EU27 overall (Eurostat October 2010). The real average growth rate of GDP for 2005–2009 was 0.5%: at a

lower rate than the 0.9% average across the EU27. The decline of 0.9% in 2008 and 4% in 2009 was especially significant for the slowdown in the annual growth rate (Eurostat October 2010). The unemployment rate has increased significantly from 3.3% in 2008 to 6.0% in 2009, compared to 7.0% in 2008 and 8.9% in 2009 for the EU27 (Eurostat June 2010). In 2008, Denmark's gross domestic expenditure on R&D (GERD) was 2.72% of GDP (estimated value given by Eurostat October 2010), well above the average for the EU27, of 1.9%. The Danish research system receives a high level of funding compared to the EU27.

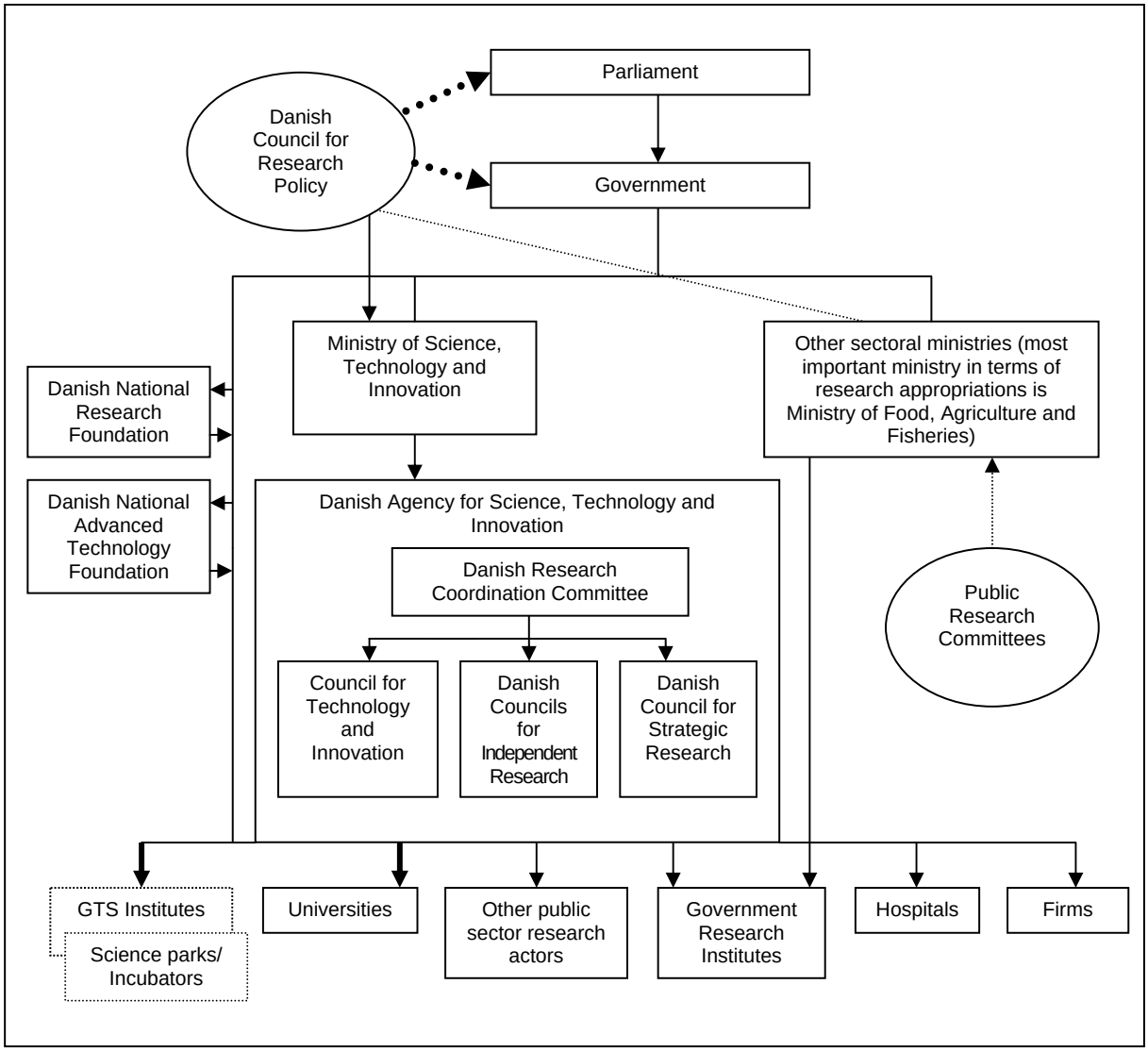
Main actors and institutions in research and innovation system

Figure 1 portrays the governance of the Danish research and innovation system. Three levels are identified: policy level (parliament, government and ministry level); implementation of the policies in agencies, research councils, research foundations and other R&D policy bodies; and, at the third level, 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 (DASTI), the research councils, the two research foundations and the various 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 central governance of the national research and innovation system is effective and has improved considerably over the last few years, but the existence of a multitude of policy measures makes this task challenging. The main present research and innovation governance system is divided into two subsystems. The advisory part is the Danish Council for Research Policy, which was established in 2004. The funding part consists of three councils: the Council for Independent Research (DCIR), which is the umbrella organisation for five research councils and supports research projects ideas based on researchers' initiatives and priorities; the Council for Strategic Research (DCSR), which supports strategic and policy-oriented research; and, the Council for Technology and Innovation (DCTI), which supports innovation oriented initiatives. Beside these funding councils there are also two independent research foundations: the Danish National Advanced Technology Foundation (DNATF), which is oriented towards commercialisation of research results, and the Danish National Research Foundation (DNRF), which is specialised in funding basic science.

Regional bodies do not play any significant role in the governance of the Danish research and innovation system.

Figure 1: Cooperation structure of the Danish research and innovation 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 70% of total R&D in 2008. In 2006, Danish industry invested 1.66% of GDP in R&D expenditure. This increased in 2008 to 2.01%. The main *public research performers* are now concentrated in the university system, performing 23% of the total R&D in 2008. Approximately 77% of publicly supported R&D takes place in that form. There are now eight universities: Copenhagen University, Aarhus University, the Technical University of Denmark, the University of Southern Denmark, Aalborg University, Roskilde University, Copenhagen Business School and the IT University. The universities are organised under their own stakeholder organisation, Universities Denmark. The *government sector,* performing 3.2% of the total R&D in 2008, has been reduced 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; now there are four. The rationale for 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 Resource mobilisation

Since 2000, Europe has made evident progress towards ERA but at the same time it is clear that Europe's overall position in research has not improved, especially regarding R&D intensity, which remains too low. The lower R&D spending in the EU is mainly a result of lower levels of private investment. Europe needs to focus on the impact and composition of research spending and to improve the conditions for private sector R&D investments.

This section assesses the progress towards national R&D targets, with particular focus on private R&D and of recent policy measures and governance changes and the status of key existing measures, taking into account recent government budget data. The need for adequate human resources for R&D has been identified as a key challenge since the launch of the Lisbon Strategy in 2000. Hence, the assessment includes also the human resources for R&D. Main assessment criteria are the degree of compliance with national targets and the coherence of policy objectives and policy instruments.

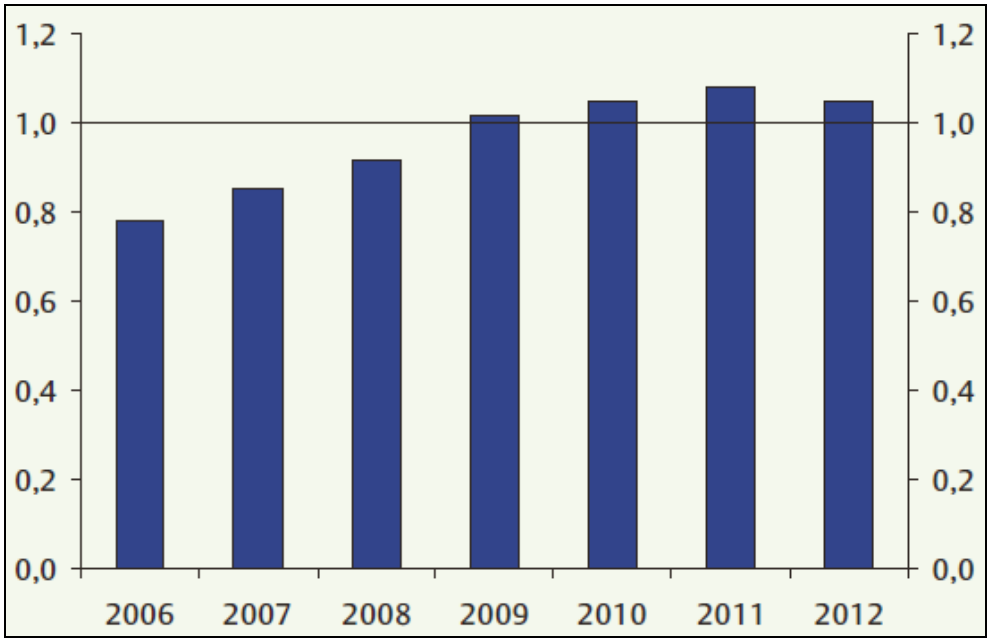
2.2.1 Resource provision for research activities

Progress towards national R&D investment goals; public support for RDI

In 2008, Denmark's gross domestic expenditure on R&D (GERD) was 2.88% of GDP (value given by Statistics Denmark August 2010), well above the EU27 average of 1.9%, but considerably lower than the two other Nordic EU member states, Sweden (3.75% of GDP) and Finland (3.73%) and still below the 3% target (Eurostat, 2010). The share of gross domestic expenditure on R&D for the higher education sector (HERD) is especially high: it stands at 0.71% in Denmark compared to an average of 0.43% in the EU27. Total R&D expenditure in the public sector amounted to €1.863b, or 0.87% of Denmark's GDP (Statistics Denmark August 2010).

Based on the Government's 2010 Budget, publicly financed R&D expenditure will exceed the target of 1% of GDP in 2010 (Finansministeriet, 2010). From 2010 to 2011 the public research budget will increase by €121m, to €2,590m.

Figure 2: The public research budget 2006-2012, Percentage of GDP

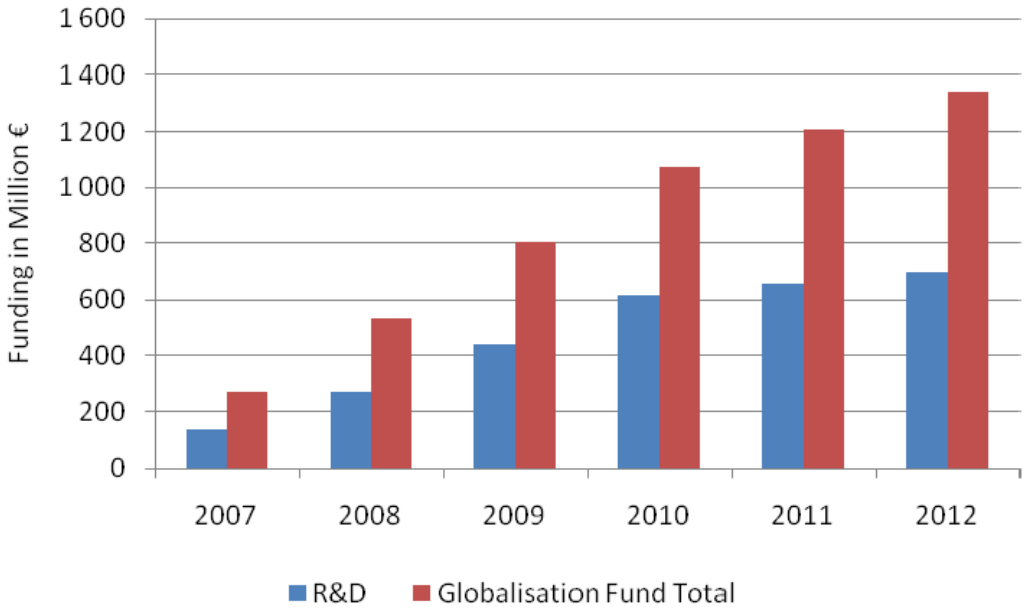


Source: Ansvarlighed og varig velfærd: Finanslovforslaget for 2011 (Finansministeriet, 2010)

Securing long-term investments in R&D

Securing long-term investments in R&D has been one of the priorities of the Danish National Reform Programme and the Globalisation Strategy for Denmark. The agreement on the implementation of the Globalisation Fund secured the long-term prioritisation of research and development (Figure 3). An analysis of the strengths and weaknesses of the Danish research and innovation system provided the basis for this strategy.

Figure 3: Distribution of the Globalisation Fund 2007-2012



Source: Denmark's National Reform Programme: Second Progress Report (Danish Government, 2007)

Main funding instruments and funding streams

The total governmental appropriations for R&D amounted to €2.178b in 2009 (provisional value provided by Eurostat June 2010). The ministry with the highest share of R&D funding is the Ministry for Science, Technology and Innovation. In 2010 the budget for this ministry was about €2.715b (DKK20.203b).

General university funds (GUF) play an important role in the Danish funding system: research financed from general university funds (GUF) received in 2009 about 44% of the government budget appropriations or outlays on R&D (GBAORD).

This can be distinguished into *core funding* and *competitive funding* of universities; the share of competitive funding is supposed to constitute 50% of the total public research funding, at the latest by 2010. The most important competitive funding instruments are governed by the two research councils, the DCIR and the DCSR.

The DCIR is responsible for researcher-driven research. It is an umbrella organisation covering five 'sub'-research councils: the Research Council for Humanities, the Research Council for Natural Sciences, the Research Council for Social Sciences, the Research Council for Medical Sciences, and the Research Council for Technology and Production Sciences. These councils fund research based on the researchers' own initiatives and that has a high quality and international standing. The DCIR had a total budget of €173.4m (DKK1,290.8m) in 2009 and €168.1m (DKK1,250.8m) in 2010.

The DCSR administers strategic research programmes in areas given political priority. The council aims to increase interaction between public research organisation and other parts of society, such as the business sector, public institutions and private research organisations, and to promote research education and international collaboration. The DCSR had a budget of €130.2m (DKK969m) in 2009 and €150.4m (DKK1,119m) in 2010.

These two research councils manage approximately 11% of the budget of the Ministry of Science, Technology and Innovation.

There is also the independent DNRF, which funds research of a high international standard. Since 1991 the fund has allocated some €402m (DKK3b) to Danish research institutions and centres of excellence, with funding running for up to ten years. In 2005 it was supporting 33 centres of excellence. The DNRF will receive an additional block of capital, of €402m (DKK3b), for funding basic research over the next 25 years. In 2009 the foundation received €36.9m (DKK275m) and since then the annual funding is to be set at about €40.2m (DKK300m).Until 2006 there was a *tax incentive* scheme in force that focused on SMEs, but was abandoned in 2006.

Collaborative funding is in place when research projects include the participation of industry participants. The share of the required private co-funding differs between the funding schemes, but is lowest for SMEs.

Structural Funds for R&D activities

Denmark makes use of European Structural funds in two operational programmes: 'Innovation and Knowledge', which receives €255m from the European Regional Development Fund (ERDF) and 'More and Better Jobs', which receives about €255m from the European Social Fund (ESF). The funding from the ERDF will be matched by the same amount from the Danish government. The Innovation and Knowledge programme has the following core targets: development of human resources, innovation, use of new technology (ICT) and entrepreneurship.

Mechanisms to build mutual trust between science and society and strengthen scientific evidence for policy making

There are two important bodies which have been tasked with building mutual trust between science and society and giving advice to the government and the parliament: the Danish Council for Research Policy and the Danish Board of Technology. The work of the Danish Globalisation Council is another example of attempts to strengthen the knowledge base in policy making. The Danish Globalisation Council was an advisory council chaired by the Prime Minister, comprising 48 high level experts from Denmark and abroad. The council's discussions, over a series of meetings, resulted in the Globalisation Strategy which contains 350 specific initiatives.

Grand challenges

The main societal challenges are addressed by research funding via the DCSR. The council finances research based on politically defined programmes focused on the following thematic priorities: sustainable energy production and use of energy; food, nutrition and health; and, nanotechnology, biotechnology and ICT. Large parts of the programme funding from the DCSR respond to the *grand challenges* identified in the Lund declaration, such as climate change and need for clean energy. In this case the DCSR has allotted €40.7m for Sustainable Energy and Environment, €8.1m for Sustainable Transport and Infrastructure, €28.1m for Individuals, Disease and

Society and €32.8m for Health, Food and Welfare. It is also important to highlight the Strategic Platforms for Innovation and Research on sustainable energy and food, which receive €16.2m.

Energy and climate challenges are addressed by the Energy policy agreement which has been implemented over the last few years and the Climate Adaptation Strategy (passed in March 2008). The Energy policy agreement was signed in February 2008 by the Danish government (formed by the Liberals and the Conservatives) as well as the Danish Social Democrats, the Danish People's Party, the Socialist People's Party, the Social Liberals and New Alliance. The agreement covers the period 2008–2011 and foresees several new funding areas for R&D: a pool of €4.7m (DKK35m) for R&D on electric cars, and for R&D on solar and wave power further €3.4m (DKK25m) each year for the four years period. At the end of 2010, the parties will discuss supplementary initiatives for the period after 2011.

The European Commission has emphasised that Denmark's growth potential depends on increasing *returns from investment in human capital, research and innovation* (European Commission, 2009a). As a part of the implementation of the European Economic Recovery Plan Denmark has adopted a revised innovation strategy, has broadened the innovation policy, and has reinforced protection of intellectual property rights (IPR) (European Commission, 2009b). The *national societal challenges* as identified in the annual Lisbon assessment highlight the need to counteract the financial crisis; the introduced R&D measures for green transport address such challenges. Demographic ageing is another national challenge addressed by R&D programmes. *Growing unemployment* is one of the societal challenges emphasised by the European Commission in its recommendations. Denmark's unemployment rate has increased significantly from 3.3% in 2008 to 7.3% in the second quarter of 2010, compared to 9.7% for the EU27 (Eurostat, September 2010).

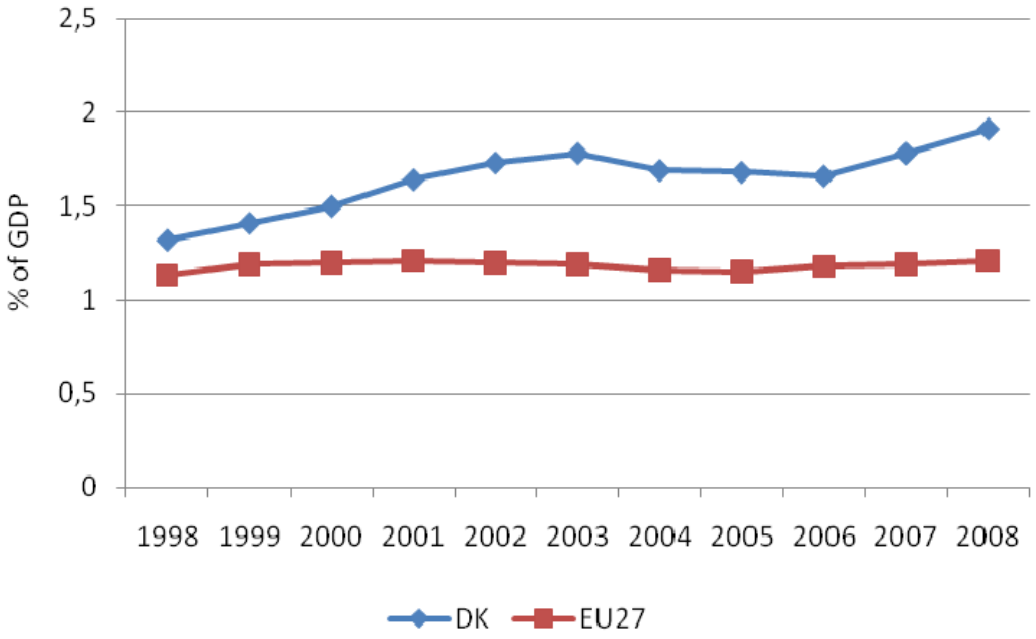
On the other hand, *demographic ageing* has started to affect labour supply, accentuating the need for reforms to stimulate participation in work and hours worked. The median age of the Danish population increased from 38.2 years in 2000 to 40.3 years in 2009. The employment rate of people aged 55 to 64 years has dropped from 60.3% in 2004 to 57.5% in 2009, much lower than the rates for Sweden (70.0%) and Norway (68.7%) (Eurostat, 2010).

2.2.2 Evolution of national policy mix geared towards the national R&D investment targets

Evolution of BERD

The share of gross domestic expenditure on R&D for the business sector (BERD) of GDP is especially high compared with other European countries (1.91% of GDP in Denmark, 1.21% in the EU27) (Figure 4). With the financial and economic crisis Danish GDP is shrinking, undergoing a decline of 0.9% in 2008 and 4.9% in 2009. With a stable BERD level this could lead to a share of BERD of over 2.0%, although no actual data is yet available.

Figure 4: BERD's share of GDP for Denmark and the EU27, 1998-2008



Source: Eurostat, June 2010

Policy mix towards increased private R&D investment

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 Danish Council for Strategic Research (DCSR): the Energy Technology, Development and Demonstration Programme (EDDP) under the Ministry of Climate and Energy; and, the Green Development and Demonstration Programme (GDDP) launched by the Ministry of Food, Agriculture and Fisheries in December 2009, which aims to promote stronger linkages between research, development and demonstration in the food, agriculture, aquaculture and fishery sectors. The total allocations for the GDDP will be about €31m, distributed annually.

The policy debate about climate change has had an impact on the priorities of strategic research funding, as the RESEARCH2015 process and the allocation of funding to related research areas have demonstrated.

As the Country Report for 2009 has shown, there are several policy routes being taken to stimulate private R&D investments.

Promoting the establishment of new indigenous R&D performing firms

One target for Danish innovation policy has been the commercialisation of public research that results in new, R&D intensive firms. The framework conditions for new R&D intensive firms have been addressed systematically. Several new policy schemes for improved framework conditions were implemented in 2008, such as Proof of Concept, the AcceleRace programme and the Gazelle Growth programme.

The policy portfolio addressing science-industry linkages and commercialisation of public research results has been at the centre of policy developments over recent years. Progress has been made in the development of Gazelle enterprises (Siune & Aagaard, 2008), but this development was also supported by the favourable

economic situation up to 2008. Since the more recent policy measures are not that large in terms of budget, and the economic situation is now critical, it remains to be seen whether the R&D intensity of SMEs and the business sector in general can be further improved. The strong policy focus on the development of the public research sector has resulted in a clear increase of public R&D funding, with even the previously mentioned low level of infrastructure investments addressed by new policy measures. We estimate that Denmark will reach the 1% target by 2010.

Stimulating greater R&D investment in R&D performing firms

In the cross field of research and innovation, the Ministry of Science, Technology and Innovation has introduced several measures to foster R&D collaboration between public research organisations and business enterprises, with the overall aim of stimulating greater R&D investments in the private sector. These policy measures are intended to enhance the R&D intensity of Danish firms and are administered by the Danish Council for Technology and Innovation. These types of policy measures include Innovation consortia, Innovation networks, Knowledge voucher and Research voucher for SME and the Knowledge Pilot Initiative.

Stimulating firms not yet performing R&D

Another focus area is the improvement of human capital in Danish enterprises, i.e. vocational and further education and lifelong learning. In the NRP (2008) several initiatives in the field of lifelong learning are highlighted (see also section 2.2.3).

One of the challenges involved in achieving the national R&D investment targets in the business sector, is the need for increased employment of R&D personnel in the business sector, especially in SMEs. A report published in 2010 highlights specific goals for increasing the employment of R&D personnel in the Danish business sector, such as the goal that 12% of small enterprises and 70% of medium sized enterprises should employ R&D personnel (Forsknings- og Innovationsstyrelsen, 2010a; p. 23). Both goals have been accomplished according to the 2010 report. Important policy instruments which support this process include the Industrial PhD Initiative and the Knowledge Pilots.

Attracting R&D-performing firms from abroad

As the Country report for 2009 has stated, inward R&D foreign direct investments (FDI) are not prioritised by the Danish government. “Laws and regulations are characterised by openness and non-discrimination, but the volume of FDI is quite small” (Klitkou, 2009b, p. 24).

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

Direct funding of firms themselves is not prioritised, but R&D collaborations between PROs and business enterprises have been more of a focus in Danish innovation and research policy, for stimulating greater R&D investments in the private sector. In August 2010 the Danish Ministry for Economic and Business Affairs revised the financial support which will be given to Danish enterprises in 2011 (Økonomi- og Erhvervsministeriet, 2010). This financial support amounts to €2.9b. The ministry differentiates between the following types of support measures: ‘green’ measures receiving €1.3b, research and globalisation measures receiving €537m, cultural measures receiving €295m, and other types of measures receiving €725m. The main part of this financial support will be given via tax measures, accounting for about €1.7b, while €1.2b is listed for specific policy measures in the Budget Proposal for 2011 (Finansministeriet, 2010). Research and globalisation support foreseen in the

Budget Proposal covers a broad range of measures, highlighting the establishment of the Renewal Fund, support for the DNATF and the DCSR, and the start of Green Labs DK subsidy programme, which will be run by the Ministry of Climate and Energy with a funding volume of €28.2m over the next three years.

In 2010 a new initiative for the strengthening of entrepreneurial universities was launched. This initiative is supported by the Danish Growth Council, the Danish Enterprise and Construction Authority and DASTI.

Increasing R&D in the public sector

Danish policy is concentrated on improving the framework conditions for R&D in the public sector. The National Reform Programmes and the Globalisation Strategy both focus on increased public R&D funding. The development in the state budget from 2007 to 2009 shows a clear increase in the budget for the Ministry of Science, Technology and Innovation. "Total expenses increased by 8%, from €2,593m in 2007 to €2,812m in 2009. It is especially notable that funding for the research council system increased by 31%, from €254m in 2007 to €331m in 2009" (Klitkou, 2009b, p. 26).

Innovation oriented public procurement policies and other policies affecting R&D investment

Denmark is in the top position on the Global Entrepreneurship and Development Index (GEDI), ranked ahead of Canada, the USA and Sweden (Acs & Szerb, 2010). The GEDI measures entrepreneurial performance in 71 countries, over three sub-indexes: activities, attitudes and aspirations. Denmark is especially strong in the activity index although somewhat weaker in the aspiration index. The activity index shows Denmark ahead in opportunities for start-ups and the quality of human resources. The aspiration index, where Denmark still has some potential for improvement, covers aspirations on new technology, high growth and internationalisation. The attitude index shows that the start-up skills lag behind the other indicators, for example in lower opportunity perception, cultural support, non fear of failure, and networking.

The Danish Enterprise and Construction Authority (EBST) is responsible for the general framework conditions for business activity and start-ups. The government has set the goal that Denmark is to be among the countries with most start-ups by 2010 and among the countries with most new growth enterprises by 2015. One of the policy measures to improve the framework conditions for innovative new start-ups is the Programme for user-driven innovation, administered by the EBST. The programme was launched in 2007 and the purpose of the programme is to strengthen the development of new products, services, concepts and processes for both businesses and public institutions, by making more use of user-driven innovation. Denmark is one of the forerunners in user-driven innovation.

According to an evaluation report, one of the most successful mechanisms for strengthening innovation in Danish firms is the Danish Innovation Consortium Scheme (Kuhn, 2010). This evaluation report measured increases in gross profit and employment, and concludes that the participating firms experienced significant increases in these parameters, which can be attributed to the scheme.

The promotion of eco-efficient technologies is the aim of an action plan that was implemented by the Danish Government in spring 2010. In 2008, public procurement spending by the Danish state, the regions and the municipalities amounted to €21.5b. Public procurement can therefore be seen as a potential driver for the development of eco-innovation. The action plan foresees using environmentally-conscious public

procurement to promote the development and demonstration of new environmental technology (Danish Government, 2010). As part of its Green Growth Strategy the Danish Government has granted approximately €28.2m, over a period of three years, to support the establishment of a few strategic test laboratories for climate technology. At these so called 'Green Labs' national and international businesses can demonstrate and test new green technologies, in full scale and under realistic circumstances. Another measure taken in this area is the establishment of the Renewal Fund (Fornyelsesfonden). The fund will provide funding to innovation projects and for market maturation in the eco sector and the welfare sector, among other things. The fund will be in operation from 2010 to 2012 and has a total budget of about €100m.

The strengthening of private investment in R&D is the target of a proposal made by the Danish government, which aims to establish a risk-capital fund based on pension funds and the state. This shall allocate about €670m for start-ups and SMEs, giving them access to early risk-capital (Finansministeriet, 2010; p. 10).

Barriers and risks for attaining the 2% R&D investment targets

The Policy Mix Report 2009 for Denmark highlights that a "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" (Klitkou, 2009b, p. 19). Another risk mentioned in the same report is the shortage of highly skilled labour. This was also confirmed as a barrier for growth in high-tech sectors in the last TrendChart report (Haase & Graversen, 2009). It remains to be seen how great the impact of increased unemployment, due to the economic and financial crisis, will be. However, a clear threat remains: migration patterns of high-skilled experts do not favour mobility towards Denmark (OECD, 2008, p. 40). Interaction between the business sector and public science is still fairly weak: private enterprises finance Danish public R&D only to a minor degree. It is an explicit policy objective to improve such interaction and a number of policy measures, targeted at improving this interaction, have been implemented. But it still remains difficult to ascertain how successful they are. An evaluation of several R&D collaborative funding schemes by an international expert panel concludes that such schemes are predominantly used by the same networks, that new interactions are not often found and that SMEs and international firms are still not sufficiently involved in such projects (Svedberg et al., 2010).

2.2.3 Providing qualified human resources

National context

The national research system – consisting of eight universities and a few governmental research institutes – employs a high proportion of Danish researchers.

The share of human resources in science and technology (HRST), amongst the economically active population aged 25–64, was 51.8% in 2009 compared to an average of 40.1% for the EU27 (Eurostat, 2010). However, when analysing the field of education the picture seems less positive. The HRST share amongst those aged 25-64, who are educated in science, mathematics and computing is only 5.4%, compared to a share of 10% across the EU27. In the field of engineering, manufacturing and construction Denmark's HRST share is 16.8% compared to the share for the EU27 of 18.6%. These lower shares for Denmark are consistent with concerns about a lack of engineers expressed by the private sector. The shares of HRST in other sectors differ as well: The share of HRST in the *public sector*

amongst the economically active population aged 25–64 was 68.8% in 2009, compared to 56.6% for the EU27 (Eurostat, 2010). A comparison across different economic sectors shows that the share of HRST in Denmark is always higher than that found in the EU27 (Table 1). The private economic sectors with the highest share of HSRT are ICT, professional, scientific and technical activities, and knowledge-intensive services. In a comparable, low-tech sector like agriculture, forestry and fishing, the share of HRST is three times as high as in the EU27. This means there is a great potential for knowledge based value creation.

Table 1: Annual share of HRST in the age group 25-64 years, employed, by economic sector in 2009, percentage of total employment

Economic sector	EU27	Denmark
Total - All NACE activities	42,1	53,0
Agriculture, forestry and fishing; mining and quarrying	10,5	35,4
Manufacturing	30,4	40,9
Electricity, gas, steam and air conditioning supply; water supply and construction	23,3	25,2
Wholesale and retail trade; repair of motor vehicles and motorcycles	29,8	35,0
Transportation and storage	21,3	27,2
Accommodation and food service activities	14,5	18,3
Total knowledge-intensive services	67,4	70,1
Information and communication	81,4	86,4
Financial and insurance activities	66,6	75,1
Professional, scientific and technical activities	81,2	88,0
Administrative and support service activities	26,7	40,8
Public administration; activities of extraterritorial organisations and bodies	56,6	68,8

Source: Eurostat

Articulation of education policies within the knowledge triangle

The level of interest in a higher education can be measured via the number of newly enrolled students. From this perspective there was a positive development in 2010: the number of newly enrolled students increased by 12% (Finansministeriet, 2010; p. 24). The availability of human resources in S&T is fairly good, but concerns have been raised in the private sector regarding access to engineers. This problem has been addressed and the numbers of PhD candidates in engineering has been doubled since 2005.

Statistics on the aggregate level indicate that Danish industry has a high absorption capacity, as companies invest heavily in R&D. This was confirmed by the Key Figure report for 2008/2009 (European Commission, 2008, p. 12). The absorptive capacity among SMEs is quite high in Denmark compared to European and other Nordic countries' averages. SMEs (those with less than 250 employees) account for about 32% of the total R&D business investments. Companies with more than 250 employees are responsible for 68% of the R&D carried out in Denmark. The Industry PhDs programme has contributed to an increased absorptive capacity in the private sector.

Denmark is a country with a flexible, mobile labour force and it also has a long tradition of in-work training policies and funding schemes. In this policy context, the recent Quality Reform (agreed in 2007) further institutionalised the processes for upgrading of skills, qualifications and further education amongst the labour force. Approximately €633m has been allocated for 2008–2011 to measures aimed at

improving possibilities for enhancing skills of employees in the public service sector, "through in-service training and upgrading the skills of semi- and low skilled workers, and better training for managers of public institutions" (Danish Government, 2007, p. 22).

Job-training is accepted as a standard and successful procedure for the continuous development of skills. Life-long learning has been a policy priority for several years in the National Reform Programmes. The Ministries for education and the Ministry of Science, Technology and Innovation are coordinating their activities related to the strategy for life-long learning.

The OECD Economic Survey on Denmark stresses that a skilled workforce is the key to higher productivity (OECD, 2009). Danish students are enjoying student grants, even when their studies are prolonged, and this may be one reason why students finish their studies and enter the labour market relatively late. The OECD suggests greater flexibility for universities to introduce tuition fees and replace today's student grants with loans. The report also points out that the integration of immigrants into the labour market has to be improved.

Main societal challenges

The Danish higher education system produces a sufficiently high number of graduates. However, the specialisation of these students is not totally aligned with the needs of the private sector and late entry into the labour market is also a hindrance to improved access to a skilled labour force. The reasons for these misalignments seem to include the high shares of students interested in humanities and social sciences and the generous student grants available.

The high quality of the vocational education system and the further education of employees are key pillars of the Danish flexicurity system.

Denmark still lags behind the leading countries in the field of entrepreneurial education and training. Due to this the Danish Government introduced a Strategy for Education and Training in Entrepreneurship, which was developed by the Ministry for Science, Technology and Innovation, the Ministry of Culture, the Ministry of Education and the Ministry of Economic and Business Affairs. The strategy covers entrepreneurial education at all levels, including the university level. In addition the government is establishing the Foundation for Entrepreneurship which will become a national knowledge centre for education and training in entrepreneurship (Danish Ministry of Science et al., 2010). The promotion of *entrepreneurial training* at Danish universities is one of the priorities in the recently launched initiative for entrepreneurial universities.

2.3 Knowledge demand

This section focuses on structure of knowledge demand drivers and analysis of recent policy changes.

Various analyses of the Danish innovation system have shown that it is knowledge-intensive and that due to this private enterprises, government and the civic sectors generate specific types of R&D knowledge demands (Forskningsstatistik, 2006; ERAWATCH, 2009; Key figures of science, technology and innovation, 2007; Eurostat, 2008; INNO-Policy TrendChart, Denmark, 2009; Kallerud, 2008).

R&D funded by the business sector provides an indication of the size of R&D-based knowledge demand that originates from this sector, and this totalled €3,875m in

2008. The business sector provides for R&D funds which are almost entirely contained within its own sector (99%); only about 0.9% of R&D business funding in 2008 went to R&D in the higher education sector (Eurostat).

The scale of *R&D funded by the government* provides an indication of the R&D-based knowledge demand that originates from the policy and societal needs of Danish society. Government funded R&D can be divided in two parts; the first part, "General university funds – GUF", provides an indication of the extent to which Danish society is willing to finance free university research; the other part, "Direct government funding", provides an indication of the competitive, mission-oriented and strategic research government funding in Denmark. The *government R&D funding* overall has more than doubled from 1991 (€707m) to 2008 (€1,605m), while the share of this for the GUF part has more than tripled in the same period (from €360m in 1991 to €1,325m in 2008) (Eurostat, 2010).

R&D funded from abroad provides an indication of the knowledge demand from overseas sources, on national R&D services. This type of R&D-based knowledge demand has increased considerably, from €78m in 1991 to €615m in 2008. The bulk of this increase originates from foreign enterprises' purchase of R&D outputs from Danish business enterprises, although of course EC-funding is also an important funding source, providing €82m in 2008 (Eurostat, 2010).

We can therefore conclude that demand for Danish R&D has significantly increased across all main knowledge demand drivers in Danish society. However, Danish business enterprise funding for Danish business R&D, and government funding of GUF, are the two types of R&D demand which increased most markedly between 1991 and 2008.

One can obtain a more detailed picture of the *knowledge demand originating from the business enterprise sector* by investigating business enterprise R&D funding patterns, by economic sector and by firm size. However, public R&D resources are allocated to serve many purposes: to create the framework conditions for a knowledge-based economy and society and for many kinds of 'public goods' which cannot be directly interpreted as reflecting any specific knowledge demand.

The Danish economy is dominated by SMEs and has few large enterprises. Economic growth has been achieved thorough a mixture of low-technology branches such as food, furniture, textiles and toys (Kallerud, 2008) and more knowledge-intensive service areas, such as software consultancy or supply and engineering consultancy. However, as highlighted in the report on Key figures of science, technology and innovation in 2007, pharmaceuticals and computer and related services are the main sectors behind the strong increases in business expenditure on R&D found across Europe (European Commission, 2007). This is also the case in Denmark, where we find the manufacture of pharmaceuticals & medicinal chemistries and software consultancy and supply to be the largest sectors regarding intramural R&D expenditures. Furthermore, the ERAWATCH Specialisation report for Denmark revealed a BERD-specialisation (i.e. a relative higher share of funding compared with EU15 average) in the sectors of food, pharmaceuticals, instruments and the service sector (2006).

It is important to mention developments in the manufacturing industry, especially the R&D expenditure by high-tech and low-tech enterprises. Between 2003 and 2006, R&D expenditures for low-tech enterprises fell by 37%, while the expenditures in the high-tech enterprises increased by 13%. The policy focus on high-tech sectors may

have contributed to this trend. It remains, however, a policy challenge to stimulate investments in R&D amongst low-tech sectors.

One can obtain a more detailed picture of the knowledge demand originating from the government sector – which to a large extent represents Danish societal needs – by investigating how government budget appropriations or outlays on R&D (GBAORD) are distributed according to socio-economic objectives. Looking at the distribution of GBAORD by socio-economic objectives, "Research financed from general university funds – GUF" accounted for the main share of Denmark's GBAORD, making up 44% of the total GBAORD in 2009. This type of funding is also the main objective for the EU27 or EU15 (Wilén, 2008), but the Danish share is still much higher, and has increased from 39% in 1997 to 44% in 2009 (Eurostat, 2010). As argued above GUF-funding provides an approximation of the size of non-targeted academic research. This type of research seems to be increasing in Denmark, and its overall share has been stable since 2004.

The second largest socio-economic objective was "Non-oriented research", receiving 19% of the total GBAORD, a higher share than found in the EU15 or EU27. In comparison to the EU15 and EU27 the Danish government seems to provide about the same share of GBAORD-funds for health, industry production, agriculture and social structures and relationships, but less funding to defence.

Societal knowledge demands are also articulated through the multiple interactions taking place within R&D policy organisations, such as the different programme committees in the DCSR or the DNATF. The programme committees in the DCSR regularly launch calls for projects in specific thematic fields. Thematic priorities in 2010 were: health, food and welfare; sustainable energy and environment; strategic growth technologies; education and creativity; sustainable transport and infra-structure; individuals, disease and society; and, strategic platforms for innovation and research. These provide a multitude of funding possibilities for researchers, but may make it difficult for potential applicants to maintain an overview and obtain long-term funding for larger projects. However, over the last few years DASTI has made several attempts to restructure such funding schemes to reduce their complexity (Haase & Graversen, 2009).

The main approaches used by policy makers to identify patterns or changes in knowledge demand are analytical studies, foresight exercises and various instruments of stakeholder involvement. Stakeholder involvement is particularly well developed. The Ministry of Science, Technology and Innovation organised a broad process that addressed the strategic knowledge demands for Danish society, which resulted in a catalogue of priorities for strategic research, RESEARCH 2015, published in May 2008. All ministries and the research councils were included in this process, along with a broad range of branch organisations. The expert panel for the process consisted of experts from universities, representatives from private think-tanks and industry stakeholder organisations. A user-panel was also involved, based on a workshop with participants from industry stakeholder organisations, companies, representatives from regional authorities, public research organisations and others. In addition, several hundred people submitted proposals for research fields. RESEARCH2015 identified 21 strategic research fields distributed over six key research areas (see 2.4.2).

2.4 Knowledge production

The production of scientific and technological knowledge is the core function that a research system must fulfil. While different aspects may be included in the analysis of this function, the assessment provided in this section focuses on the following dimensions: quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation.

2.4.1 Quality and excellence of knowledge production

R&D funding has increased considerably over the last decade, providing a valuable input for knowledge production. The availability of high quality research infrastructure could still be improved, although this has been addressed in policy actions over several years. The improved access to human resources in science and technology has been a major task. This has been addressed by changing funding priorities for education at the PhD level.

The main knowledge producers in the Danish R&D system are the universities along with a few government research institutes and a network of private, non-profit R&D organisations. In general there is a strong focus on university–industry relationships in Danish research and innovation policies, which seems to reflect a "technology push" understanding of the role of research in industrial and social development, whereby it is assumed that it is the research taking place in universities that generates innovation. Some of the Danish universities have a high standing in international comparisons. The University of Copenhagen is one of the most important universities in the ERA. It is 40th among the world best universities on the 2010 Shanghai ranking list of universities, and 7th place in Europe.

Interdisciplinary funding instruments broaden the focus of research and ensure openness to new scientific opportunities. They contribute to collaboration between research groups, established in different research fields. Examples include interdisciplinary research programmes funded by the Research Council for Strategic Research, such as the programme for food and health, or the programme for nanotechnology, biotechnology and ICT. Furthermore, the DNATF targets the research areas of nanotechnology, biotechnology and ICT and funds projects within at least two of these areas. Similar funding schemes are provided by the Strategic Research Council.

A recently published report on bibliometric research performance indicators for the Nordic countries shows a clear increase in the publication output from Denmark (Schneider, 2010a). When applying fractionized publication counts, Denmark's publication output has increased from 29.120 in the 1999-2003 to 32.448 in the 2004-2008 (Schneider, 2010a, p. 11). However, the growth in publication output for Denmark is lower than the growth for the world, which means a decreasing share of world publication output: from 0.698% in the first period to 0.636% in the second period. When considering the impact of Danish publications it appears that they achieve a very high citation rate, ranking just behind Switzerland, the USA and the Netherlands (Schneider, 2010a, p. 23). Compared with the world average, Danish scientific publications are highly concentrated in clinical medicine, biomedicine and agriculture (Schneider, 2010b). Denmark has a lower profile in chemistry, material science, physics, mathematics, ICT and engineering, and Denmark is close to world average in geosciences and social sciences. These findings are coherent with the findings presented in the ERAWATCH Specialisation project (ERAWATCH Country Specialisation, 2006).

2.4.2 Policy aiming at improving the quality and excellence of knowledge production

The CREST synthesis report on policy mix concluded that a higher degree of competition for public research funds would stimulate scientific (CREST, 2007). A programme for competitive funding for universities (UNIK) was launched in 2007, but was not continued. The programme funded four clusters of excellence for the period of 2009-2014. Each of these four UNIK clusters received approximately €16m. The government pointed out in the Globalisation strategy that Denmark lacks a tradition of systematic evaluation of research quality, and as a consequence has created a quality barometer, to monitor and evaluate development trends. Furthermore, a bibliometric research indicator was introduced into the policies for distribution of core funding for universities, to strengthen the quality of Danish research. Since 2009 DASTI has published a 'Research barometer' on Danish research in an international perspective. This publication summarises statistics on several relevant issues, such as international research funds, human resources for research in Denmark, the international ranking of Danish universities, and publication and patent specialisation.

In June 2009, the government came to a cross-political agreement with the opposition about a model for the distribution of basic funding to the universities. Universities will be measured according to several indicators, one of them being the 'bibliometric research indicator'. In 2010, this performance measure was applied for the first time. The results are open and can be seen at the home page of DASTI.[1]

To ensure a better pattern of specialisation within knowledge creation, the DNRF has supported several centres of excellence since 1993. These centres are funded for a longer period of time (5–10 years). The Foundation distributes approximately €53m annually, to such centres in Denmark, on a competitive basis. This corresponds to about 2% of annual public research expenditure. The further funding of the DNRF has been secured ensuring the continuation of the successful centres of excellence scheme.

A bottom-up process of consultation on research priorities resulted in a catalogue of strategic research fields, named RESEARCH2015. RESEARCH2015 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, Danish research conditions and possibilities, and national and international research perspectives, have been identified. The identified strategic research fields have been used in deciding political priorities for strategic research areas in 2009. New calls for project proposals from the Strategic Research Council from March 2010 apply these priorities.

2.5 Knowledge circulation

Tackling the challenges that European society faces in the 21st century will require a multi-disciplinary approach and coordinated efforts. Many debates and conferences, e.g. the Lund Declaration recognise that such complex issues cannot be solved by single institutions, technology sectors or MS acting alone. Hence strong interactions within the "knowledge triangle" (education, research and innovation) should be promoted at all levels. Moreover, in the context of increasing globalisation, cross-

[1] http://www.fi.dk/forskning/den-bibliometriske-forskningsindikator/indikator-statistik

border flows of knowledge are becoming increasingly important. This section provides an assessment of the actions at national level aiming to allow an efficient flow of knowledge between different R&D actors and across borders.

2.5.1 Knowledge circulation between the universities, PROs and business sectors

There are several funding instruments which are targeted at inter-sectoral R&D co-operation, between the business sector and public research organisations. In an evaluation report published in September 2010, an international evaluation panel presented the results of an evaluation of several funding schemes which aimed at fostering such co-operation (Svedberg et al., 2010). The following funding instruments were evaluated: research consortia under the Independent Research Council for Technology and Production; Strategic Research Centres and Strategic Research Alliances under the DCSR; and, High-technology Projects and High-technology Platforms under the DNATF. The evaluation panel concluded that these funding instruments are functioning well and that the evaluated projects appear to be based on a high level of knowledge transfer between the public and the private sector (Svedberg et al., 2010; p. 11). This panel also highlights that the participation of SMEs in the selected projects appears to be too low and should be investigated further. The same point applies to the participation of international partners, to facilitate cross-border cooperation (see also 2.5.2).

In 2010, the Council for Strategic Research and the Council for Technology and Innovation launched a new initiative, inviting proposals for Strategic Platforms for Innovation and Research. This new policy measure targets inter-sectoral R&D co-operation and improved linkages between research and innovation. This coordinated call for proposals is based around two sectors as initial pilot projects: the energy and the food sector. Both pilot projects will have a total budget of €13m, with 40% from co-funding by the participating organisations (cash or in-kind). The platforms will be funded for 5-7 years.

The creation of academic spin-off companies is assessed as being a proper mechanism for circulating new, educated R&D personnel from the universities into industry. This is therefore the domain of the universities and not necessarily of the government research institutes, which has been confirmed by statistics (DASTI, 2008). The statistics reveal a certain increase in this type of activities after 2004.

The following recent initiatives of the *Danish Council for Technology and Innovation* should also be mentioned:

The Industrial PhD initiative, dating back to 1970, is aimed at enhancing research and development in the Danish business sector. It aims to do this by training researchers to gain insight into business related aspects of research and development, and by building personal networks of knowledge between companies and Danish or foreign universities and research institutions. Industry PhDs have received very favourable evaluations in the subsequent years; according to these evaluations the Industry PhD scheme successfully enhances research-based knowledge circulation between HEIs and the business sector.

Research Voucher for SMEs

A similar initiative for facilitating *research collaboration* with academic and research institutions also began in 2008: this policy measure funds up to €2m worth of research collaboration with SMEs annually (in 2008 and 2009).

Knowledge Vouchers for SMEs

This initiative started in 2008 and targets SMEs without previous experience of 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 is intended to improve the collaboration between SMEs and academic and research institutions, contribute to increased commercialisation of public research results, and to reorient the attention of the academic and research institutions towards the needs of SMEs. These vouchers were funded with €5.36m in 2008 and the same amount again in 2009. A further round for the "New Knowledge Voucher" will start in November 2010. This New Knowledge Voucher will integrate the former research voucher and the former knowledge voucher.

Proof of concept

This measure has the objectives of facilitating the transfer of knowledge from research to business, attracting risk-willing investors, and stimulating cooperation between public research institutions, innovation incubators and other partners.

Knowledge Pilot Initiative

This initiative was introduced in 2005, granting subsidies to companies with less than 100 employees who engage a highly educated employee for the first time. The initiative provides individual companies with €19,440 for the recruitment of a recent graduate, to work on a specified project over a six-to-twelve month period. About 18% of the total grant is used for the necessary education and training of the candidate and the remaining funds contribute to the graduate's salary.

With the reorganisation of the Danish universities and sectoral research institutes, the majority of sectoral research institutes are now incorporated into universities. One intention behind this restructuring process was to improve the quality of research in these research institutes; the other was to equip universities with better capacities to collaborate with the industry, by using the newly-acquired research institutes as a collaboration catalyst and spearhead.

The shortage of engineers is thought to be one of the main reasons why Danish companies move production out of Denmark: every fifth company that moved abroad has stated this is the main reason for their decision. The decreasing number of S&T students has been addressed by a policy measure from the Ministry of Science, Technology and Innovation to increase the subsidy to universities for experimental courses. The decreasing number of students in technological sciences has been especially alarming: only 7% of all enrolled students in 2008 studies technological subjects, 15% studied natural sciences, and the majority studied humanities (36%), social sciences (33%) or medicine (9%) (Universitets- og Bygningsstyrelsen, 2010).

2.5.2 Cross-border knowledge circulation

The Globalisation Strategy (2006) highlighted that Danish participation in the EU Framework Programmes is declining and it therefore proposed several actions to improve Danish access to the European knowledge networks. This declining trend has been confirmed in a recent analysis of the development of the share of funding allocated to Danish participation in FPs, from the FP4 to FP6; this fell from 3.10% for FP4, to 2.67% for FP5 and to 2.38% for FP6 (DASTI, 2008a). However, the latest data shows a slight increase: the Danish share of FP7 funding (2007 to November 2009) reached 2.49% (DASTI, 2010b). Danish participation in the FP7 PEOPLE programme is also very low compared to the other FP7 programmes (DASTI, 2010b;

p. 31ff.). When analysing cross-border mobility of researchers funded by the PEOPLE programme under the FP7, there are four times as many researchers who come to Denmark that there are Danish researchers who go abroad. To improve participation in the 7th Framework programme the DCSR gives financial support for the writing of project proposals. Since 2006 the Council earmarked €1.34m annually for this purpose. DASTI (under the Ministry of Science, Technology and Innovation) has also introduced several measures and organisational changes for improving Danish participation in FP7: The Danish EU Research Office in Brussels assists Danish researchers and research organisations and promotes Danish participation in FP7; the EuroCenter under DASTI is specialised in information and consulting services regarding the FP7; and other measures from DASTI include the START-scheme and Pre-project grants for SMEs. In general, national research programmes still allow limited access for foreign researchers. However, this is not the case for programmes under the DCTI. In most programmes under this council foreign participation and cooperation is encouraged, through higher rankings in the evaluation process and through the inclusion of foreign research institutes in project consortia.

Collaboration with Nordic and Baltic countries is fostered through collaboration under the Nordic Council of Ministers. The Ministry of Science, Technology and Innovation also has a focus on research collaboration with strong economies outside Europe: the ministry signed bilateral agreements on research collaboration with China, India, Israel and Japan. Danish Innovation Centres have been established in Silicon Valley, USA, in Shanghai, China and in Munich, Germany.

Other access points to international knowledge are foreign students who come to Denmark to study and subsequently stay, and Danish students who study abroad and return to Denmark. About 8,000 Danish students study abroad and about 12,000 foreign students study in Denmark .About 60% of foreign graduates remain in Denmark one year after graduation (Ministry of Science, Technology and Innovation, Press release of the 20.8.2008).

2.5.3 Main societal challenges

Research and innovation in energy and food related research fields are funded by a new type of targeted policy instruments – the so-called Strategic Platforms for Innovation and Research (SPIR). SPIRs support cooperation between different research performers, as well as between different sectors and between Danish and foreign research groups.

2.6 Overall assessment

The policy mix that is addressing research, innovation and education policy has been the centre of attention of recent Danish policy. The Globalisation Strategy combines efforts to boost R&D, innovation and education policy. However, it takes time to realise this multitude 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 increased in 2008, to 1.91%, but it may be difficult to achieve the 2% target for this sector. Therefore, to achieve the 2% target the Danish R&D policy ought to stimulate more R&D in the business sector, even if abroad range of new policy measures supporting this goal have already been introduced.

More recently introduced policy measures that facilitate increased participation in the FP7, focus on collaboration with countries outside the EU, and that aim to attract highly qualified labour from abroad, may also all contribute to improved access to international knowledge.

New policy measures, such as the SPIR measure, provide more funding, over a longer period for research and will trigger equivalent co-funding from private enterprises. The use of European funding by Danish research organisations and SMEs has also been the focus of several evaluations, and this has attracted more attention in the research community. The economic crisis has contributed to an increasing unemployment rate and may endanger further education of a highly skilled workforce.

The recent policy measures attempt to strengthen the previously identified strongholds in the Danish research system. A policy opportunity arises from the restructuring of the Danish R&D system and the follow-up policy measures aimed at world-class universities: these should become more competitive, entrepreneurial and more responsive to the needs of industry. From 2010 the knowledge production of universities is to be measured using bibliometric indicators, and core funding distributed accordingly. Universities, with the exception of the DTU, only have limited experience with, and capacities for, patenting, licensing, start-up companies and other commercialisation efforts. A problem here is that enhanced university IPR policies may disturb inter-sectoral knowledge exchange. IPR issues have been experienced to be a barrier in cooperative R&D projects and should be further investigated and addressed at a higher policy level. Technology transfer will need to be strengthened and possible conflicts of interests be addressed in standard agreements on IPR and in strategic collaboration agreements between universities and industry partners.

Table 2: Summary of main policy related opportunities and risks

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• Publicly financed expenditure for research and development is to reach 1% of GDP in 2010 • Long-term funding for universities, and the introduction of new funds providing access to investment capital and improved infrastructure • Green Growth Strategy creates new opportunities • Establishment of the Renewal Fund will boost funding of innovation projects in the eco and the welfare sector	• 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 • Growing unemployment may have a negative impact on the possibilities for employees to keep their knowledge base updated
Knowledge demand	• Broad stakeholder involvement in the development of research priorities 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 and new funding instruments	• 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 such as Denmark
Knowledge production	• Focus on world-class universities based on development contracts and bibliometric indicators as a basis for distribution	• Distribution of core funding of universities based on bibliometric indicators may lead to unintended effects (an

	of the increased university core funding • Orientation towards international excellence may boost quality oriented research production	increase of low impact publications or less publications in new multidisciplinary fields), if they are not well-communicated and not combined with other indicators
Knowledge circulation	• New policy measures to support participation in FP7 • Strong focus on collaboration with China and countries outside Europe • New policy instruments targeting inter-sectoral R&D cooperation	• Policy efforts insufficient to counter decreasing numbers of S&T students and engineers • IPR issues may disturb inter-sectoral R&D cooperation

Table 3: 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 R&D infrastructure investments	Opportunity to modernise the public research infrastructure because of two new funds and action plan for infrastructure
Limited 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 there is a risk that the economic crisis may endanger R&D output
Shortage of highly skilled labour	Lifelong learning strategy improves skills development of the work force, but the risk is that increasing unemployment has a negative impact on education of scientists and engineers
Relatively weak science-industry linkages	Firms' opportunities to cooperate with stronger public R&D sector

3 Interactions between national policies and the European Research Area

3.1 Towards a European labour market for researchers

The Communication Better careers and more mobility: A European Partnership for Researchers proposed by EC in May 2008 aims to accelerate progress in four key areas:

- Open recruitment and portability of grants;
- Meeting the social security and supplementary pension needs of mobile researchers;
- Providing attractive employment and working conditions;
- Enhancing the training, skills and experience of researchers

The Commission has also launched concrete initiatives, such as dedicated information services for researchers, in particular through the activities grouped under the name of EURAXESS – Researchers in Motion. Based on the assessment of the national situation in the four key dimensions detailed above, this section will conclude if national policy efforts are supporting a balanced 'brain circulation', with outward mobility levels matching inward mobility levels. High levels of outward mobility coupled with low levels of inward mobility often signal an unattractive national labour market for researchers and unsuitable research infrastructures. This

may trigger, despite the policy efforts supporting the mobility the 'brain drain' rather than brain circulation.

3.1.1 Stocks and mobility flows of researchers

Danish researchers at universities and research institutes are less internationally mobile than researchers in the European Union in general. Information on Danish researcher mobility and career paths have been retrieved from the reports produced by the MORE project, specifically the "Study on mobility patterns and career paths of EU researchers".[2]

Higher education sector - international mobility

Amongst Danish researchers in the higher education sector, 44% have been internationally mobile, i.e. they have worked in a country other than the one where they attained their highest educational degree; this is below the average of 56% for all EU27 researchers. Meanwhile, 36% of internationally mobile Danish researchers in the higher education sector have experienced at least one move to a new employer, in another country, in their researcher career, in comparison to 50% of all internationally mobile EU27 researchers. About 85% of Danish, internationally mobile researchers in the higher education sector have had at least one research visit in another country in their researcher career; for the EU27 the share is 78%. Finally, 28% of Danish researchers in the higher education sector have been internationally mobile in the last three years, about the proportion as found across the EU27 overall.

Non-university research institutes sector – international mobility

When it comes to Danish respondents in the research institute sector, 47% have been internationally mobile, i.e. have worked in, or made a research visit of three months or more, in a country other than the one where they attained their highest educational degree. Amongst Danish, internationally mobile respondents in the research institutes sector, 46% have experienced at least one move to a new employer in another country over their researcher career (compared to 58% in the EU27 research institutes sector). A significant share (68%) of the Danish, internationally mobile respondents in the research institutes sector have also experienced at least one research visit to another country during the course of their research career (compared to 58% in the EU27 research institutes sector). Finally, only 18% of the Danish respondents in the research institutes sector have been internationally mobile over the last three years. This is significantly lower share compared with respondents from EU27 research institute sector (35%).

Inflow of researchers to Denmark

Denmark has attracted increasing numbers of researchers from EU27 and third countries. Danish universities have also registered increasing numbers of foreign PhD candidates: up from 339 in 2004/05, to 457 in 2007/08 (Danish Agency for International Education, 2009: p. 38). Of the foreign PhD candidates that came to Denmark in 2007/2008, 53% came from the European Research Area and 28% from Asia.

[2] The MORE-project is a large scale study on the mobility patterns and career paths of EU researchers, commissioned by the European Commission (DG Research, Directorate C). More specific, the project has studied at career paths and international mobility of Danish researchers in the higher education sector and in the non-university research institutes sector as compared with EU27. The information is based on two separate mobility surveys, one for researchers in the higher education sector (2009) and one for researchers in the non-university research institutes sector (2010), both surveys covered all EU27 Member States.

Annual statistics on the recognition of professional qualifications in Denmark, provided by the Danish Agency for International Education, can give further indications on inflow of foreign researchers (Danish Agency for International Education, 2010). Since 2007 the agency has had to assess the professional qualifications of emigrants entering Denmark. Under this system, a PhD qualification gives a high score, which is necessary for getting a 'green-card' for access to Denmark (at least 100 points are required, and a PhD receives 80 points). In 2009 1,395 individuals had their professional qualifications recognised. This process is especially popular among health personnel, such as doctors (285), specialised medical doctors (194), dentists (33) and nurses (397). However, in 2009 only 2% of the 2,226 applicants had a PhD.

3.1.2 Providing attractive employment and working conditions

Providing attractive employment and working conditions are priority areas in Denmark, since the employment system for public researchers generally displays a high levels of flexibility (SGHRM, 2009; p. 12). 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 also reveals a huge difference between these sectors, both for employees with long-cycle higher education and for employees with PhDs. However, the specific field of an individual's education is important in shaping these differences: 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 20% higher remuneration in the private sector, compared to the public sector (Statistics Denmark, 2009).

The remuneration gap between men and women in Denmark is very small compared to other countries (below 5% after 15 years of working life). The difference in the annual average salary between men and women is 6%. However, there are differences between scientific domains in terms of remuneration gaps (European Commission, 2007a; table 65, based on Eurostat data). The EU gender equality directives have been implemented in Danish law via, the Act on Gender Equality and the Act on Equal Treatment of Men and Women.

However, there is evidence of a considerable loss of female research talent. Although more women than men graduate from Danish universities today, only 28% of all senior lecturers, and 14% of all professors, are women (Ministry of Science, 2009b; p. 5). The Ministry of Science, Technology and Innovation conducted a mapping study of *best practice initiatives* for recruitment and retention of female talents at Danish universities in 2009, which highlights the following initiatives to address this pattern:

- Mentor programme for female PostDocs and lecturers at Copenhagen University;
- Internationalisation grants distributed in areas with a biased gender distribution at Copenhagen University (KU);
- Funds for the development and operation of networks for female researchers at the University of Southern Denmark (SDU);
- SDU appointment of a gender equality consultant for addressing discriminatory behaviour and improving work culture;

- Several measures for achieving a balance between working life and family life have been introduced at different research organisations, such as flexibility schemes and the possibility to do part-time work, access to a “global workplace”, encouragement to go on maternity/paternity leave, and at the end of the leave the opportunity to return to a research term without any teaching obligations;
- More permanent positions to reduce uncertainties for young female talents;
- Ensure increased competition for the tenured positions through considerable broad research position advertisements;
- Ensure fairer competition for the tenured positions by involving members of both genders in evaluation committees;
- More women in decision-making bodies such as boards, councils and committees;
- More women in research management to be achieved in part through the Danish Research Council for Independent Research allocating €4.6m to promote female research managers, and the DCSR requirement that strategic research centres and strategic research alliances must establish a steering group which include both male and female researchers;
- More female researchers to be encouraged via the KU, which introduced a principle according to which faculties/departments are rewarded with an extra professorship if they employ a certain number of female professors.

In March 2010 a career programme for excellent researchers started, the Sapere Aude programme. The programme aims to provide encouragement for individual and talented researchers to conduct their own research programme independently, and develop international networks. Sapere Aude is a talent development programme for the elite and mainly serves three purposes: strengthening young research talents, encouraging female researchers and being a launching point for the research elite to apply for funding at international research councils and foundations. The programme addresses the three career stages from the post doctoral level to the associate professor level and professor level. This Danish programme is inspired by a similar scheme in the Netherlands.

3.1.3 Open recruitment and portability of grants

Open and competition-based recruitment of researchers has been implemented at Danish higher education institutions and other public research organisations. Research job vacancies are published on the EURES Portal, the EURAXESS portal or at the job portals of the different organisations. The Ministerial order on the Appointment of Academic Staff at universities stipulates that ‘positions at professor and associate professor levels have to be posted internationally’, while this is not mandatory for assistant professor, post-doc or PhD levels positions (SGHRM, 2009; p. 8).

The NRP 2008 highlights the internationalisation of education programmes: €12.1m (DKK90m) was allocated for 2007–2009 for funding Danish students to go abroad and highly-qualified foreign students and teachers to come to Denmark. An example of 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 border, in the region of Öresund. The number of foreign PhD students at Danish universities almost doubled between 2000 and

2007, up from 870, or 17% of all PhD students, to 1,631, or 25% of all PhD students (Ministry of Science, Technology and Innovation, 2009).

Denmark participates in international co-operation through the Europass Framework, and is active in the implementation of the Bologna Process concerning higher education, and the Lisbon Recognition Convention. Recognising academic and professional qualifications from other countries is a prerequisite for foreign researchers to be able to apply for researcher positions in Denmark. The Danish Agency for International Education provides assessments of non-Danish degrees, diplomas and certificates as well as information about international recognition of Danish qualifications. In the case of regulated professions, applicants must have their professional qualifications authorised by the responsible Danish authority. There are about 100 regulated professions. Temporary service providers from EU/EEA countries, in most cases, only need to submit a declaration regarding their professional qualification. For some professions, gaining access on the basis of foreign qualifications is more difficult. If the profession involves a governmental function, Danish citizenship may also be a requirement, as in the cases of judges, police and priests. The DCIR participates in the EUROHORCS initiative, authorizing researchers moving to other countries to take the remainder of any ongoing grant with them, while the DCSR has not signed the letter of intent 'Money follows researchers' (SGHRM, 2009; p. 9).

3.1.4 Meeting the social security and supplementary pension needs of mobile researchers

Denmark is part of the European system that coordinates national social security rules. Payments are also made to national pension funds in addition to salaries for all foreign researchers employed in Denmark. The terms of employment of foreign researchers must be in accordance with those of the scientific staff at universities in general. Information on the transferability of social security and supplementary pension rights is posted on the internet portal 'workindenmark.dk'.

The "Scientific Visa" package has not been implemented in Denmark. Instead, other schemes have been used to facilitate work entry and provide favourable tax conditions for foreign researchers. 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, 2,474 researchers and key employees were attached to the scheme". The researcher taxation scheme was revised in 2008 to provide a choice between 25% gross taxation for three years (previously the only option) and 33% gross taxation for five years. Foreign researchers now have the option to take shorter research stays in Denmark as guest teachers, before appointments under the special researcher taxation scheme (see also 3.6.2).

3.1.5 Enhancing the training, skills and experience of European researchers

There are three mechanisms for enhancing the competencies of Danish researchers: the Danish PhD Programme, the Industrial PhD initiative and regular competence development. The PhD Programme involves independent research work under supervision and a PhD thesis, a set of PhD courses, involvement in research groups, stays at foreign research organisations, and dissemination of research results by teaching and other channels. The target for total enrolment on PhD scholarships is 2,400 annually, from 2010. This includes 150 industrial PhDs, and 20 industrial PhDs in the public sector. PhD programmes are offered at all Danish universities and

foreign PhD students are increasingly enrolled on these: the number of foreign PhD students increased from 247 in 2000 to 616 in 2008 (Universitets- og Bygningsstyrelsen, 2009). These foreign students are concentrated in engineering (45%) and natural sciences (one third). English is normally the working language in these doctoral programmes.

International PhD programmes are also offered on the Öresund Campus, collaboration between universities in the Öresund region, including three Swedish universities (Chalmers University of Technology, Lund University and University of Gothenburg) and two Danish universities (the Technical University of Denmark and the University of Copenhagen).

Two Danish universities are members of the EUA Council for Doctoral Education (EUA-CDE): the Aalborg University and Aarhus University. The EUA-CDE works towards international cooperation in doctoral education and research training.

Denmark has a long tradition of linking academia and industry during PhDs (see 2.5.1). The Industrial PhD initiative gives training researchers insight into business related aspects of research and development, and the chance to build personal networks of knowledge between companies and universities, or other public research institutions.

Regular competence development is a right regulated by all employment contracts in Denmark. Universities offer courses and training to their researchers and part-time teaching staff, often through Centres for Learning or Learning Labs (Ministry of Science, 2009a; p. 7).

3.2 Research infrastructure

Research infrastructures (RIs) are a key instrument in the creation of new knowledge and, by implication, innovation, in bringing together a wide diversity of stakeholders, helping to create a new research environment in which researchers have shared access to scientific facilities. Recently, most EU countries have begun to identify their future national RI needs, budgets and priorities in the so called National Roadmaps for Research Infrastructures. These strategic documents also set out a strategic view on how to guarantee and maintain access to research facilities. Although some countries invest heavily in RIs, none can provide all the required state-of-the-art facilities on a national basis. Several large RIs have already been created in Europe. While optimising the use and development of existing RIs remains important, new infrastructures are needed to respond to the latest research needs and challenges. European Strategic Forum for Research Infrastructures (ESFRI) was established in April 2002 to support a coherent approach to policy-making on RIs in Europe and to act as an incubator for international negotiations on concrete initiatives. This section assesses the research infrastructures national landscape, focusing on the national RI roadmap and national participation in ESFRI.

3.2.1 National Research Infrastructure (RI) roadmap

The DCSR conducted a survey in 2005 of Danish research infrastructure. The results were published in the report “Future research infrastructures – needs survey and strategy proposal” in 2005), which offered 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; and*
- Participation in new international infrastructures over the next 8-10 years requires €13.4m (DKK100m) annually.

The following *national* projects were also mentioned as highly important to address more immediately:

- 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; and
- Investigations on registers and databases.

The report also pointed to several *international* projects relevant for Denmark:

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

The needs identified above led to the establishment of a national programme for investment in research infrastructure. As part of the political Welfare Agreement of November 2006[3], a decision was made to establish a programme to run from 2007 to 2009. The idea of a special programme for research infrastructures was also one element of the Globalisation Strategy 2006. The total funds allocated to the programme were €80.5m (DKK600m), with the highest priority given to investments of national strategic importance, and which are utilised by several institutions. The programme has an annual budget of €27m (DKK200m) for 2007–2009, for establishing national research infrastructure and funding Danish participation in international research facilities. Subsequently, the programme is fully in line with the conclusions in the DCSR report from 2005.

In November 2008, the political agreement between the government and the opposition on the distribution of the globalisation pool for R&D included an increase in investment in research infrastructure between 2010 and 2012. The National Programme for Research Infrastructure has been continued into 2009, with a further €26.8m (DKK200m) allocated for the year. The programme provides funding for establishing major national research infrastructures and Danish membership or participation in major international research infrastructures (DASTI, 2009a).

In March 2010 the Ministry of Science, Technology and Innovation published an Action Plan for research infrastructure (Ministeriet for Videnskab, Teknologi og Udvikling, 2010). The action plan acknowledged that there is still a great need for

[3] In April 2006, the Government presented its proposal for reform of the Danish welfare system. The proposal was based on three elements:

- The Danish Welfare Commission's work
- The Globalisation Strategy
- A report from the Tripartite Committee for lifelong learning and education for everyone on the labour market.

On that basis a comprehensive political agreement was reached in June 2006: "Agreement on wealth and welfare and investments in the future" (Welfare Agreement).

improvement in research infrastructure. A comparison between Denmark, Sweden and Norway reveals that in 2009 Denmark spent €76m (DKK563m), Sweden €87m (DKK646m) and Norway €159m (DKK1.185m) on this area. Denmark is also a member of 15 larger international research infrastructures, with total funding of about €32m (DKK240m).

The Action Plan highlights that national framework conditions for research have to be improved across individual research organisations. A 'road map' for the development of research infrastructure is to be developed, based on a mapping of the short-term and long-term infrastructure needs in the following six areas:

- material and nano technology:
- biotechnology, health and life sciences;
- physics and astronomy;
- energy, climate and environment;
- humanities and social sciences; and
- e-Science.

According to the time plan this road map will be published at the end of 2010, and first funding provided in 2011[4]. The Action Plan also emphasises the importance of European and Nordic cooperation on research infrastructure. It proposes that funding provided by the Nordic Council of Ministers and NordForsk be used for infrastructure, which is prioritised in the national road maps and which might establish Nordic facilities. The ministry is interested in hosting one or several international research infrastructures listed by the European Strategy Forum on Research Infrastructures (ESFRI).

3.2.2 National participation in the ESFRI roadmap. Updates 2009–2010

The Action plan for research infrastructure (Ministeriet for Videnskab, Teknologi og Udvikling, 2010: p. 56ff.) gives an overview of 12 projects listed by the ESFRI, which are officially supported by the DASTI:

- CESSDA Council of European Social Science Data Archives;
- CLARIN Common Language Resources and Technology Initiatives;
- DARIAH Digital Research Infrastructure for the Arts and Humanities;
- SHARE Upgrade of the Survey of Health, Ageing and Retirement in Europe
- ICOS Integrated Carbon Observation System;
- LIFEWATCH Science and Technology Infrastructure for Biodiversity Data and Observatories;
- EATRIS European advanced translational research infrastructure in medicine;
- ECRIN Pan European infrastructure for clinical trials and biotherapy;
- ELIXIR European Life-Science Infrastructure for Biological Information - A Major Upgrade;
- INSTRUCT An Integrated Structural Biology Infrastructure for Europe;

[4] http://www.fi.dk/forskning/infrastruktur/den-danske-roadmap-for-forskningsinfrastruktur

- XFEL European X-Ray Free-Electron Laser Facility; and
- ESS European Spallation Source in Lund, Sweden.

A decision about the level of Danish funding for the different projects has not yet been taken. Denmark has supported the Swedish candidacy to host the ESS over several years, which was confirmed in 2009. Denmark is going to co-host ESS by establishing a data and computation centre on the Danish side of Öresund.

3.3 Strengthening research organisations

The ERA green paper highlights the importance of excellent research institutions engaged in effective public-private cooperation and partnerships, forming the core of research and innovation 'clusters', mostly specialised in interdisciplinary areas and attracting a critical mass of human and financial resources. The Universities/ research institutions should be embedded in the social and economic life where they are based, while competing and cooperating across Europe and beyond. This section gives an overview of the main features of the national higher education system, assessing its research performance, the level of academic autonomy achieved so far, dominant governing and funding models.

3.3.1 Quality of National Higher Education System

Denmark has eight universities: the University of Copenhagen, Aarhus University, the Technical University of Denmark (DTU), the University of Southern Denmark, Aalborg University, Roskilde University, the Copenhagen Business School, and the IT University of Copenhagen. These universities vary in size but are all regulated by the University Act. Five universities are general universities: the University of Copenhagen, Aarhus University, the University of Southern Denmark, Aalborg University and Roskilde University. The other universities are specialised: the DTU is specialised in engineering and technology, the Copenhagen Business School in business and management, and the IT University of Copenhagen in ICT.

Universities Denmark (former Danish Rectors' Conference) is the coordinating body of university level education in Denmark and is also the interest organisation of Danish universities.

In 2009 there were about 122,420 students enrolled at Danish universities (according to Universities Denmark) while the total population of Denmark was 5.5 m. In 2009 18,834 students started at Danish higher education institutions, of whom 14,046 came from Denmark, 1,700 came from western countries and 1,400 came from non-western countries. The number of PhDs has increased over the last years, from 1,076 in 2007, to 1,134 in 2008 and to 1,239 in 2009. The share of PhDs taken up by women increased in the same period from 43% to 46%.

Private enterprises finance only a small proportion of Danish public R&D. The share of HERD financed by business R&D expenditures in 2008 was just 2.2% (Eurostat, June 2010). It seems that Danish business R&D expenditures are kept inside the business sector. However, according to statistics from Universities Denmark, private funding of university research has increased dramatically – despite of the financial crisis – over the last three years: from €113m in 2007, to €167m in 2009.

The mission statements of all Danish universities cover quality of academic research and higher education, interaction and exchange of knowledge with the private sector and society in general, and strengthening international cooperation. This implies that third missions are an important task for Danish universities. Most universities use

third mission indicators on the number of patents, number of spin-off firms funded by faculty members and annual revenues (income) from sales of licences from patents and copyright. Most of the universities also have their own technology transfer office. The most successful university in these areas is the DTU.

Some of the Danish universities have a high standing based on international comparisons. The University of Copenhagen is one of the most important universities in the ERA. It is in 40th place amongst the world's best universities on the Shanghai ranking list of universities, or 7th place in Europe. The University of Aarhus is 98th in the World ranking, while the DTU is ranked between 151 and 200.

The quality of higher education is ensured by the Danish accreditation system. This system of external quality assurance is an important supplement to internal quality assurance in the Danish higher education system. According to the Danish Act on the Accreditation Agency for Higher Education, the Accreditation Council can make decisions regarding accreditation of all higher education study programmes in Denmark.

3.3.2 Academic autonomy

The reform of the university system in Denmark was planned in response to an evaluation of the university sector by an OECD panel in 2002. Several new government initiatives emerged in response to this, including the University Act of 2003 which gave the universities more autonomy and self-governance. Furthermore, it was agreed that the allocation of funds to universities was to change.

The reform of the university sector involved the following processes:

- Reorganisation 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). These mergers have increased and diversified the economic base of the universities, and 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, as well as representatives for the academic and non-academic staff, and two seats for students. 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, 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 and department heads are appointed and no longer elected.

It can be said that this leads to a high level of autonomy regarding management of research budgets and hiring of research personnel. The universities sign development contracts with the Minister for Science, Technology and Innovation,

lasting for 3 years. These contracts are based on performance indicators and describe the level of ambition for the universities. The universities then get funding based on these performance indicators, with funding received as a lump sum, allowing autonomy to decide on its distribution. The government is not involved to interfere in the appointment of new researchers, but has defined the overall framework for how to proceed. However, this management process is due to the mentioned reforms of the university sector not based on staff democracy but on professional management. Decisions about researchers' salaries are delegated to the universities, but salary negotiations are determined by an agreement between the government and trade unions. The decision on research agendas or research specialisation is reserved by the university, and interference from the ministry is not welcomed by the academic community. However, the increased share of competitive funding for mission-oriented research, based on strategic priorities, contributes to pressure on universities to align their research specialisation with nationally agreed priorities.

3.3.3 Academic funding

We can distinguish between core funding and competitive funding of universities, both of which will be strengthened in the future. The share of competitive funding is to make up 50% of the total public research funding by 2010 at the latest. The distribution of both types of university funding is largely based on performance indicators. In June 2009, a political agreement on a new distribution model for core funding to the universities was reached. The new distribution model is a modification of the former 50–40–10 model, which covered indicators for education, external funding and PhD graduates. The new model includes bibliometric indicators as well, and will be introduced stepwise over the period 2010–2012. The envisioned distribution for 2012 is: 45% based on education appropriations, 20% based on external funding of R&D activities, 25% based on bibliometric indicators, and 10% based on PhD graduates. This means a stronger focus on performance measures for the Danish universities. This development has been disputed by academics.

3.4 Knowledge transfer

The importance of knowledge dissemination and exploitation in boosting competitiveness and contributing to the effectiveness of public research has been increasingly recognised by EC and EU Member States. Following the publication of the ERA Green Paper in April 2007, the EC Communication "Improving knowledge transfer between research institutions and industry across Europe" was issued, highlighting the importance of the effective knowledge transfer between those who do research, particularly HEIs and PROs, and those who transform it into products and services, namely the industry/SMEs.

Several Member States have taken initiatives to promote and facilitate knowledge transfer (for instance new laws, IPR regimes, guidelines or model contracts) and many others are planning to intensify their efforts in this direction. However, these initiatives are often designed with a national perspective, and fail to address the trans-snational dimension of knowledge transfer. This section will assess the national policy efforts aimed to promote the national and trans-national public-private knowledge transfer.

3.4.1 Intellectual Property (IP) Policies

Intellectual property rights (IPR) have been much debated in recent years. In 1999, the Act on Inventions at Public Research Institutions was passed by parliament. This changed the rules for patenting at universities. Prior to this Act, the rights to inventions made by university researchers belonged to the researchers, while the government research institutes could claim the IPR. Since January 2000 all public research organisations can claim the rights to inventions made by their researchers, the researchers are obliged to disclose inventions and shall receive a reasonable royalty payment from their organisation. The implementation of the Act was supported by considerable funding efforts by the Ministry of Science, Technology and Innovation. In 2004, an evaluation of the Act was undertaken (Evaluering af forskerpatentloven). The evaluation concluded that the Act has been well received by the researchers and the funding was appreciated, but the outcome (number of patents and licenses) was modest.

The legal framework conditions in the Act on Inventions at Public Research Institutions were supplemented by the Act on Technology Transfer at Public Research Institutions in 2004. The objective of the Act was to support:

- transfer of knowledge between public research institutions and industry;
- the establishment of research-based enterprises; and
- cooperation between public research institutions, foundations and associations.

Since 2004, commercialisation of public research results has been assessed annually. In 2004, DASTI established an inventor service counselling office. An external evaluation of this office has shown that it has acted effectively and will be continued, in a strengthened form, until 2013 (Inhouse Consulting, 2008).

A code of conduct for research cooperation between universities and companies was developed by The Confederation of Danish Industries and The Danish Rectors' Conference (Burmeister & Ørnsholt, 2004). This document differentiates between different types of cooperation, such as co-financed research, sponsored research, commissioned research, consulting services, industrial and co-financed Ph.D. studies and examination projects for students. The case of ownership is easily resolved for commissioned research and consulting services: here the IPR belongs to the company which has commissioned the research. For co-financed research, where both parties have contributed with own resources, the IPR ownership has to be negotiated based on the contributions made by both parties. The calculation of the current value of IPR is highly uncertain and the document recommends that this be considered before cooperation. Since academic researchers have an interest in publishing research results, and as such openness can harm the cooperating company's possibilities to profit from IPR, both parties have to come to an agreement on the publication of results, including time and scope of publishing. The IPR resulting from co-financed projects typically belongs to both parties and should be shared, although the university can give up or sell its rights to the company.

The case for IPR involving work by *PhD students* is more difficult. In the case of industrial PhDs, the PhD student is employed by the company and the IPR belongs to the company. In the case of co-financed PhDs, the student is employed by the university and the university has the right to exploit the inventions made by the PhD student, but an agreement with the company on sharing the rights is suggested by the document. The rights of university tutors should be negotiated at the start of a doctoral project. *Bachelor and graduate students* are not covered by the Inventions

Act and the Public Administration Act since they are not employed at the university. “Co-financed projects that involve students should include information to the students about the contract commitments of the project. To the extent necessary, students can be committed on specific terms” (Burmeister & Ørnsholt, 2004, p. 30).

While the number of Danish university patents is comparable with other European countries, the commercialisation of these patents is not such a focus of attention. Research organisations in Belgium, Netherlands, Switzerland and Germany produced 4 to15 times as many license agreements than Danish institutions. The best-practice institutions in Denmark are Risø National Laboratory, under the Technical University of Denmark. All the general universities and the DTU have a technology transfer office (TTO), but staffing is prioritised very differently: the number of staff varies from more than ten full-time employees, to less than one full-time post (DASTI, 2008). The two remaining independent research institutes each have TTOs with 1 or 2 fulltime employees. The DTU has Denmark’s first and largest university-based science park, Scion-DTU, which has provided a large number of spin-offs (Klitkou, 2009a, p. 36). The annual funding of the university TTOs also differs. Comparing budgets for TTOs in 2008, f the DTU had in a budget of about €1.5m, the University of Aarhus a budget of €0.9m, and the University of Copenhagen a budget of €0.8m. The other universities had TTO budgets below €0.3m.

Due to the merger of the majority of the research institutes with universities there are only a few research institutes with technology transfer activities. According to the latest statistics on patenting, universities applied for 109 patents in 2009 and research institutes for only 3 (Forsknings- og Innovationsstyrelsen, 2010b). Their personnel resources also differ significantly: the universities have 45.8 fulltime equivalents while research institutes report just 2.2.

In 2000, the Ministry of Science, Technology and Innovation established five patent consortia to deal with patenting and to increase collaboration between public research institutions and businesses. These consortia are organised in a national network for technology transfer (see techtrans.dk). The aim of the network is to provide a national forum for public researchers and staff from companies involved in commercialisation of public research. The network contributes to developing skills, increasing professionalization and sharing experience regarding the patenting process and in dealing with IPR.

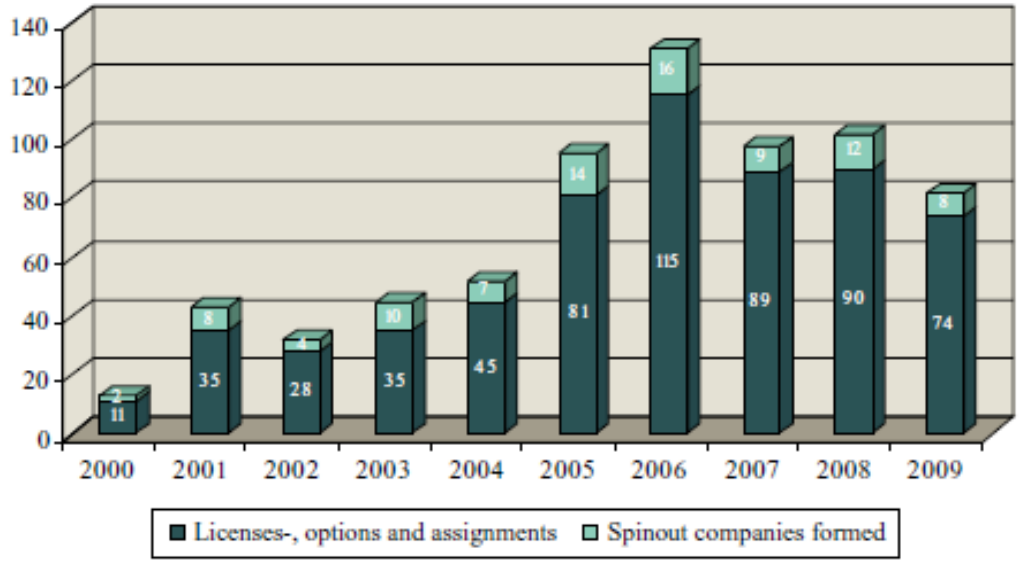
There is room for substantial improvement of the Danish commercialisation system. The Council for Research Policy has recommended improved incentives for institutions and researchers, more transparency and better coordination, improved technology transfer efforts and improved efforts to identify research with commercialisation potential. There are still problematic issues regarding IPR in collaborative R&D projects. The evaluation report on funding schemes aiming at cooperation between public research organisations and private firms highlights that “the main obstacle to these funding instruments appears to be intellectual property rights (IPR). IPR is a source of confusion and frustration among the participants in the research projects, and it seems that the obstacles are increasingly grave in projects characterised by applied research and product development” (Svedberg et al., 2010; p. 11). The evaluation panel recommends that IPR issues should be further investigated and addressed at a higher level.

3.4.2 Other policy measures aiming to promote public-private knowledge transfer

Spin-offs

The creation and support of innovative spin-off and start-up companies is the target of several policy measures. However, the Public research commercialisation survey for 2008 pointed out that private investors have become more reluctant to invest in university inventions. Since the financial crisis it has become increasingly difficult to attract private capital for university inventions, where the time horizon is often long and the commercial and technological risks are high (Forsknings- og Innovationsstyrelsen, 2009). The new survey for 2009 confirmed these problems regarding private investors (Forsknings- og Innovationsstyrelsen, 2010b).

Figure 5: The number of commercialisations 2000–2009



Source: Public research commercialisation survey: Denmark 2009

Inter-sectoral mobility

Inter-sectoral mobility of researchers is high in Denmark in comparison to other EU27 countries (MORE, 2010). Approximately 80% of the industrial PhD programme contributes to improved mobility between universities and companies while only around 20% of traditional PhDs gets positions in the private sector (DASTI 2007).

Promoting research institutions-SME interactions

There are several policy instruments in place which facilitate interactions between research organisations and SMEs, such as Knowledge Vouchers for and Research Vouchers for SMEs (see 2.5.1).

EU cohesion policy

The Danish operational programme Innovation and knowledge, funded by the ERDF, has defined targets including promoting interaction between academia and the business community, encouraging spin-offs from academia and creating of more incubators.

Involvement of private sectors in the governance bodies of HEIs and PROs

Public-private knowledge transfer is ensured by the involvement of representatives from the private sector in the governance of higher education institutions. At several

universities the majority of board members are external members and some of them come from the private sector.

3.5 Cooperation, coordination and opening up national research programmes within ERA

The articulation between the R&D Framework Programmes, the Structural Funds and the Competitiveness and Innovation Programme is still underdeveloped in terms of coordination, synergies, efficiency and simplification. The policy fragmentation at EU and national level, and between EU and national policies can hinder the build of critical masses of research excellence, leads to the duplication of efforts, sub-optimal impacts of the different instruments and unnecessary administrative overheads. Differences between research selection procedures and criteria can also be an obstacle to the overall spread of excellence. This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU, all part of the drive to create an integrated ERA.

3.5.1 National participation in intergovernmental organisations and schemes

Denmark is participating in several of the major collaborative intergovernmental arenas, such as the European Space Agency (ESA), the European Southern Observatory (ESO), the European Organization for Nuclear Research (CERN), and the European Molecular Biology Laboratory (EMBL). Information about the following intergovernmental cooperation arenas is extracted from DASTI's websites, the EW Country Fiche on Denmark and experts at DASTI.

European Space Agency

Denmark was one of the founding members of the European Space Agency (ESA) and is actively participating in ESA projects and programmes. ESA's annual total budget is about €3,744m for 2010, and Denmark's contribution is just below 1% of this budget. The membership allows Danish researchers and companies to participate in scientific space missions, experiments and the exploitation of data and research results. ESA develops technology for the benefit of societal areas such as transport, communication, climate, environment, meteorology and security. Danish researchers are experts on earth observation, space technology, astrophysics and space medicine, and Danish companies have participated in the development of equipment for scientific missions, satellites, ground control and the International Space Station (ISS). According to information provided by DASTI, Denmark participates in the following ESA programmes: ISS Exploitation, including Automated Transfer Vehicle (ATV), European Life and Physical Sciences Programme (ELIPS), Earth Observation Envelope Programme (EOEP), Future Launchers Preparatory Programme (FLPP), Aurora programme, incl. ExoMars, Global Monitoring for Environment and Security (GMES), Advanced Research Telecommunication System (ARTES), and the Navigation system Galileo.

European Southern Observatory

Another European research area related to space science which is of considerable importance to the Danish research community is the European Southern Observatory (ESO). Denmark has been a member of ESO since 1967. ESO's annual budget was €130m in 2010 and Denmark is funding about 2% of this budget. ESO develops

telescopes, optical and infrared instruments for use in ESO's observatories. ESO has three observatories in Chile and plans to build the Extremely Large Telescope.

COST

The Danish research community is also benefitting from the research networks organised by European Cooperation in the field of Scientific and Technical Research (COST). Researchers at Danish research institutions participate in about 200 out of 250 networks in all scientific areas, all running over a four year period. COST participation plays a role in the coordination and opening up of national research programmes. Danish participation is particularly strong in the areas of medicine and agriculture.

EUREKA

Danish EUREKA participants can use various national programmes as their platform for participating in joint EUREKA-projects. The Innovation Consortia Scheme, the Industrial PhD programme, strategic research projects within DASTI or other national programmes such as funding from the DNATF or from the Ministry of Environment and Energy in the EUDP programme can all provide such a platform. Danish participation is concentrated in the following networks: ITEA2, CELTIC, E!-SURF, ACQUEA and EUROAGRIFoodChain. Danish partners can, however, also participate in individual EUREKA-projects.

Denmark is actively participating in Eurostars, which is jointly powered by EUREKA, the European Commission and 34 EUREKA-member states.

FP7

In January 2010 an evaluation of Danish participation in the 6th and 7th EU Framework Programmes was published (Technopolis, 2010). According to this evaluation there is no clear positive or negative trend concerning Denmark's participation in EU Framework programmes. FP6 saw Danish participation in 11.1% of all projects, while the latest Danish share for the 7th Framework programme signal a decline: up to November 2009 Danish organisations were involved in 680 FP7 projects, out of a total of 6,913, or a share of 9.8%. Denmark has performed strongly in the following areas under FP7: Energy, Environment (including climate change), Food, agriculture & biotechnology, and Health. Danish organisations have been allocated €324m in funding from FP7, out of a total of €13b.

3.5.2 Bi- and multilateral agreements with other ERA countries

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, to specialise in ICT, food,

environment and logistics. A network specialised in health is also associated with the Öresund Science Region.

In 2008 the Innovation Center Denmark in Munich, Germany was opened. This is the third innovation centre after a centre in Silicon Valley and another one in Shanghai. These innovation centres serve Danish enterprises and research organisations to establish contacts with international leading research and innovation groups.

3.5.3 Other instruments of cooperation and coordination between national R&D programmes

Beside projects under the EU Framework Programmes, Denmark is also active in a number of other ERA related cooperative actions, such as European Technology Platforms (ETP), Joint Technology Initiatives, Article 169 initiatives, ERA-NETs, and ERA-NET Plus. These activities have been mapped in a report published by DAST (DASTI, 2010a). The report concludes that Denmark is best represented in Article 169 Initiatives and Joint Technology Initiatives, while participation in ERA-NETS is rather low. The following information is extracted from the report and the provided database. Summing up all Danish participation in the different types of instruments, Denmark participates in 55 out of 106 actions. The main thematic focus is on actions for social sciences and humanities, energy, ICT, transport and security. The lowest participation levels are achieved in areas such as nano science, material science and production technology.

Denmark participates in 23 out of 36 *ETPs*: ACARE, ARTEMIS, Biofuels, ECTP, eMobility, ERTRAC, ESTP, ETPIS, EUROP, FABRE TP, Food for Life, FTC, FTP, GAH, MANUFUTURE, NanoMedicine, NEM, NESSI, Photonics21, RHC, SmartGrids, TPWind, and WSSTP.

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 four of them, although to different degrees: Artemis (Embedded Computing Systems), IMI (Innovative Medicines Initiative), Clean Sky (Aeronautics and Air Transport), and Fuel Cells and Hydrogen.

Denmark is represented in all *four Article 169 initiatives*: BONUS, the Joint Baltic Sea Research Programme, EDCTP, the European and Developing Countries Clinical Trials Partnership, EMRP, the European Metrology Research Programme, EUROSTARS, and AAL, Ambient Assisted Living. The report stresses that required national co-funding seems to be a barrier for participation.

Participation in ERA-NETs and ERA-NET PLUS is not as extensive as participation in the three other types of actions. At the end of 2009, just 22 out of 54 active *ERA-NETS* had Danish participants: CIR2CLE, Complexity, CORE Organic II, EMIDA, ENR2, ERA-ARD-II, ERACOBUILD, ERA-IB, ERA-NET TRANSPORT, ERA-NET TRANSPORT II, ERA-PG, EraSME2, ERNEST, EUROCOURSE, EU-SEC II, ICT-AGRI, INNER, MNT ERA-NET 2, NEW OSH ERA, SEAS-ERA, SmartGrids ERA-Net, and SPLASH (EUWI).

Denmark is represented in four out of nine new *ERA-NET Plus actions*, including: iMERA+, a metrology network; BONUS+, a Baltic Sea research network; HERA JRP, a continuation of the ERA-NET HERA, a partnership of research funding agencies in the field of humanities; and, NORFACE Plus, a partnership between fourteen research councils engaged in social science research funding, to increase co-operation in research and research policy in Europe.

Danish researchers have been fairly successful in the first four rounds of the *European Research Council* (ERC). Danish researchers had an average a share of 1.7% of all funded grants. They received 11 starting grants overall in 2007 and 2009, and seven advanced grants in 2008 and 2009. This success can be explained by the fact that Danish researchers are familiar with the requirements of basic science funding instruments. The ERC is fairly similar to the DCIR in its focus on basic science. The DCIR is aiming at better cooperation with the European Research Council. In 2010, the DCIR launched a comprehensive career programme for excellent researchers, the "Sapere Aude" programme. The programme should enable grantees having successfully completed a career stage at national level to proceed and participate in the ERC international competition, thus combining national and ECR funding.

There are several European arenas where research funding agencies, science academies and research councils cooperate and where Denmark participates.

Denmark is represented in the *European Union Research Organisations Heads of Research Councils* (EUROHORCs) by the DCIR. The *Money-follows-researcher initiative* is granted by the DCIR.

The High Level Group for *Joint Programming Initiatives* (JPI) also includes Danish representatives from DASTI and the Council for Strategic Research. The Council for Strategic Research prepared a proposal for the thematic priorities of joint programming initiatives. This proposal is based on the RESEARCH2015 catalogue and has been open for a hearing process with input from research organisations, research councils and relevant ministries. At the end of October 2009 it was decided to concentrate on proposals covering food, climate and health issues. In May 2010 the first wave of JPIs was launched, which were: Agriculture, food security and climate change, Health, food and prevention of diet related diseases, and Cultural heritage, climate change and security. Beside that Denmark already participates in a JPI on Neurodegenerative diseases, including Alzheimer disease. In all JPIs Danish contacts are established, either with relevant ministries or research organisations. The Council for Strategic Research functions as a secretariat.

3.5.4 Opening up of national R&D programmes

The openness of Danish national research programmes to European and international researchers has been limited, but there are some differences between programmes and also some important changes. Generally, according to Danish law, Danish funding schemes are open to researchers based abroad, regardless of their nationality, provided that their research is judged to be of benefit to Danish research. Accordingly, both DCIR and DCSR welcome applications that comprise elements of international research cooperation, to support the best Danish researchers and groups of researchers in their efforts to coordinate and develop their cross-border research collaboration. DCIR and DCSR therefore make no requirements regarding the applicant's citizenship, to the registered office of the research institutions or to a specific geographical location for the implementation of the research activities in question, but in all events, the application will be assessed on the basis of whether the project applied for benefits Danish research.

Some research programmes have already specifically announced the possibility to fund foreign research groups, but, according to Danish law concerning research counselling, it has to be documented that any funded foreign research activities clearly strengthen Danish research groups. Foreign research groups can also apply

for funding within the Strategic Network Project scheme. Recently there has been a new approach to promoting international collaboration, 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 here is that the funded research activities must promote and strengthen Danish research.

A specific instrument supporting 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.

3.6 International science & technology cooperation

In 2008, the European Commission proposed the Strategic European Framework for International Science and Technology Cooperation to strengthen science and technology cooperation with non-EU countries. The strategy identifies general principles which should underpin European cooperation with the rest of the world and proposed specific orientations for action to: 1) strengthen the international dimension of ERA through FPs and to foster strategic cooperation with key third countries through geographic and thematic targeting; 2) improve the framework conditions for international cooperation in S&T and for the promotion of European technologies worldwide. Having in view these aspects, the following section analyses how national policy measures reflect the need to strengthen the international cooperation in S&T.

3.6.1 International cooperation strategies

The Danish Research Coordination Committee has had a specific role in relation to the promotion and coordination of international research collaboration. However, as of 2011 the Committee will be closed down. In June 2010, the committee published a paper on the financing of international research activities during 2009 (Danish Research Coordination Committee, 2010). The paper highlights that in the field of internationalisation the research councils and foundations have a strategic focus on joint financing and researcher mobility. Financing includes both the provision for the necessary funding for participation in international research and innovation initiatives and support for finding foreign collaboration partners for jointly financed activities. Strategies for researcher mobility will be addressed in section 3.6.2. The paper pointed out that different funding organisations are subject to different legislation and therefore have very different levels of funding for international activities. The following table gives an overview of the development of different funding agencies (Danish Research Coordination Committee, 2010).

Table 4: Shares of funds given out directly to international research activities in 2008 and 2009, in percentage

	Total funds		Funding of international activities		Share of funding of international activities	
	2008	2009	2008	2009	2008	2009
Danish Councils for Independent Research	€153m	€165m	€14.4m	€14.8m	9%	9%
Danish Council for Strategic Research	€99m	€157m	€1.9m	€5.5m	2%	4%
Danish Council for Technology and Innovation	€126m	€102m	€4,2m	€3.2m	3%	3%
Danish National Research Foundation	€43m	€37m	€6.4m	€7.0m	15%	19%
Danish National Advanced Technology Foundation	€38m	€38m	€0	€0	0%	0%

Source: Notat (Danish Research Coordination Committee, 2010); Note: The figures for funding of international activities for the Danish Council for Technology and Innovation include only direct funding to Danish participants in such projects and not international participants.

These shares of funding do not include grants to research groups, since such data has not been collected systematically. However, random studies carried out in 2008 suggest real shares may be much higher for the DCIR and the DCSR, possibly two to three times as high as stated in the table.

Several new initiatives for the coordination of international activities were set up in 2009, such as the FACIT committee (Funding Agency Coordination of International Tasks), and a pool of €6.7m for research collaboration, set up in 2009 by the Ministry of Science, Technology and Innovation. The Ministry of Science, Technology and Innovation has initiated several collaboration agreements and other policy measures to ensure an improved knowledge exchange between Danish and knowledge communities outside Europe. This is in line with the Danish government's globalisation strategy "Progress, Innovation and Cohesion – Strategy for Denmark in the Global Economy" (2006). These collaboration agreements include:

- Bilateral agreements (Memorandums of Understandings) about research cooperation with countries outside the EU in areas, where both countries demonstrate strong capabilities, such as Israel (support and strengthen the joint industrial activities within industrial R&D, with focus on biotechnology and ICT), China, India (strengthen research and innovation activities in biotechnology) and Japan (strengthen research collaboration in life sciences).
- In April 2010 the newly appointed Danish Minister of Science Charlotte Sahl-Madsen and Dr. Bai Chunli, president of the Graduate University of the Chinese Academy of Sciences (GUCAS), signed an agreement about the building of a joint Danish-Chinese university centre in Beijing. The university centre is expected to host 300 master thesis students as well as 75 PhD-students and 100 researchers. The scientists will be recruited equally from Denmark and China. The centre is expected to be opened in 2013.
- Partnership agreements on research cooperation together with research and innovation networks and authorities in leading research nations, such as the Center for Information Technology in the Interest of Society (CITRIS) at the UC Berkeley, USA (specialised in energy, biotechnology and nanotechnology), and the Human Sciences & Technologies Advanced Research Institute (H-STAR) at

Stanford University, USA (specialised in ICT, communication, media, organisation and learning and industrial design).

- Establishing innovation centres in leading research, innovation, and industrial communities outside the ERA, such as Shanghai, China and Silicon Valley, California.

The DNRF has also established research-based collaboration programmes with the following foreign research foundations and organisations: the National Natural Science Foundation of China (NSFC) and the National Science Foundation (NSF) in the USA. The DNRF will contribute €17.4m over several years to establish virtual centres of excellence with Danish and Chinese researchers. These will target cancer research, nanotechnology, sustainable energy and ICT.

The DCSR supports the establishment and coordination of international research networks: in 2009 the DCSR supported five such EU networks to promote Danish participation in large, strategic EU projects (Danish Research Coordination Committee, 2010, p. 4). The preparation of applications for the EU's FP7 is supported both by the DCIR and the DCTI.

3.6.2 Mobility schemes for researchers from third countries

As has been stated in the paper of the Danish Research Coordination Committee, the research councils and foundations have a strategic focus on researcher mobility (2010). This includes recruiting researchers and knowledge workers from abroad as well as sending Danish researchers abroad, with the help of mobility schemes. There are three main schemes relevant for facilitating mobility from third countries. These are the internet platform WorkinDenmark.dk, the 25% gross income tax scheme and the Niels Bohr visiting professorship. Workindenmark.dk supports international researchers who want to apply for a job in Denmark. The internet portal has a job and CV database. Relevant information for foreign researchers on Denmark, and on specific Danish initiatives, can also be found at this website.

The 25% gross income tax scheme is targeted at foreign researchers and other key employees. It applies to all foreign researchers, not just to researchers outside the ERA. Since 1992, researchers who meet the requirements stated in section 48E of the Danish Withholding Tax Act have been able to choose a special gross income tax scheme, for up to three years. Since 2000 researchers with approved research qualifications may choose to be taxed in accordance with section 48E without having to meeting the special remuneration requirement of this provision (see below). The approved researcher will be able to obtain permanent residency in Denmark without supplementary taxation for the period in which the 25% scheme was applied. In order to be granted approval of research qualifications, the researcher must be able to document qualifications corresponding to the level of a position as assistant professor or above, or as researcher/project researcher. Such positions require qualifications at the PhD level or equivalents. The universities, government research laboratories and Danish Research Councils have the competency to approve research qualifications. If the position is at an institution covered by the Danish Act on Universities, or the Danish Act on Government Research Institutions, the application can be processed by the institution in question.

The Danish Ministry of Taxation requires that approval of research qualifications has been granted by the start of the employment period. This requirement is considered to be met if the approval is granted within the period following the start of an employment period that is usually spent by the research institutions or research

councils on the approval procedure. The Danish research councils may refuse to process any application for certification that the work performed corresponds to research and development if it has not been documented that the remuneration requirement of section 48E of the Danish Withholding Tax Act has been fulfilled. The remuneration requirement for 2003 was €7,240 (DKK54,300) per month. It must also be stated in the employment contract that the work to be performed corresponds to research and development work. Certification is given on the basis of the OECD's guidelines, as stated in the Frascati Manual 1993: "The scheme was revised in 2008 to allow the possibility of choosing between 25% gross tax for three years and 33% gross tax for five years. Moreover, foreign researchers now have the possibility of shorter stays in Denmark as guest teachers before appointment under the special tax scheme (Ministry of Science, 2009a; p. 7).

The Niels Bohr visiting professorship is awarded by the DNRF. The professorship programme aims to internationalise Danish research: foreign professors, with high scientific achievements are anticipated to help to strengthen existing Danish research centres at an international level. The centres of excellence funded by the DNRF have a high level of internationalisation at all levels of employment.

4 Conclusions

4.1 Effectiveness of the knowledge triangle

The following table gives a short assessment on the effectiveness of policies in the knowledge triangle.

Table 5: Effectiveness of knowledge triangle policies

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	The Ministry of Food, Agriculture and Fisheries and the Ministry of Climate and Energy have their own R&D programmes which are coordinated with the DCSR: the Energy Development and Demonstration Programme (EDDP, launched in 2008) under the Ministry of Climate and Energy, and the Green Development and Demonstration Programme under the Ministry of Food, Agriculture and Fisheries (GDDP, launched in December 2009).	The coordination between the Ministry of Science, Technology and Innovation and those sectoral ministries with R&D portfolios is strengthening research policy. The policy portfolio addressing science-industry linkages and commercialisation of public research results have been at the centre of policy development over the last few years. Policy measures are not that large in terms of budget, and the economic situation is now challenging. It remains to be seen whether the R&D intensity of SMEs and of the business sector in general can be further improved.

	Recent policy changes	Assessment of strengths and weaknesses
Innovation policy	The Ministry for Economic and Business Affairs revised the financial support for enterprises in 2011: this financial support amounts to €2.9b. There are 'green' measures, research and globalisation measures, cultural measures, and other types of measures. The main part of this financial support will be provided via tax measures – about €1.7b – while the rest will come from specific policy measures. The 2011 Budget Proposal includes the Renewal Fund, support for the DNATF and the DCSR and the start of Green Labs DK subsidy programme by the Ministry of Climate and Energy.	R&D collaboration between PROs and business enterprises has been more in the centre of Danish innovation and research policy, with the aim of stimulating greater R&D investments in the private sector. Clear strengths are the focus on user-driven innovation, open innovation, design innovation, employee-driven innovation and innovation in the public sector. The shortage of highly skilled labour is critical for growth in high-tech sectors.
Education policy	A report published in 2010 highlights goals for increased employment of R&D personnel in the Danish business sector, including the goals that 12% of small enterprises and 70% of medium sized enterprises should employ R&D personnel. The level of interest in higher education can be measured via the number of newly-enrolled students. From this perspective developments during 2010 show a positive trend: in 2010, the number of new enrolled students increased by 12%. In 2010, the Strategy for Education and Training in Entrepreneurship was introduced.	Growing unemployment is one of the societal challenges emphasised by the European Commission in its recommen-dations for Denmark. The rate of unemployment has increased from 3.3% in 2008 to 7.3% in the second quarter of 2010 (compared to 9.7% in the EU27 in 2010). This may endanger the goals of increased employment of R&D personnel in SMEs. The increased number of students overall can be seen as a strength.
Other policies	An action plan implemented by the Danish Government in spring 2010 aims to promote eco-efficient technologies. This plan foresees environmentally-conscious public procurement being used to promote development and demonstration of new environmental technology. Strengthening private investment in R&D is the aim of the Danish government's proposal for the establishment of a risk-capital fund by pension funds and the state. This will allocate about €670m to give start-ups and SMEs access to early risk-capital.	Sustainable development is key target, but also a key driver for Danish policy, covering a broad range of interacting policy fields. The Danish experience of the development of wind energy technology – from a renewable source of energy for Danish peasants, to dominating the global world market – shows that this kind of development can have a major impact on R&D capacity, employment and science-industry linkages, as well as sustainability.

4.2 ERA 2020 objectives – a summary

The following table gives a short assessment of national policies supporting the ERA 2020 objectives.

Table 6: Assessment of the national policies/measures supporting the strategic ERA objectives (derived from ERA 2020 Vision)

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive single European labour market for male and female researchers	2009 the Ministry of Science, Technology and Innovation conducted a mapping study of best practice for recruitment and retention of female talents.	A high supply of human capital for science & engineering is in place, which is matching the labour market demand to a great extent, but a lack of engineers has been a problem. The economic crisis has contributed to increased unemployment. Overall the working conditions for researchers are attractive: a flexible labour market and a small remuneration gap between men and women. However there has been a loss of female research talents. Danish researchers are less mobile than EU27 researchers in general, which may have negative repercussions for international networks of Danish researchers. Denmark has increasingly attracted researchers from EU27 and third countries.
2	Increase public support for research	The public budget for R&D increased in nominal value from €2.242b in 2008 to €2.375b in 2009; and, as percentage of GDP, reached the 2009 target of 1%, during 2009.	Overall high level of public R&D expenditure, which is minimally affected by the crisis due to long-term planning.
3	Increase European coordination and integration of research funding	In 2009 and 2010 several evaluations and reports covered Danish participation in the 6th and 7th EU Framework Programmes and other instruments for cooperation and coordination. Danish representatives participated in the Joint Programming Initiatives (JPI). The DCSR decided following thematic priorities for JPIs based on a hearing process: food, climate and health issues. In May 2010 the first wave of JPIs was launched. All the strategic research programmes with 2010 calls promote increased openness to European and international researchers.	Strong engagement of Danish research funding bodies in European research initiatives. Denmark is represented in the European Union Research Organisations Heads of Research Councils by the DCIR. The 'Money-follows-researcher initiative' is granted by the DCIR. Danish R&D programmes are open to foreign researchers, but require that the funded research activities promote and strengthen Danish research. Danish research environments may be reluctant to share their resources with foreign colleagues as long as the research programmes in other countries are not open to them.
4	Enhance research capacity across Europe	Several governmental strategies strengthen the R&D specialisation in food, biotechnology and energy, such as the Climate Adaptation Strategy and the Green Growth Strategy.	Increased funding of energy and food related RD&D will strengthen Denmark's position in the ERA and will have an impact also on other ERA-countries.

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	The Action plan for research infrastructure (March 2010) gives an overview over 12 projects listed by the ESFRI, which are officially supported by DASTI, and highlights that national framework conditions for research have to be improved across individual research organisations. A 'road map for the further development of research infrastructure' is to be developed based on short-term and long-term needs for such infrastructure in the following areas: material and nano technology, biotechnology, health and life sciences, physics and astronomy, energy, climate and environment, humanities and social sciences, and e-Science. Denmark is going to co-host ESS by establishing a data and computation centre.	There are still great needs for the improvement of research infrastructure. Denmark spends not enough in research infrastructure. A further weakness is that the list of prioritised areas for the development of research infrastructure still seems very diverse and difficult to accomplish. A strength is that these needs are addressed by policy actions.
6	Strengthen research institutions, including notably universities	In June 2009 a political agreement was reached on a new distribution model of core funding to universities. The new model is a modification of the former model, which covered indicators for education, external funding and PhD graduates. The new model also includes bibliometric indicators and will be introduced stepwise over the period 2010–2012.	The new distribution model shows a stronger focus on performance measures for the Danish universities. This development has been led to some dispute amongst academics on academic freedom.
7	Improve framework conditions for private investment in R&D	The EDDP launched in 2008, and the GDDP launched in December 2009; aiming at stronger linkages between research, development and demonstration. The Budget Proposal for 2011 covers a range of measures, such as the start of the Renewal Fund and the Green Labs DK subsidy programme. The promotion of eco-efficient technologies through public procurement is the aim of an action plan implemented by the government in 2010. The strengthening of private investment in R&D is the target of the establishment of a risk-capital fund by the pension funds and the state.	The financial crisis has had a negative impact on private R&D investments. Energy and food related RD&D are target areas for private investments. The co-funding provided by the two programmes will further facilitate private investments in these areas. The start of Green Labs DK will facilitate the establishment of larger test facilities in Denmark. The establishment of a risk capital fund is a vital step and will help new start-ups to get access to early risk capital.

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
8	Promote public-private cooperation and knowledge transfer	In 2010, the DCSR and the DCTI launched an initiative, inviting proposals for Strategic Platforms for Innovation and Research. This coordinated call for proposals covered two sectors for initial pilot projects: the energy and food sectors. A large number of innovation policy measures have been restructured into just a few programmes, which will reduce complexity.	Commercialisation of public research is facing problems because of the financial crisis: private investors are reluctant to invest in university start-ups. New policy measures may strengthen inter-sectoral R&D co-operation and improved linkages between research and innovation.
9	Enhance knowledge circulation across Europe and beyond	The latest evaluation report on participation under FP7 shows a slight increase after a declining trend: the Danish share of FP7 funding (2007 –November 2009) reached 2.49%, while the share for FP6 was 2.38%.	Danish research environments are fairly successful in participating in FP7 projects, but they take less responsibility for the leadership of such projects. Low mobility of Danish researchers might reduce knowledge exchange in ERA.
10	Strengthen international cooperation in science and technology and the role and attractiveness of European research in the world	Several new initiatives for the coordination of international activities were set up in 2009, such as the FACIT committee (Funding Agency Coordination of International Tasks), and the pool for research collaboration. The DNRF will establish virtual centres of excellence with Danish and Chinese researchers.	The need for international cooperation, both regarding funding and policy coordination, is receiving more attention. Denmark's strong position in some fields of energy and biotechnology and life sciences may attract foreign researchers and facilitate research cooperation. Other science fields may benefit less from international cooperation.
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	Other ministries contribute to innovation and research in Denmark, such as the Ministry of Climate and Energy (with the new Green Labs DK programme), and the Ministry of Food, Agriculture and Fisheries (with the Green Development and Demonstration Programme). The Renewal Fund and the Risk capital fund were established in 2010.	Research, higher education and innovation policy is fairly well coordinated, within one ministry. In addition, this ministry is coordinating action in the field of innovation and entrepreneurship, along with other ministries. Political coordination on entrepreneurial education is a strength. Access to more capital will provide better framework conditions for knowledge based start-up companies. .
12	Develop and sustain excellence and overall quality of European research	In 2010 the model for the distribution of basic funding to the universities was based on various performance measures for the first time, one of them being the 'bibliometric research indicator'. Danish universities are placed in good positions in the Shanghai ranking list of leading universities in Europe.	The introduction of the new bibliometric performance indicator may boost high quality research publishing, as the Norwegian case has shown. However, the system has to be developed continuously, because interdisciplinary fields or new, still small science fields need special attention.

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
13	Promote structural change and specialisation towards a more knowledge-intensive economy	The development of public procurement for eco-innovations, the introduction of Green Labs DK, the new Green Development and Demonstration Programme in 2010.	Specialisation in ecology, climate and energy technology and food and agriculture related RD&D will gain from these new measures. The focus on user-driven innovation, open innovation, design innovation, employee-driven innovation and innovation in the public sector will strengthen knowledge intensive services.
14	Mobilise research to address major societal challenges and contribute to sustainable development	Energy and climate challenges are addressed by the Energy Policy Agreement and the Climate Adaptation Agreement. The Energy Policy Agreement covers the period 2008–2011 and foresees new funding for R&D: on electric cars, solar and wave power. Other examples are increased public procurement for eco-innovations, Strategic Platforms for Innovation and Research, Green Labs DK and the new Green Development and Demonstration Programme.	Sustainable development is a core target for Danish policy, and the new policy measures introduced should support that further.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	An action plan for research evaluation for 2008–2010 was formulated by the Ministry of Science, Technology and Innovation and has been realised over the last few years.	There are two bodies which have been tasked with building mutual trust between science and society and giving advice to the government and the parliament: the Danish Council for Research Policy and the Danish Board of Technology. The systematic evaluation policy has contributed to a more systematic policy and may facilitate further policy learning.

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List of Abbreviations

ASTRID	Aarhus STorage RIng in Denmark
CNRS	French National Center for Scientific Research
COST	European Cooperation in the field of Scientific and Technical Research
CU	Copenhagen University
DASTI	Danish Agency for Science, Technology and Innovation (Forsknings- og Innovationsstyrelsen)
DCGC	Danish Centre for Grid Computing (Dansk Center for Scientific Computing)
DCIR	Danish Councils for Independent Research (Det Frie Forskningsråd)
DCSR	Danish Council for Strategic Research (Det Strategiske Forskningsråd)
DCTI	Danish Council for Technology and Innovation (Rådet for Teknologi og Innovation)
DGGC	Danish Centre for Grid Computing
DNATF	Danish National Advanced Technology Foundation (Højteknologifonden)
DNRF	Danish National Research Foundation (Danmarks Grundforskningsfond)
DTU	Technical University of Denmark
EBST	Danish Enterprise and Construction Authority (Erhvervs- og Byggestyrelsen)
EDDP	Energy Technology, Development and Demonstration Programme (Energiteknologisk Udviklings- og Demonstrationsprogram)
ERA	European Research Area
ERC	European Research Council
ERDF	European Regional Development Fund
EROHS	European Research Observatory for the Humanities and Social Sciences
ESF	European Social Fund
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Southern Observatory
ESS	European Spallation Source
ETP	European Technology Platform
EUA-CDE	European University Association – Council for Doctoral Education
EUROHORCs	European Union Research Organisations Heads Of Research Councils

FP	European Framework Programme for Research and Technology Development
FTE	Fulltime equivalent
GBAORD	Government budget appropriations or outlays on R&D
GDDP	Green Development and Demonstration Programme
GDP	Gross Domestic Product
GEDI	Global Entrepreneurship and Development Index
GERD	Total intramural R&D expenditure
GEUS	Geological Survey of Denmark and Greenland (De Nationale Geologiske Undersøgelser for Danmark og Grønland)
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
HRST	Human resources in science and technology
ICT	Information and Communication Technology
IGL	Integrated Guidelines for Growth and Jobs
ILL	Institut Laue-Langevin
IPR	Intellectual property rights
JTI	Joint Technology Initiative
NCoE	Nordic Centres of Excellence
NordForsk	Nordic Research Board
NORIA	Nordic Research and Innovation Area
NRP	National Reform Programme
NSF	National Science Foundation (USA)
NSFC	National Natural Science Foundation of China
PPS	Purchasing Power Standards
PRO	Public research organisations
R&D	Research and development
S&T	Science and technology
SDU	University of Southern Denmark
SF	Structural Funds
SGHRM	Steering Group on human resources and mobility
SME	Small and medium enterprises
SPIR	Strategic Platforms for Innovation and Research (Strategiske forsknings- og innovationsplatforme)
TTO	Technology transfer office
UNIK	University Research Investment Capital (UNiversitetsforskningens InvesteringsKapital)
XFEL	European X-Ray Laser Project