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An assessment of research system and policies

Denmark

Antje Klitkou and Aris Kaloudis

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Executive Summary

Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. This strategy is reflected in Guideline No. 7 of the Integrated Guidelines for Growth and Jobs (IGL) which aims to increase and improve investment in research and development, in particular in the private sector. This report aims at supporting the mutual learning process and the monitoring of Member States' efforts. The main objective is to characterise and assess the performance of the national research system of Denmark and related policies in a structured manner that is comparable across countries. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. This report is based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

The Danish economy is one of the most dynamic and innovative in the world, but this achievement is rather the result of a flexible labour market and of a dynamic and open industrial innovation activity rather than a result of a high-performing research-driven innovation system.

Many policy reforms have taken place in order to establish Denmark as a *research-driven globalised knowledge economy*. There is a consensus and political commitment on this issue, backed by all political parties and by the Danish people.

As a natural component of this globalisation strategy, Denmark has committed itself to the Lisbon and Barcelona objectives with policies and long-term budgetary planning targeted towards the 1% public R&D of GDP objective in 2010. The greatest share of this additional public R&D funding will be competitive.

Scientifically and technologically, Denmark shows an increasing specialisation within health, medicine and animal sciences. The (fragmented and scarce) evidence we have on this issue suggests that this scientific specialisation matches the strong industrial specialisation which Denmark shows within the food sector, agriculture and services. Furthermore, Denmark is also one of the leading countries within renewable energy research (especially wind energy) and the country also disposes a competitive industrial base in this technological area.

Public R&D activities correspond well thematically with private sector R&D activities; public and private knowledge supply seem hence to co-evolve.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	• Broad policy consensus on the importance of research and development (R&D) for the future of Danish economy and society. • Government policy oriented towards inclusion of stakeholders from industry and the academia in developing Danish research policy and securing the resource mobilisation.
	Securing long term investment in research	• Long-term planning for development of public R&D expenditure to meet the 1% Barcelona target in 2010.
	Dealing with barriers to private R&D investment	• Rather high share of business R&D, but 2% target will not be reached by 2010. • Purchase of R&D from higher education institutions (HEI) by industry is limited.
	Providing qualified human resources	• Relatively low numbers of PhDs and engineers. • Varying quality of PhD education, but increasing focus on the quality of PhD education.
Knowledge demand	Identifying the drivers of knowledge demand	• Common thematic orientation between public and private knowledge demand drivers. • Stakeholder involvement in public R&D priority settings and foresight exercises. • Modest degree of participation in EU Framework Programmes and ERA-NETs may weaken the influence on research priorities in the EU.
	Co-ordination and channelling knowledge demands	• Research and Innovation policy under one ministry. • Danish Council for Research Policy is an adequate instrument for co-ordination of research policy. • Research Coordination Committee allows co-ordination between the main research funding organisations. • A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge.
	Monitoring of demand fulfilment	• Broad and frequent use of international benchmarking. and systemic evaluation, but evaluation of specific R&D programmes often ad hoc and irregularly.
Knowledge production	Ensuring quality and excellence of knowledge production	• Long experience with centres of excellence. • Well-performing technical university which has been further strengthened considerably the late years. • Good funding of interdisciplinary research. • Good performance in medical science fields, plant and animal sciences, but weaker performance in natural sciences and engineering (based on bibliometric data).
	Ensuring exploitability of knowledge	• Increased focus on commercialisation of public research results and patents. • Coherence between R&D thematic focus in the public and private sector and economic specialisation – strengths in food, pharmaceuticals, instruments and energy sectors.

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	• Private enterprises purchase only in a minor degree Danish public R&D and IPR ownership of universities may become a field for conflict of interests between firms and universities. • Modest rates of commercialisation of university research. • National network for technology transfer strengthens professionalization of technology transfer from public research to industry, but staffing of technology transfer offices (TTO) and qualification of TTOs not prioritised in all organisations.
	Profiting from international knowledge	• Modest participation of Higher Education Institutions (HEIs) in the EU Framework programmes. • National research programmes with limited access (participation and funding) to foreign researchers. • Agreements on research collaboration with China, India etc.
	Enhancing absorptive capacity of knowledge users	• Small and medium sized enterprises (SME) have high absorptive capacity. • High levels and well organised Lifelong learning • Industry PhDs have successfully contributed to increased absorptive capacity in private firms.

A series of policy reforms and new policy measures aim at increasing the quality of university research and its interaction with the private sector.

Denmark faces the following main challenges:

- There seems to be a shortage of persons with technological and natural sciences background and this is an issue of concern and public debate in Denmark.
- Mobilisation of public R&D-funds is satisfactory in Denmark. However, the co-ordination and channelling of these funds seem to represent a challenge as there is a relative large number of agencies and Ministries controlling each a relative large number of R&D-programs and R&D-projects of low volume.
- Although we argue that there seems to be a consistency of knowledge demand and supply in the Danish system, university R&D purchases by Danish business is still relatively low. Either there are other (more effective) channels for knowledge flows between the national private and public R&D sectors, or this is a sign of a potential weakness in the Danish R&D system.
- The introduction of several new schemes targeting university-industry collaboration may help eventually to increase and improve the quality of university-industry links. However, they are numerous and their level of funding is low, a fact which may contribute to a further fragmentation of the system of policy measures.
- A number of sectoral research institutes have been merged with universities in the hope of increasing research quality and societal responsiveness of the overall public R&D base. This merger may not work as intended. The main immediate risk seems to be the weakening of links between the newly merged institutes and a number of private companies, in particular SMEs and those operating in low-tech sectors, due to adjustments of their acquisition routines and policies as they are now part of larger university organisations.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• According to Globalisation Strategy, 50% of public R&D funding shall be competitive by 2010. • Long-term funding for universities based on Welfare agreement, and introduction of new funds providing access to investment capital and improved infrastructure • Policy focus on PhD education and increasing number of PhDs • Policy measures to attract foreign researchers and PhD students • Globalisation Strategy combines a boost to R&D and higher education with a tri-party agreement on life-long learning	• Limitations for immigration may endanger attraction of foreign researchers • Increased competitive funding may have a negative impact on academic freedom • Increased competitive funding will lead to an extra burden for researchers who have to apply for competitive funding • Policy decision to abandon tax incentives for business R&D in 2006
Knowledge demand	• Broad stakeholder involvement ensures good match between research policy and user needs • Energy R&D has been strengthened • Further strengthening evaluation, benchmarking and accountability culture	• A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge. • The identified strategic research areas may be too diverse for a small country as Denmark.
Knowledge production	• Strengthened universities based on restructuring of public R&D system • Focus on world-class universities based on development contracts and bibliometric indicators as a basis for distribution of the increased university core funding	• Distribution of core funding of universities based on bibliometric indicators may lead to unintended effects, if they are not well well-understood by the research community and combined with other output indicators.
Knowledge circulation	• New policy measures to support participation in EUFP7 • Strong recent policy focus on collaboration with China and other countries outside Europe • New policy instruments in place targeting university-industry collaboration	• Policy efforts insufficient to counter decreasing numbers of S&T students and engineers • Traditional good experiences with science-industry linkages at sectoral research institutes can get lost with the integration in bureaucratic structures of universities, and SMEs may suffer

The European Research Area as such does not play a central role in the current Danish research policy debate. Nevertheless, the Danish government has fully adopted the Lisbon objective and its Globalisation strategy has proposed reinforcing Danish participation in EU framework programmes and other international research activities. Regarding European mobility of researchers, the Danish participation in the Marie Curie Actions is at the same level as for all participating countries in the EUFP6, about 10% of all EUFP6 financial contributions go to these actions both for Denmark and in total. When analysing the financial contribution of the EUFP6 to research infrastructures, Denmark received a much lower share of funding than expected. Most national research programmes are still not open for foreign researchers although there are some exceptions. On the other hand, Denmark is active in Nordic research co-operation schemes. This includes Nordic research institutions, joint research programmes, Nordic Centres of Excellence (NCoE), grant schemes and the co-ordination and planning of major infrastructure investments.

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1 - Introduction and overview of analytical framework

1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area

As highlighted in the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. This strategy is reflected in Guideline No. 7 of the Integrated Guidelines for Growth and Jobs. This aims to increase and improve investment in research and development (R&D), with a particular focus on the private sector. One task within ERAWATCH is to produce analytical country reports to support the mutual learning process and the monitoring of Member States' efforts.

The main objective is to analyse the performance of national research systems and related policies in a comparable manner. The desired result is an evidence-based and horizontally comparable assessment of strength and weaknesses and policy-related opportunities and risks. A particular consideration in the analysis is given to elements of Europeanisation in the governance of national research systems in the framework of the European Research Area, relaunched with the ERA Green Paper of the Commission in April 2007.

To ensure comparability across countries, a dual level analytical framework has been developed. On the *first level*, the analysis focuses on key processes relevant to system performance in four policy-relevant domains of the research system:

1. Resource mobilisation: the actors and institutions of the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system.
2. Knowledge demand: needs for knowledge have to be identified and governance mechanisms have to determine how these requirements can be met, setting priorities for the use of resources.
3. Knowledge production: the creation and development of scientific and technological knowledge is clearly the fundamental role of any research system.
4. Knowledge circulation: ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production.

These four domains differ in terms of the scope they offer for governance and policy intervention. Governance issues are therefore treated not as a separate domain but as an integral part of each domain analysis.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
• Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources	• Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment	• Quality and excellence of knowledge production • Exploitability of knowledge production	• Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

On the *second* level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see Figure 1). The way in which a specific research system responds to these generic challenges is an important guide for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter into the analysis in terms of how they contribute to system performance in the four domains. Based on this framework, analysis in each domain proceeds in the following five steps. The first step is to analyse the current situation of the research system with regard to the challenges. The second step in the analysis aims at an evidence-based assessment of the strengths and weaknesses with regard to the challenges. The third step is to analyse recent changes in policy and governance in perspective of the results of the strengths and weaknesses part of the analysis. The fourth step focuses on an evidence-based assessment of policy-related risks and opportunities with respect to the analysis under 3) and in the light of Integrated Guideline 7; and finally the fifth step aims at a brief analysis of the role of the ERA dimension.

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory[1] and other important publicly-available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Where appropriate, quantitative information and indicators are used to support the analysis. Following an introductory overview of the structure of the national research system and its governance, Chapter 2 analyses resource mobilisation for R&D. Chapter 3 looks at knowledge demand. Chapter 4 focuses on knowledge production and Chapter 5 deals with knowledge circulation. Each of these chapters contains five main subsections corresponding to the five steps of the analysis. The report concludes in Chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and risks across all four domains in the light of the Lisbon Strategy's goals.

[1] ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS. The ERAWATCH Research Inventory is accessible at http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home. Other sources are explicitly referenced.

1.2 Overview of the structure of the national research system and its governance

Introduction

Denmark is a small country with only 1.1% of the total EU27 population. GDP per capita is 68% above EU27 average in 2007, the annual average growth rate of GDP for 2000–2005 is 3.7%, the same level as the EU27 (European Commission, 2008). The unemployment rate is low with only 4.8% in 2007 versus 7.1% on EU27 (data retrieved from Eurostat July 2008). The Danish research system receives a high level of funding compared to EU27 (Table 1). In 2006, Denmark's GERD was 2.43%, well above the average of the EU27 of 1.84%, but still considerably lower than the two other Nordic EU member states, Sweden (3.82% of GDP) and Finland (3.45%) (Eurostat, 2008). In recent years GDP has grown much faster than the R&D expenditure and consequently the percentage of GDP spent on R&D has declined from 2.58% in 2003 to 2.43% in 2006. The absolute volume of GERD however has increased since 2003 at an average annual growth rate of 3.02%. Especially high are the shares for gross domestic expenditure on R&D for the business sector (€3.560b or 1.62% of GDP, 1.17% in EU27) and the higher education sector (0.63% in Denmark, 0.4% in EU27). The R&D expenditure of the public sector in total amounted to €1.756b or a share of 0.79% of the GDP (Eurostat, 2008).

Main actors and institutions in research governance

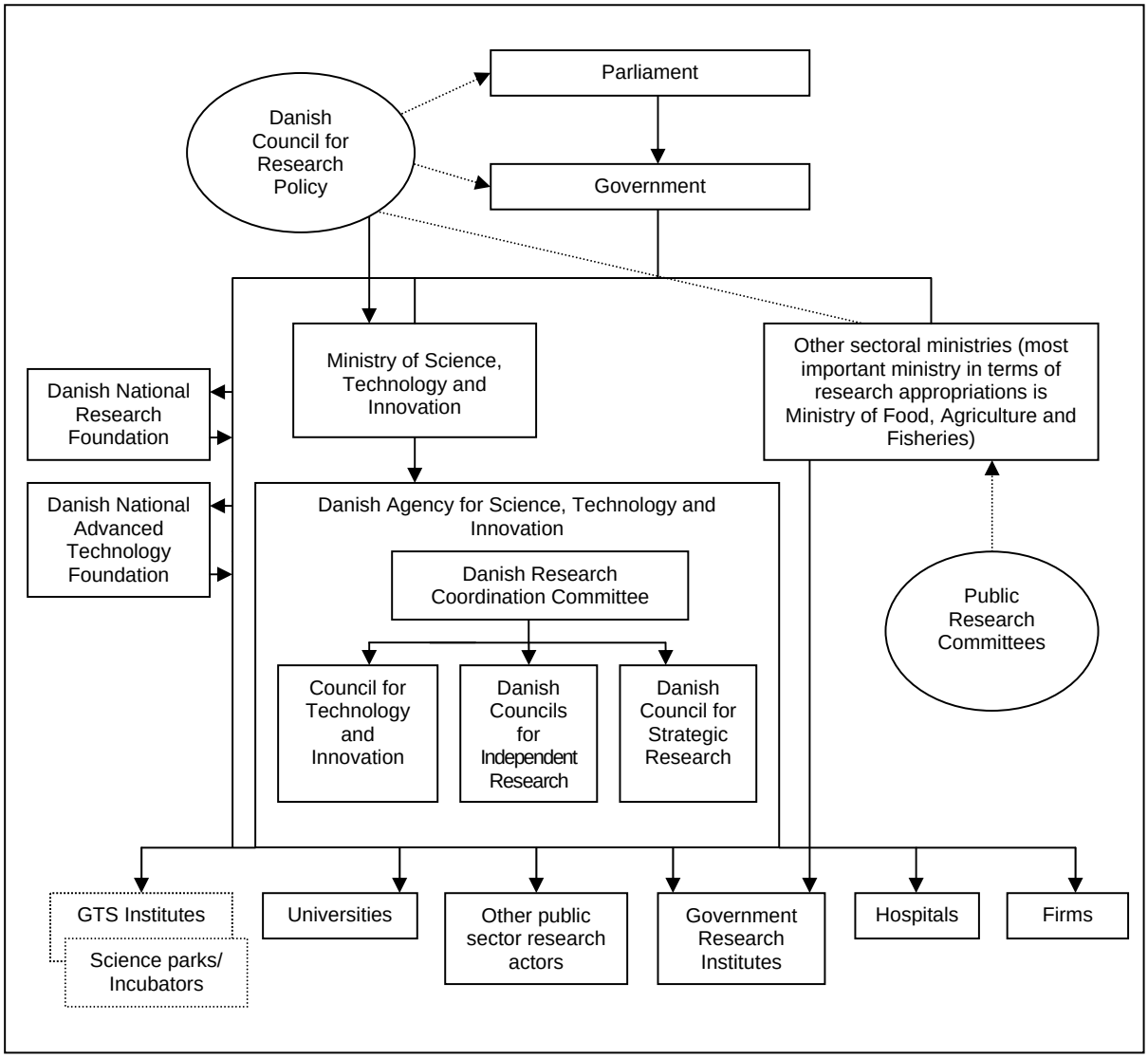
Figure 1 portrays the Danish research system and its governance. Three levels are identified in the chart: policy level (parliament, government and ministry level); implementation of the policies in agencies, research councils, research foundations and other R&D policy bodies; and organisations engaged in R&D. An important issue is the coordination between the Ministry of Science, Technology and Innovation, the Danish Agency for Science, Technology and Innovation, the research councils, the two research foundations and the R&D instruments of the sectoral ministries, such as the R&D programme of the Ministry of Food, Agriculture and Fisheries, and the Energy Technology Development and Demonstration Programme under the Ministry of Climate and Energy.

The main current research governance system is divided into two subsystems. The advisory part, the Danish Council for Research Policy, was established in 2004. The funding part consists of two research councils. The Council for Independent Research is the umbrella organisation for five research councils and supports research projects ideas based on researchers' initiatives and priorities. The other funding subsystem consists of the Council for Strategic Research which supports strategic and policy-oriented research. Other notable changes in the Danish research governance structure during recent years include the establishment of the Council for Technology and Innovation, and the Danish National Advanced Technology Foundation, oriented towards commercialisation of research results. In addition there is also the Danish National Research Foundation, specialised in funding basic science.

The Role of Regions in Research Governance

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

Figure 1: Danish R&D system and its governance



Source: ERAWATCH Research Inventory 2008, Structure of the Research System

The main research performer groups

The *business enterprise sector* is the main R&D performer, funded mainly by the business sector and performing 68% of the total R&D in 2005 (Tables 1 and 2). In 2005, *Danish industry* invested 1.67% of GDP in R&D expenditure. This decreased slightly in 2006 to 1.62%.

The main *public research performers* are now concentrated in the *university system,* performing 25% of the total R&D in 2005. More than 60% of publicly supported R&D takes place there (Tables 1 and 2). As a result of the latest reform of the Danish system of public research organisations implemented in 2007, there are now mainly five universities, combining existing universities and most of the public sector institutes: Copenhagen University, Aarhus University, the Technical University of Denmark, University of Southern Denmark and Aalborg University.

The *government sector,* performing 6% of the total R&D in 2005, has been changed dramatically due to the merger of the majority of the research institutes with the universities in January 2007. Before 2007, there were 15 government research institutes, i.e. public institutes financed by Danish ministries, including institutes for

food, the environment, space exploration and social research. In 2005, these institutes received €201m (DKK1.5b) in public funding, out of which €102.5m (DKK764m) was for research.

In 2006 there were seven accredited technological service institutes in Denmark (GTS-net). The GTS-net is doing applied technologically-oriented R&D for Danish industry. 81% of GTS funding is market-based, 11% is publicly funded. Public support for GTS institutes was €33.13m (DKK247m) in 2005. The government will now allow other institutions to apply for some of this funding.

Table 1: Total intramural R&D expenditure (GERD) by sectors of performance in EU27 and Denmark 2006. In million euro and per cent.

	EU27		DK	
	M€	% of GDP	M€	% of GDP
All sectors	213 127.425	1.84	5 348.554	2.43
Business enterprise sector	135 716.183	1.17	3 560.149	1.62
Government sector	28 777.258	0.25	360.133	0.16
Higher education sector	46 665.811	0.4	1 396.016	0.63
Private non-profit sector	1 968.173	0.02	32.253	0.01

Source: Eurostat

Table 2: Total intramural R&D expenditure (GERD) by sectors of performance and source of funding in Denmark. In Million €. 2001, 2005.

		Source of funding							
		All sectors		Business enterprise sector		Government sector		Abroad	
		2001	2005	2001	2005	2001	2005	2001	2005
Sectors of performance	All sectors	4 278.4	5 093.9	2 627.4	3 032.2	1 206.8	1 405.0	332.2	512.9
	Business enterprise sector	2 934.2	3 476.8	2 565.5	2 990.3	89.6	84.2	270.0	396.7
	Government sector	503.5	328.6	37.3	6.7	392.0	264.5	25.6	36.9
	Higher education sector	809.2	1 254.4	24.3	29.5	714.0	1 044.1	34.9	74.9
	Private non-profit sector	31.6	34.1	0.4	5.6	11.2	12.1	1.8	4.4

Source: Eurostat

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research system. Its actors have to ensure and justify that adequate financial and human resources are most appropriately mobilised for the operation of the system. A central issue in this domain is the long-term horizon required until the effects of the mobilisation become visible. Increasing system performance in this domain is a focal point of the Lisbon Strategy, with the Barcelona EU overall objective of a R&D investment equivalent to 3% of GDP and an appropriate public/private split as

orientation, but also highlighting the need for a sufficient supply of qualified researchers.

Four different challenges in the domain of resource mobilisation for research which need to be addressed appropriately by the research system can be distinguished:

- Justifying resource provision for research activities;
- Securing long term investment in research;
- Dealing with uncertain returns and other barriers to private R&D investment; and
- Providing qualified human resources.

2.1 Analysis of system characteristics

2.1.1. Justifying resource provision for research activities

Rationales for support of research

The main driver of R&D policy in Denmark is the expectation that R&D will contribute to ensuring that Denmark will become a leading knowledge-based society, a leading entrepreneurial society and the most competitive society in the world.

The National Reform Programme (October 2005) addresses the challenges of the knowledge society and concludes with a number of goals. The Programme confirms the 3% objective: public R&D investments should reach 1% of GDP in 2010 and private investment in R&D should reach 2% of GDP in the same year. The programme aims at improved interaction with public research, doubling the number of PhDs and increasing the numbers of students, improving the primary and lower-secondary school system, ensuring continued improvements in the framework conditions for innovation and entrepreneurs, and appropriating €1.34b for increased efforts in research, innovation, entrepreneurship and education until 2010.

The March 2006 Globalisation Strategy has a focus on education, research, entrepreneurship and innovation, turning R&D into one of the main pillars of government policy. The document repeats the Lisbon 3% objective, arguing that public R&D expenditure should reach 1% of GDP by 2010. The Globalisation Strategy has also discussed the links between ERA and Danish R&D policies. The Strategy concluded that it should be easier for Danish companies and research institutions to take part in the EU Framework Programme. By the use of information and R&D funding, larger Danish companies are to be encouraged to take part in EU projects, preferably in co-operation with SMEs.

Importance of R&D

The Danish government has a strong emphasis on securing the necessary financial support for the Danish research system. The share of the total government budget appropriations or outlays on R&D (GBAORD) of the total government expenditure has increased from 1.35% in 2005 to 1.41% in 2006 and 1.55% in 2007, while the share for EU27 still has been higher with 1.62% in 2006 (Eurostat). An analysis of the historical development of GBAORD reveals however, that the average annual growth rate (AAGR) for GBAORD has declined. In the period 1995–2000 this was 7.6%, and in the period 2000–2005, just 2.3% (European Commission, 2008).

Role of public debate to enhance public understanding of science

Public debate on the role of science, on research policy in general, and on special fields of science, is present in the Danish media. Over the last years the restructuring of the Danish R&D system and especially the changes regarding the higher education institutions have been important issues in the public debate.

Government policy is oriented towards inclusion of stakeholders from industry and the academia in developing Danish research policy. The Globalisation Council has, for instance, members from Danish Industry, The Danish Labour Organisation, the Danish Trade and Service Organisation, the Central Organisation of Academics, and several others. Among relevant private agencies interested in research policy we find the Confederation of Danish Industries, the major enterprises, The Danish Federation of Small and Medium-Sized Enterprises, and The Danish Academy of Technical Sciences.

An important intermediary organisation for enhancing the public understanding of science is the Danish Board of Technology. The Board conducts technology assessments to generate debate in the target groups. Further, the Board launches projects offering an assessment of new technology. Special emphasis is placed on the interaction between technology, society and people. The Board of Technology publishes a range of publications to stimulate debate on technology. Public hearings on energy policy or foresight studies facilitate the public debate.

2.1.2. Securing long-term investment in research

Base financing of research

With the introduction of the Danish Universities Act in 1992 and the new University Act in 2003, Danish universities have been given freedom and responsibility to plan their own activities and long-term development. At the same time, a substantial part of the universities' financial base was transferred to direct productivity management in the form of performance measurement-based grants. Universities are obliged to sign development contracts with the Ministry of Science, Technology and Innovation.

The universities, the public research organisations and the hospitals obtain funding from the Ministry of Science, Technology and Innovation distributed on so-called basic and programme financing. In 2006, the higher education institutions received two third of their total funding by basic allowances (€936m), while the sector research institutes received just half of the funding by that channel (€135m) and the private non-profit institutions about one third of the total funding (€12m) (Dansk Center for Forskningsanalyse and Danmarks Statistik, 2008). The government has announced that a greater part of the university funds in the future will be allocated through competition rather than as basic funds. Since January 2008, basic funding of universities is based on an evaluation of the institution’s ability to reach objectives given in a development contract (i.e. the funding contract between the university and the ministry).

In 2006, R&D at higher education institutions (HEI) received the highest amount of funding (€1,404m), while the public research organisations (PRO) received much lower R&D support (€272m) (Dansk Center for Forskningsanalyse and Danmarks Statistik, 2008). Analysing the development of R&D investments from 1997 to 2006 for HEIs and PROs, an increase for the HEIs can be seen and a decrease for the PROs (Forskning og udviklingsarbejde i den offentlige sektor. Forskningsstatistik

2006, Table 34). The R&D investments for HEIs have increased by more than 50 per cent, from about €900m in 1997 to about €1404m in 2006. This increase is based on an increase of running expenses, investment expenses halved (from €77m to €37m). The R&D investments for the PROs decreased from €435m in 1997, to €356m in 2006. Here the decrease occurred in both running and investment expenses.

The low level of infrastructure investments can be seen as critical, both for HEIs and PROs. The main reason for the high running costs is probably the high cost level for permanent staff.

Long-term financing of research

In the Globalisation Strategy from 2006 the Danish government declared that half of public R&D funding is to be competitive by 2010. Moreover, this funding is to cover all costs, including overheads. On the other hand, the Globalisation Strategy has also led to an increase of public spending on R&D. In 2006, the Globalisation Fund was introduced for increased investments in education, research, innovation, entrepreneurship and adult vocational training. The fund has been earmarked based on the "Welfare agreement" between the government and the political parties in the Parliament. It will gradually increase to €1.3b in 2012. This is an important new element of the current Danish multi-annual R&D budget planning.

Use of European funding and shared infrastructure facilities

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

For the period 2000–2006, Denmark allocated almost €932m derived from European Structural Funds. Denmark benefits from Objective 2 of the structural funds – development of regions, business, skills and technical assistance. In addition to regional actions under the Objective 2 programme, and Denmark benefits from Objective 3 measures for education, training and employment.

In the Danish National Strategic Reference Framework the government describes how and in which priority areas it intends to use the structural funds for the period 2007–2013 (Erhvervs- og Byggestyrelsen, 2006). Regarding expenditure on research, the government declares that basic research activities will not receive financial support from the structural funds. However, SF investments will be made available for research where this can be used directly, among other things for the purpose of the improvement of transfer of knowledge. The focus is primarily on the interaction between research and innovation. Denmark has launched an operational programme: 'Innovation and Knowledge', which will receive €255m from the European Regional Development Fund and a matching contribution from the Danish government. The Innovation and Knowledge programme has following core targets: development of human resources, (i.e. improving availability of research-based supplementary training), innovation (promoting interaction between academia and business/industry community, recruiting better qualified staff to enterprises), use of

new technology (ICT) and entrepreneurship (i.e. encouraging spin-offs from academia, creating more incubators).

In 2004, the Danish Ministry of Science, Technology and Innovation asked the Danish Council for Strategic Research to survey existing research infrastructures and to give an assessment of the need for access to new national and international research infrastructures (Danish Council for Strategic Research, 2004). The report listed three European research infrastructures:

- European Research Observatory for the Humanities and Social Sciences (EROHS)
- European X-ray Free Electron Laser (XFEL)
- European Spallation Source (ESS) – Denmark has expressed interest in co-hosting ESS with Sweden in Lund, but the final decision on the location of ESS is not made yet. The other candidate is either Bilbao in Spain or Debrecen in Hungary.

Denmark is represented in the European Strategy Forum on Research Infrastructures (ESFRI) and has expressed interest in participating in twelve of the ESFRI projects (NordForsk, 2008).

When analysing the financial contribution of the EUFP6 to research infrastructures Denmark received a much lower share as the EUFP6 in total (DASTI, 2008a).

2.1.3. Dealing with uncertain returns and other barriers to business R&D investment

Importance of large firms and multinationals in business R&D

In 2005, Danish industry invested 1.67% of GDP in R&D. Because GDP has grown much faster than the Business R&D expenditure, this share declined in 2006 slightly to 1.65% (Eurostat and Danmarks Statistik, 2008). However, the absolute volume of BERD has increased every year since 2004, and was at €3.628b in 2006 (Eurostat, 2008). According to the Danish Centre for Research Analysis (Indikatorer for Dansk Forskning og Innovation, 2005) 17% of Danish companies undertook R&D in 2003. Another 11% reported innovation activity without R&D. Among larger companies (250+ employees) more than 50% undertook R&D. Danish industry funds most of its own R&D.

Just 10 enterprises accounted for about one third of the total business enterprise intramural R&D expenditure (BERD) in 2003. The seven most important were: Novo Nordisk (Pharma & Biotech), Lundbeck (Pharma & Biotech), Novozymes (Chemicals), Danfoss (Engineering & Machinery), Danisco (Food), Chr. Hansen (Pharma & Biotech) and Grundfos (Engineering & Machinery).

An analysis of the size distribution of Danish companies financing own R&D in 2005 reveals that R&D investments are still concentrated in the largest companies: 62% of the business enterprise R&D expenditures are located in the group of the largest companies with at least 500. In the last report on Danish business R&D in 2006, (Danmarks Statistik, 2008), the companies were grouped in four classes: In the first group (1–49 employees) 2604 companies account for 14% of total expenditure; in the second group (50–249 employees) are 519 companies with 16% of the expenditure; in the third group (250–999 employees) 163 companies with 22% of R&D

expenditure, and in the fourth group (at least 1000 employees) just 50 companies but accounting for 48% of all R&D expenditures. We conclude that concentration of business R&D expenditures is still high, as in most other European countries. One per cent of the firms account for almost half of all R&D expenditures. But compared to the two other Nordic countries, the share of R&D expenditures by SMEs is quite high: 29% of R&D expenditure in 2005 came from SMEs (1–249 employees) in Denmark, but just 20% in Finland and Sweden. The strong position of SMEs in Denmark is more similar to the situation in Belgium, but there the concentration in the largest companies is minor. We conclude that in spite of the high concentration of R&D expenditures in larger firms, R&D activities in SMEs are important.

Venture capital

After a period of very low venture capital investment in the 1990s, according to data from Eurostat and the European Innovation Scoreboard, Denmark has had very high scores in early-stage venture capital since 2001, especially in 2004. The level of early-stage investments was at 0.051% of GDP in 2005, second in Europe after Sweden (Eurostat, 2008). The venture capital at expansion and replacement stage was highest in Denmark in 2005 with 0.35% of GDP.

The Business Development Finance (*Vækstfonden*) is a Danish government-backed investment fund. The fund was established in connection with selling off a public enterprise (public life insurance) in 1991. Following a national debate, the capital earned from this sale was to be used to improve the capital market for research and development activities of Danish SMEs. The main thematic focus of the fund is life science/med-tech as well as high-tech firms. The fund also facilitates access to international venture capital. The fund has co-financed growth in more than 3,500 Danish companies since 1992, with a total of investment of €871m (http://www.vaekstfonden.dk).

With the *Væksfonden* Denmark seems to have got a policy measure able to attract higher level of research intensive venture capital in the country.

Government incentives for private R&D

The Danish business sector is rather R&D intensive compared with other countries. The share of intramural expenses for business R&D is far above the EU27 level and above the OECD average, only few countries in Europe have a higher share: Sweden, Finland and Germany (Danmarks Statistik, 2008).

The share of R&D performed in the business sector directly financed by government sources is rather low: in 2005 went 6% (€84.2m) of the total government funding to the business sector (Source: Eurostat

Table 2), while 2% of the R&D performed in the business sector was funded by the government. The share of the total government funding to the business sector has even decreased since 2001 (7% or €89.6m). In 2005 enterprises with 250-999 employees received 62% (€52.3m) of the public funding, while small enterprises with less than 50 employees received just 4% (€3.6m) (Dansk Center for Forskningsanalyse, 2006a). An explanation for the decreasing share could be the increase of the GDP, but the absolute numbers of the government funding decreased as well, not just the share. As in many other OECD countries the government is addressing this challenge by focussing especially on R&D collaboration between universities and business enterprises (see for example projects funded by the Danish National Advanced Technology Foundation).

As regards R&D tax incentives schemes Denmark had in 2005 R&D allowances (deduction of expenses from taxable income) between 100 and 150% (CREST, 2006). The tax scheme 150 % Tax Deduction on Certain Research Expenditures focused on SMEs which could additionally to the deduction of costs that the SMEs paid to the public research institutions in a collaborative research project also apply for a deduction of own labour costs related to collaborative projects. Annually there were only €3.35m in foregone tax revenues per year. This experimental tax scheme had however a time-limit and was terminated after 2006.

Hence, one may conclude that Denmark is one of the Member States in EU with few and decreasing in importance government incentives (in particular tax incentives) for private R&D, but there are new policy measures that are meant to stimulate collaborative R&D between SMEs and public research institutions (see Chapter 5.3 in this report). The Danish government has the goal that business R&D expenditures shall reach the 2% of GDP goal in 2010. According to the latest statistics (May 2008), this goal will not be easy to reach. After a peak of 1.78% in 2003 the share went continuously down: 2004: 1.69%, 2005:1.67% and 2006: 1.65% (Eurostat).

2.1.4. Providing qualified human resources

Providing high quality postgraduate education

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

Denmark has a high share of human resources in science and technology: about 37% of the population (15-74 years old) compared to 26% for EU27 in 2006. The share of doctorate students in science and technology fields is at 0.27%, as a percentage of the population 20-29 year old (Eurostat, 2008). This is low compared to other European countries, such as Austria (0.47%), Finland (1.33%), Sweden (0.87%) or the UK (0.54%).

The enrolment of students to the public higher education institutions has continuously increased over the last years, but the latest enrolment numbers for Danish universities in 2008 show a decrease of 12 percent. This has been addressed in the public debate as critical for providing the future human resources for R&D. The main reasons for this decrease are a tight labour market and tougher requirements for admission of students to university studies.

Several measures concerning *improved research training* have been developed. In 2004, the Danish government decided to increase the allocations for research training in order to increase the annual intake from 1000 to 1500 PhD students in 2006. This goal could be achieved: In 2006, 1500 PhD students were admitted, while in 2002 there were 1110 PhD students. According to the second progress report on the national reform programme (2007) PhD programmes are now to take place at graduate schools with academic environments of an appropriate size. The government will allocate considerable funds to increase the number of PhD students. The number is to be increased gradually to reach 2400 PhD students in 2010. The increase in the number of PhD students is primarily to be in the fields of natural science, technical science, IT and health science.

The evaluation report on PhD Education in Denmark (2006) pointed out that there is a capacity for an expansion of PhD training in the Danish university system, but the panel was critical of the structures under which graduate schools have been organised. The system of graduate schools is too varied in kind and quality according to the report. The panel recommended that incentives for continued quality enhancement be secured through three main funding streams (p. 12):

- faculty endowments or core grants;
- competitive funding;
- funding for applied PhD research.

Securing career perspectives for researchers

The employment of highly educated labour is one of the most important channels for disseminating knowledge from public research institutions to private firms. Today, about 50 per cent of all graduates are employed in private firms. The employment conditions in the private sector for researchers have been addressed by the *Industrial PhD Initiative* (see chapter 5.1.3).

Attractiveness for foreign researchers

The recent OECD Survey on Denmark emphasized that high-skilled migration patterns may be problematic: “Even if small in size, there is a clear brain drain with high-skilled Danes moving abroad while, on the other hand, Denmark attracts relatively few high-skilled immigrants compared with English speaking countries. Moreover, the high-skilled immigrants who come have considerably lower employment rates than their native peers. This could reflect that language barriers matter more in high-skilled jobs... The fact that underemployment is so clear for immigrants across all skill levels could also indicate that discrimination plays a role (OECD, 2007e). The top countries for migration from Denmark are the two other Scandinavian countries, Sweden and Norway, English speaking countries, such as USA, Canada, UK and Australia and Germany (OECD, 2008). Immigration to Denmark from the Scandinavian countries is at the top, but is below the emigration numbers to these countries.

Because of the above-mentioned shortage of a highly skilled workforce and for improving the capabilities of the best Danish research groups, in 1992 the Danish government introduced a taxation scheme specific to researchers and key employees who took up residence in Denmark for a limited period of time. In 2000, this scheme was revised. The scheme implies that well-paid employees and researchers recruited abroad have access, subject to a number of conditions, to choose – for a period of not more than 36 months – taxation at the rate of 25% of the remuneration with no deductions - instead of the normal income tax. The purpose of the scheme is to enable Danish industries and Danish research institutions to attract and retain foreign research and development employees. However, permanent residence permits are more difficult to obtain and a number of restrictions pose growing barriers for highly skilled workers from outside the EU.

The Danish National Research Foundation commenced a new initiative in 2005 to support highly qualified and internationally recognised visiting researchers from all scientific fields. The visiting researchers shall develop their research during a stay of at least one year and up to a maximum of five years in collaboration with researchers at Danish universities. It will also be possible for one or two young assistant

researchers to be included. The goal of the programme is to strengthen the international orientation of Danish basic research. The Foundation wants to strengthen well-established research groups at an international level by attracting expertise of high scientific quality from abroad.

2.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Danish research system in terms of resource mobilisation for R&D can be summarised a follows:

Danish R&D policy is characterised by a high commitment to long-term planning of public R&D and inclusion of stakeholders from industry and academia in developing Danish research policy. A main issue of these long-term planning processes is to secure the needed financial resources. An acknowledged challenge for the future is to provide qualified human resources for R&D and innovation.

Main strengths	Main weaknesses
• Long-term planning for development of public R&D expenditure with focus on 1% target • Government policy oriented towards inclusion of stakeholders from industry and the academia in developing Danish research policy and securing the resource mobilisation • High share of R&D in business sector • High venture capital investments • Policy consensus on importance of R&D for Danish economy	• Relatively low number of PhDs • Varying quality of PhD education • Business R&D 2% target will not be reached by 2010. • Purchase of R&D from higher education institutions (HEI) by industry is limited.

2.3 Analysis of recent policy changes

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

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

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

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

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

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

Challenges	Main policy changes
Justifying resource provision for research activities	• Increased public R&D expenditures in government budget
Securing long term investments in research	• Introduction of two new competitive funding pools for universities (Infrastructure Pool and UNIK)
Dealing with uncertain returns and other barriers to business R&D investments	•
Providing qualified human resources	• Introduction of 12 elite PhD courses at Danish universities • Plans to revise researcher taxation scheme

2.4 Assessment of policy opportunities and risks

The main opportunities and risks for resource mobilisation in Denmark arising from recent policy responses include:

Policy opportunities in resources mobilisation arise from the combination of policy responses to policy weakness and strengths. This becomes especially clear with the policy focus on the improved infrastructure of universities, access to investment capital for universities and improved PhD education.

Main policy opportunities	Main policy-related risks
• According to Globalisation Strategy 50% of public R&D funding shall be competitive by 2010, covering all costs, overheads included • Long-term funding for universities based on Welfare agreement, and introduction of new funds providing access to investment capital and improved infrastructure • Policy focus on increasing number of PhDs and improved PhD education • Policy measures to attract foreign researchers and PhD students • Globalisation Strategy which combines a boost to R&D and higher education with a tri-party agreement on the financing of life-long learning	• Limitations for immigration may endanger attraction of foreign researchers • Increased competitive funding may have a negative impact on academic freedom • Increased competitive funding leads to an extra burden for researchers who have to apply for competitive funding • Policy decision to abandon tax incentives for business R&D in 2006

2.5 Summary of the role of the ERA dimension

The European funding channels contribute only in a modest degree to an appropriate resource mobilisation in Denmark. According to the ERA-NET Review 2006, Denmark participated in 28 full ERA-Nets or 39% of all ERA-Nets, and according to a recent report on the Danish participation under the EUFP6, the share of funding from

the EU Framework programmes for Danish project participation is decreasing (DASTI, 2008a).

The participation in the Marie Curie Actions is at the same level as for all participating countries in the EUFP6, about 10% of all EUFP6 financial contributions go to these actions both for Denmark and in total (DASTI, 2008a).

3 - Knowledge demand

The purpose of this chapter is to analyse and assess how research-related knowledge demand contributes to the performance of the national research system. It is concerned with the mechanisms to determine the most appropriate use of and targets for resource inputs.

The setting and implementation of priorities can lead to co-ordination problems. Monitoring processes identifying the extent to which demand requirements are met are necessary but difficult to implement effectively due to the characteristics of knowledge outputs. Main challenges in this domain are therefore:

- Identifying the drivers of knowledge demand;
- Co-ordinating and channelling knowledge demands; and
- Monitoring demand fulfilment.

Responses to these challenges are of key importance for the more effective and efficient public expenditure on R&D targeted in IG7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

3.1.1. Identifying the drivers of knowledge demand

Structure of knowledge demand

As has been shown in various analyses of the Danish innovation system (Forskningsstatistik, 2006; ERAWATCH, 2006; Key figures of science, technology and innovation, 2007; Eurostat, 2008; INNO TrendChart Denmark, 2007; Kallerud, 2008) the Danish innovation system is knowledge-intensive and, therefore, private enterprises, government and the civic sectors generate specific types of R&D knowledge demands.

R&D funded by the business sector provides an indication of the size of R&D-based knowledge demand originated from this sector. It has increased significantly from €915m in 1991 to €3,032m in 2005. The business sector funds almost entirely R&D within its own sector (98.6%); only about 1%of total R&D business funding in 2005 went to R&D in the higher education sector (Eurostat, 2008).

R&D funded by government provides an indication of the size of R&D-based knowledge demand originated from the policy needs and societal needs of the Danish society. R&D funded by government can be divided in two parts; the first part, the “General university funds - GUF”, provides an indication of to what extend the Danish society is willing to finance free university research; the other part, the “Direct government funding” provides an indication of the competitive and strategic research

government funding in Denmark. *The government R&D funding* has doubled from 1991 (€707m) to 2005 (€1405m) whereof the GUF part has tripled in the same period (from €275m in 1991 to €755m in 2005).

R&D funded from abroad provides an indication of the knowledge demand from abroad to national R&D services. This type of R&D-based knowledge demand has increased considerably from €78m in 1991 to €513m in 2005 whereof the bulk of this increase originates from foreign enterprises' purchase of R&D from Danish business enterprises. Of course, EC-funding is also an important funding source from abroad (€75m in 2005).

In 2006, 46% of public R&D expenditure went to *basic research*, 40% to *applied research* and 14% to *development tasks*. These proportions have been stable since 2003 (Nyt fra Danmarks Statistik, Nr. 228).

We can thus conclude that the demand for Danish R&D has significantly increased from all main knowledge demand drivers in the Danish society. However, Danish business enterprise funding of Danish business R&D and government funding of GUF are the two types of R&D demand which increased mostly between 1991 and 2005.

Drivers of business knowledge demand

One can obtain a more detailed picture of the knowledge demand originated by the business enterprise sector by investigating business enterprise R&D funding patterns by economic sector and by firm size.

The Danish economy is dominated by SMEs and has few large enterprises. Economic growth has been achieved by low-technology branches such as food, furniture, textiles and toy (Kallerud, 2008) and knowledge-intensive services, such as software consultancy and supply and engineering consultancy. However, as it has been highlighted in the last report on Key figures of science, technology and innovation in 2007, pharmaceuticals and computer and related services are the main sectors behind the strong increase in business expenditure on R&D (European Commission, 2007). This is also the case in Denmark – here we find manufacture of pharmaceuticals & medicinal chemistries and software consultancy and supply as 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 food sector, pharmaceuticals, instruments and service sector (2006).

It is important to mention the development of manufacturing industry, especially the R&D expenditure by high-tech and the low-tech enterprises (Table 3). 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, thus, a policy challenge to stimulate investments in R&D by low-tech sectors.

Table 3: R&D expenditure in selected industry branches. 2003-2006. In Million €, 2006 prices

	2003	2004	2005	2006
Manufacturing	2 218	2 288	2 272	2 373
… High-tech	1 848	1 932	1 969	2 094
… Medium tech	81	91	87	96
… Low tech	289	265	216	183
ICT services	965	887	1 048	1 053

Source: Danmarks Statistik 2008, Table 3B

Drivers of societal knowledge demand

One can obtain a more detailed picture of the knowledge demand originated by the government sector – which into a large extend represents Danish societal needs – by investigating how government budget appropriations or outlays on R&D (GBAORD) are distributed by 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, with 44% of the total GBAORD in 2006 (see Table 6). This is also the main objective for EU27 or EU15 (Wilén, 2008), but the Danish share is still much higher and has increased from 39% in 1997 to 44% in 2007. As argued above GUF-funding is a first approximation of the size of non-targeted academic research. This type of research seems, therefore, to be increasing in Denmark, though it is expected that a larger part of GUF-funds will be transferred to targeted competitive R&D funds for higher education institutions.

The second largest socio-economic objective was the "Non-oriented research", with 19% of the total GBAORD, also higher than the respective shares for the EU15 or EU27.

Relative to the EU15 and to EU27 the Danish government seems to provide more GBAORD-funds for health, agriculture and social structures and relationships and less funding to industry production and defence

Government budget appropriations or outlays on R&D for *human health* have a high priority in the current Danish R&D system increasing from 1.6% of GBAORD in 1997, to 8.5% in 2006 (Table 6). Here Denmark has followed the European trend. EU15 appropriations on health-related R&D were at 5.9% in 1997 and 7.4% in 2006. This specialisation is consistent with the business specialisation in manufacturing of pharmaceuticals and medicinal chemicals.

Table 4: Total GBAORD by socio-economic objectives. 2006. In per cent.

Nomenclature for the analysis and comparison of scientific programmes and budgets	EU27 %	DK %
Exploration and exploitation of the earth	2	1
Infrastructure and general planning of land-use	2	1
Control and care of the environment	3	2
Protection and improvement of human health	7	8
Production, distribution and rational utilization of energy	3	2
Agricultural production and technology	3	6
Industrial production, and technology	10	6
Social structures and relationships	3	6
Exploration and exploitation of space	5	2
Research financed from general university funds (GUF)	30	44
Non-oriented research	17	19
Other civil research	2	1
Defence	13	1
Total appropriations in million €	***87,839.5***	***1,587.1***

Source: Eurostat

Government budget appropriations or outlays on R&D for *agricultural production and technology* are also very important for Denmark, but here we can observe a reversal in the trend after 2000 when looking at the share of the total GBAORD. This increased from 7.7% in 1997 to 11.2% in 2000, but fell to 5.6% in 2006. The respective share for EU15 has been stable at around 3% (see Table 6). This specialisation is somehow compatible with the business specialisation in manufacturing of agricultural and forestry machinery, and manufacturing of machinery for food, beverage and tobacco processing.

Government budget appropriations or outlays on R&D for *industry production and technology* are quite important for Denmark, but also here we can observe a declining trend – from 10.4% in 1997 to 8.4% in 2001 and 6.4% in 2006, while the importance for EU15 is slightly increasing – from 9.2% in 1997 to 10.3% in 2006 (see Table 6). The business specialisation shows also a declining tendency as can be seen in the EW Specialisation study.

Analysing the government budget appropriations or outlays on R&D for *energy,* a decline since 1997 is observed – from 2.6% in 1997 to 2.1% in 2006. A similar trend can be found for EU15 – from 3.3% in 1997 to 2.6% in 2006. It is difficult to identify the industrial specialisation in energy related industry sectors, but as far as is known, the production of energy technology and equipment is important: the export of energy technology and equipment has increased from 5.2% of the total industrial exports in 1996, to 9.2% in 2007 (for details, see *Energistyrelsen og Energibranchen, 2008*).

The last sectoral specialisation to be mentioned here is R&D expenditure for *defence*. This objective is almost absent in the Danish R&D system, and therefore differences with other European countries such as the UK, France, Sweden and Spain (Wilén, 2008) are especially visible in this field. Social issues, on the other hand, have much higher importance (6.5% of total GBAORD) than in EU15 or EU27 (both 3%) (see Table 4).

Furthermore, societal knowledge demands are articulated in the multiple interactions taken place within R&D policy organisations, such as the different programme committees in the Danish Council for Strategic Research or the Danish National

Advanced Technology Foundation. The programme committees in the Danish Council for Strategic Research regularly launch calls for projects in specified thematic fields: thematic priorities in 2006 were sustainable energy production and use of energy, relations between food, nutrition and health and interdisciplinary application of nanotechnology, biotechnology and ICT. The Council has also identified Innovation Accelerating Research Platforms; these are areas where Denmark has internationally recognised researchers, competitive business clusters and/or a need for research-based solutions. Priority areas are food, health, renewable energy and nano-, bio- and information technologies – that is a mixture of "new" activities and research for existing industries. There exist a multitude of funding possibilities for researchers, but it may be difficult to keep an overview and to obtain long-term funding for larger projects.

Drivers of knowledge demands that are intrinsic to the research sector

HERD is relatively high in Denmark as mentioned previously. Basic funding for universities is used for funding internal initiated research at the universities.

The Danish Councils for Independent Research (DCIR) consist of several sub-councils and they fund specific research activities, within all scientific areas, that are based on the researcher's own initiatives and that improve the quality and internationalisation of Danish research. In 2007, the DCIR funded researcher-initiated research for more than €134m and a total of 922 projects.

From figure 4 in the ERAWATCH Specialisation report it can be seen that some changes occurred in the funding of scientific fields between 1993 and 2003. It is unclear whether these changes are the result of conscious policy priorities or reflect changes in the university intrinsic knowledge demand.

Processes for identifying the drivers of knowledge demand

The main routes used for the identification of knowledge demand from the perspective of policy makers are analytical studies, foresight exercises and various instruments of stakeholder involvement. Stakeholder involvement is especially well developed.

Foresight exercises have been used systematically for encouraging debate, raising awareness and mobilising discussions among key actor groups (Eerola, 2006). In the period 2001 to 2004, the Danish government carried out a Technological Foresight Pilot Programme. The aim of the programme was to carry out eight foresight studies in the three-year period, and to identify issues of strategic importance for science, technology, education, regulation, and innovation policy in these areas. The initiative conducted five foresight studies (including bio- and health care technology, ICT - pervasive computing, future green technologies, hygiene and nanotechnology) and in 2006 conducted four studies (including the ageing society, ICT - from soil to table, cognition and robots as well as mobile and wireless communication).

Some examples of Danish foresight exercises are the following.

- Danish Energy Foresight contributed to reformulation of the Government's energy policy and expenditures on energy-related R&D.
- Danish Green Technology Foresight initiated three more targeted foresight exercises.

- Nanotechnology Foresight contributed to political decisions concerning the focus areas of the recently (2005) established Danish National Advanced Technology Foundation.

As mentioned above, it seems that the Danish research system is capable of identifying and adapting the research system to meet societal, industrial and academic knowledge demands.

3.1.2. Co-ordinating and channelling knowledge demands

Co-ordination processes

The Ministry of Science, Technology and Innovation coordinates the policies for research and innovation (see Koch, 2008), and currently allocates approximately 75% of the government grants to research and innovation. Co-ordination between sectoral ministries is made on an informal basis at the initiative of the Ministry of Science, Technology and Innovation.

Below the ministerial level there is a system of research advisory and funding councils. The main advisory council, the Danish Council for Research Policy, was established in 2004 and is a relevant instrument for co-ordination of research policy issues. The Council advises the Minister for Science, Technology and Innovation on research policy, including framework conditions for research, research funding, large national and international research initiatives, development of the national research strategy, international research cooperation, and researcher education and recruitment.

The Danish Agency for Science, Technology and Innovation administers the funding that is earmarked for independent research and for thematically defined and politically prioritised research areas. The agency also functions as secretariat for the research councils and several committees.

To improve co-ordination further, and to assist in implementing legislation of the various current reforms, the Council for Technology and Innovation has been established. The council advises the minister about technology and innovation policy, and makes decisions in a number of specific grant affairs. The council has also the task of administering the initiatives given to the council by the minister, such as the GTS-system, the Industrial PhD initiative and the high-tech networks.

The programme commissions under the Council for Strategic Research coordinate the evaluation of project proposals with research programmes under other sectoral ministries.

The research advisory and funding system is coordinated by the Coordination Committee which has the responsibility of promoting co-ordination and co-operation between the research councils and between the research councils and the rest of the research and innovation system. The committee is a "consensus organ" that has no authoritative role vis-à-vis the research advisory system.

Co-ordination with EU and other European countries

As reported above, Denmark is not among the most active participants in the EU Framework programmes and the participation in the ERA-Nets is modest as well. Denmark participated in 28 full ERA-Nets or 39% of all ERA-Nets (Guy et al. 2006,

Table 4). In comparison, the other Nordic countries (Sweden, Finland, and Norway) participated in at least half of the ERA-NETs.

Denmark is actively participating in the Nordic research co-operation, both financial and in collaborative research projects. Nordic research co-operation involves Nordic research institutions, fixed-term research programmes, Nordic Centres of Excellence (NCoE), grant schemes and the co-ordination and planning of major infrastructure investments. The overall objective is to promote research of the highest possible international quality. The financial scope of this collaboration is not large, but the impact is considerable.

The Nordic Research Board was established in early 2005 to co-ordinate Nordic research. NordForsk has three roles: co-ordination, financing and policy advice. The objective of NordForsk's coordinating activities is to develop the Nordic Research and Innovation Area (NORIA) as a globally leading and attractive region for research and innovation.

3.1.3. Monitoring demand fulfilment

Evaluation of Danish research has become quite common during the 1990s. This includes both evaluations commissioned by research councils, parliament, government agencies and the Danish Council for Research Policy. Danish research evaluation has contributed to the further development of evaluation methods (see Foss Hansen, 2006, and Albaek & Rieper, 1999).

The Danish government makes extensive use of international benchmarking, including indicators produced by the OECD and the EU. The government has considered opinions expressed by consultative bodies, and some are internal reviews. However, the government has signalled that the quality of evaluations should be improved in the future. Recently, systematic attempts have been made to increase the role of evaluations. The use of indicators and benchmarking has played an important role in the work of the Globalisation Council. Furthermore, the government asks for a more systematic evaluation of all research programmes to ensure that allocation of funds is strictly related to quality. Finally, the research funding organisations are to ensure that evaluation methods are centrally developed in a systematic way, and that results and experiences are gathered and used.

We can distinguish between more systemic evaluations, evaluations of the implementation of new relevant laws and evaluations of certain organisations, research programmes or science fields. While the former are quite common in Denmark, the latter are more ad hoc and not undertaken regularly. Examples for systemic evaluations are the OECD evaluation of the Danish university sector in 2002 and the evaluation of PhD education in 2006.

3.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Danish research system in terms of knowledge demands can be summarised a follows:

In the Danish research system many efforts have been undertaken to make the public R&D base still more responsive to industrial and societal knowledge demands, such as, stakeholder involvement, foresight studies, systemic evaluations and co-ordination of research policy. However, there is a long tradition for non-oriented

research funding and general university funds are rather high, compared to the EU average.

Main strengths	Main weaknesses
• Unifying Research and Innovation policy under one ministry • Apparently good match between public and private knowledge demand drivers • Stakeholder involvement in priority setting and foresight exercises • Extensive use of international benchmarking and systemic evaluation • Participation in the Nordic research co-operation allows influence on prioritising of joint research activities • Danish Council for Research Policy is a relevant instrument for co-ordination of research policy • Research Coordination Committee allows co-ordination between the main research funding organisations	• Modest degree of participation in EUFP and ERA-NETS may weaken the influence on research priorities in the EU • Evaluation of specific R&D programmes often ad hoc and irregularly • A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge.

3.3 Analysis of recent policy changes

Stakeholder involvement has been central in the development of the Globalisation Strategy (2005) and in the continuation of this process. The Ministry of Science, Technology and Innovation organised a broad process that addressed the strategic knowledge demands for the Danish society. The process resulted in a catalogue of priorities for strategic research - Forsk2015 - and was published May 2008. All ministries and the research councils were included in this process and also a broad range of branch organisations.

The expert panel consisted of experts from universities, and representatives from private think-tanks and industry stakeholder organisations. The involvement of the user panel was based on a workshop with participants from industry stakeholder organisations, companies, representatives from regional authorities, public research organisations and others. In addition several hundred persons submitted proposals for research fields.

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

The stagnation for energy R&D in 2002/2003 had been addressed by the government. In 2007, the government has taken the initiative to double public investment in the RD&D in energy technology from €67m in 2006 to €134m in 2010 (Danish Government, 2007).

The evaluation and accountability culture of the Danish research policy system has been further developed by new initiatives, such as the recent report of the Strategic

Research Council on impact assessment of strategic research (2008) or the evaluation of the public service for inventors (2008), commissioned by DASTI.

Challenges	Main policy changes
• Fragmentation of public R&D funding	• Development of a catalogue of priorities for strategic research
• Need for further improvement of evaluation culture	• New initiatives for impact assessment of strategic research

3.4 Assessment of policy opportunities and risks

The main opportunities and risks for knowledge demands in Denmark arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

Main policy opportunities	Main policy-related risks
• Stakeholder involvement will ensure better match between research policy and user needs • Energy RD&D has been strengthened • Strengthening evaluation, benchmarking and accountability culture	• The identified strategic research areas may be too diverse for a small country as Denmark

3.5 Summary of the role of the ERA dimension

As has been reported before, the Danish participation in the EUFPs and the ERA-NETS is modest. However, it is possible to assess the match of knowledge demands between Denmark and the EUFP6 by comparing the shares of the financial contributions to the different knowledge areas (DASTI, 2008a). Danish R&D is much more active in several knowledge areas compared to EU27. These areas are:

- Life sciences, genomics and biotechnology for health;
- Food quality and safety;
- Sustainable development, global change and ecosystems, and here especially.

It seems that the knowledge demand profile of the Danish society does not coincide exactly with the knowledge and funding profile of the EUFP6. The areas of ICT, nanotechnology and aeronautics are topics of minor interest for Danish society compared to the thematic priorities of EUFP6, though recent national R&D policies prioritise areas such as nanotechnology and ICT.

4 - Knowledge production

The purpose of this chapter is to analyse and assess how the research system fulfils its fundamental role to create and develop excellent and useful scientific and technological knowledge. A response to knowledge demand has to balance two main generic challenges:

- On the one hand, ensuring knowledge quality and excellence is the basis for scientific and technological advance. It requires considerable prior knowledge accumulation and specialisation as well as openness to new scientific opportunities which often emerge at the frontiers of scientific disciplines. Quality assurance processes are here mainly the task of scientific actors due to the expertise required, but subject to corresponding institutional rigidities.
- On the other hand there is a high interest in producing new knowledge which is useful for economic and other problem-solving purposes. Spillovers, which are non-appropriable for economic knowledge producers as well as the lack of possibilities and incentives for scientific actors to link to societal demands, lead to a corresponding exploitability challenge.

Both challenges are addressed in the research-related Integrated Guideline and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1. Improving quality and excellence of knowledge production

The main knowledge producers in the Danish R&D system are the universities; in addition there are also some government research institutes and a network of private-non-profit R&D organisations.

Ensuring academic knowledge quality

In 2002, the Danish authorities asked the OECD to evaluate the Danish university sector. The OECD expert panel concluded that the research quality of Danish universities is at a high level, despite the rather limited funding to university research. The panel gave the following recommendations based on the evaluation:

- The government should set a national strategy for the universities. To spread research funding over many small universities would scarcely improve the quality of research.
- The new university boards should review the objectives of their individual universities as they determine the strategy for the future.
- The government should consider whether the status of the universities should be changed from special administrative entities to foundations under private law to enable them to operate as private sector bodies while continuing to receive public funds. The government should consider relinquishing central control over universities.

In accordance with the recommendations, there have been several new initiatives, including the University Act of 2003 which gave the universities more autonomy and self-governance. Universities are obliged by the University Act to enter into development contracts with the Ministry of Science, Technology and Innovation. These contracts measure performance and shall improve research excellence.

The synthesis report on policy mix stated that a higher degree of competition for public research funds would stimulate scientific excellence. “Denmark, for example, plans to increase the proportion of funds awarded via competitions to 50 per cent of all research funding by 2010” (CREST, 2007).

Enabling and supporting specialisation of knowledge creation

For ensuring a better specialisation of knowledge creation, the Danish National Research Foundation has supported since 1993 centres of excellence. These centres are funded for a longer period of time (5–10 years). The Foundation distributes on a competitive basis annually between €27m and €34m to such centres in Denmark. This corresponds to about 2% of annual public research expenditure.

As has been reported before, NordForsk, under the Nordic Council of Ministries, also gives funding to Nordic centres of excellence. An example is the Nordic Centre of Excellence Programme on Food, Nutrition and Health. This was launched in 2006 with co-financing by NordForsk and the National Research Councils and will run until 2011. The total annual funding will be approximately €2.3m. The Danish centre of excellence under this programme is the HELGA: Nordic Health – Wholegrain Food, co-ordinated by the Danish Cancer Society.

The Danish scientific publications are highly concentrated in clinical medicine; other fields with high output are biology and biochemistry, physics, plant and animal sciences, and chemistry. The specialisation of profile (compared to EU15) of Danish scientific publications reveals scientific competitive advantages in pharmacology, clinical medicine, immunology, microbiology, agricultural sciences, plant and animal sciences and environmental sciences (ERAWATCH Country Specialisation, 2006).

Ensuring openness to new scientific opportunities

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 are 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 Danish National Advanced Technology Foundation targets the research areas of nanotechnology, biotechnology and ICT and funds projects within at least two of these areas. Similar funding schemes can be found in the Strategic Research Council.

4.1.2. Improving exploitability of knowledge production

Mechanisms to appropriate knowledge returns

Denmark entered the EPO in 1990. The number of EPO patent applications has increased considerably – from 331 in 1990 to 977 in 2004. The increase is especially clear if the numbers are normalised.

EPO patent applications per million labour force increased from 139 in 1992, to 233 in 2004, compared to 216 for the EU27. EPO patent applications per million inhabitants increased from 64 in 1990, to 181 in 2004 compared to 108 for the EU27.

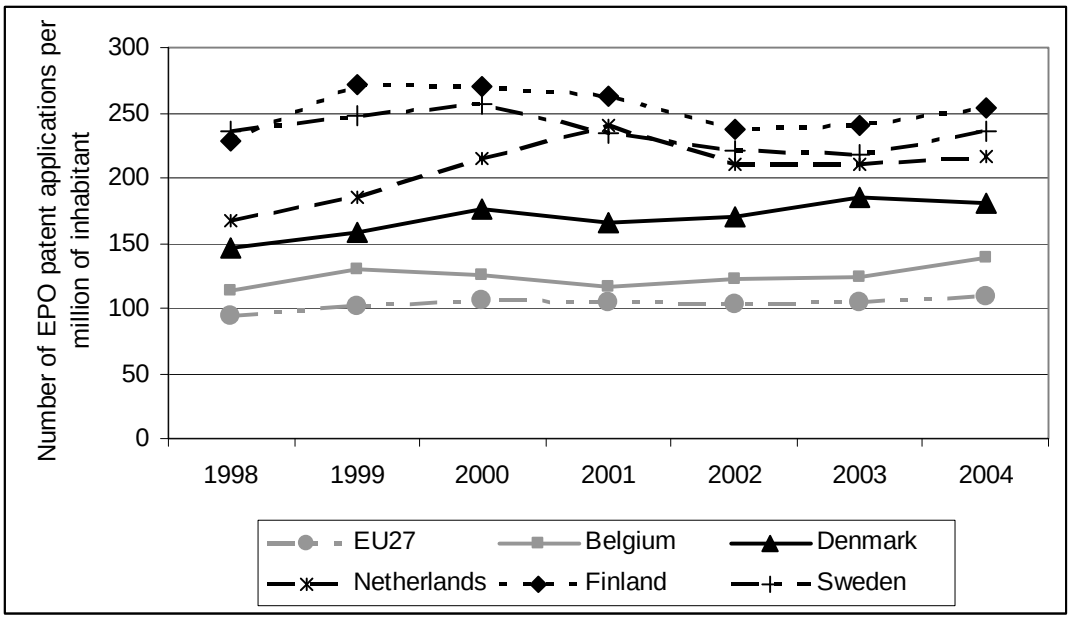
When comparing these achievements with those of other EU member states, Denmark shows an average performance (Figure 2). However, Denmark has a higher patent application growth rate than the other benchmark countries, except the Netherlands. This can be explained by the increasing importance of medical and biotech R&D in Denmark.

The development of patenting in the periods 1993–97 and 1999–2003 has been especially successful in industry sectors such as office machinery, electronic equipment and instruments (ERAWATCH Country Specialisation Report, 2006). Comparing the patent specialisation profile with the specialisation profile of business R&D expenditure the analysis we find a coherent strong position both in patenting and BERD for food, pharmaceuticals and instruments sectors.

Processes facilitating the matching of scientific knowledge production and economic specialisation

There is in general 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 and whereby it is the research taking place in universities that generates innovation.

Figure 2: Number of Patent applications to the EPO by priority year at the national level: Denmark, EU27 and selected other EU member countries. Total number of applications per million inhabitants. 1998–2004.



Source: Eurostat

One of the visions of the Danish government is to be in the international forefront in terms of cooperation between industry and public knowledge institutions (meaning universities, colleges and research institutes). However, Denmark will face major challenges if this objective is to be reached. In September 2003, the Danish government therefore published the action plan, “New ways of interaction between research and industry – turning science into business”. The action programme focused on incentives for establishing cooperation and interaction between knowledge institutions and companies. The only technical university in Denmark is the Technical University of Denmark (DTU). In January 2007, the University merged with the Risø National Laboratory and several other government research institutes. These institutes are now departments of the University. DTU aims to be among the leading universities within priority areas such as nanotechnology, biotechnology, ICT, energy and environmental technology, food science and medical technology, and space and robotic technology. With the merger of several research institutes active in these fields, this is an ambitious but achievable goal.

In several research programmes collaboration between academia and industry is addressed, supporting the further development of clusters such as the Energy Technology, Development and Demonstration Programme, the Strategic research programme for environmentally sustainable energy and energy production, the Innovation Accelerating Research Platforms, the Interdisciplinary Research programme on the correlation between food, nutrition and health, the Strategic Programme on the Interdisciplinary Application of Nanotechnology, Biotechnology and Information and Communications Technology and the Jysk-Fynsk IT programme.

The government stated in the Globalisation strategy that Denmark lacks a tradition of systematic evaluation of research quality. As a consequence, the government wishes to create a quality barometer, to be able to monitor and evaluate development trends.

4.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Danish research system in terms of knowledge production can be summarised as follows:

The performance of the Danish research system is satisfactory. In particular, it shows strengths in medical sciences, plant and animal sciences, and there is coherence between specialisation of business R&D and patenting activity. Interdisciplinary funding instruments and long experiences with centres of excellence have strengthened the Danish knowledge production.

Main strengths	Main weaknesses
• Good performance in medical science fields, plant and animal sciences etc. • Coherence between specialisation of BERD and patenting • Focus on interaction between public science and industry • A strong technical university which has been strengthened considerably by recent restructuring reform of the Danish R&D system • Interdisciplinary funding instruments • Long experience with centres of excellence	• Weaker performance in natural sciences and engineering (bibliometrics)

4.3 Analysis of recent policy changes

The fragmentation of the university structure was addressed by changes in 2006 and 2007 through a number of mergers of universities and government research institutes. Twenty-five universities and research institutes were merged into eight universities and three government research institutes (Danish Government, 2007, 20).

The Danish government has announced that it will introduce a bibliometric research indicator, which is to strengthen the quality of Danish research. The indicator will be utilised for the distribution of the increasing core funding that the universities are to receive in the coming years. However, in the research community it has been debated if such a performance based funding system may have a negative impact on academic freedom and may also lead to an extra burden for researchers.

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

Challenges	Main policy changes
• Fragmentation of public R&D system	• Restructuring of Danish R&D system • Continuation of the Danish National Research Foundation and the Centres of Excellence scheme

4.4 Assessment of policy opportunities and risks

The main opportunities and risks for knowledge production in Denmark arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

The recent policy measures attempt to strengthen the identified strongholds of 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: they shall be more competitive and entrepreneurial and more responsive to the needs of industry. The knowledge production of universities shall be measured by bibliometric indicators. The use of bibliometric indicators may lead to unintended consequences, if they are not well communicated in the research community.

Main policy opportunities	Main policy-related risks
• Strengthened universities based on restructuring of the public research system • Focus on world-class universities based on development contracts and introduction of bibliometric indicators as a basis for distribution of the increased university core funding • Funding for Danish National Research Foundation secured – centres of excellence	• Distribution of core funding of universities based on bibliometric indicators may lead to unintended consequences, if they are not well communicated in the research community and combined with other indicators

4.5 Summary of the role of the ERA dimension

One challenge is to increase the Danish participation in the EUFP7 and in the ERA-NETs. Danish enterprises do not use the possibilities under EUFPs effectively enough. The Ministry of Science, Technology and Innovation has, for this purpose, introduced a specific scheme the Pre-project grant for the 7th EU framework programme, which is a continuation of the support for projects under EUFP6. “The rules should be changed so that the research councils can give financial support to international cooperation. And the research councils should be given the opportunity to use funds for national co-financing to promote Danish participation in EU framework programmes and other international research activities” (Danish Government, 2006, Annex, p. 5).

5 - Knowledge circulation

The purpose of this chapter is to analyse and assess how the research system ensures appropriate flows and sharing of the knowledge produced. This is vital for its further use in the economy and society, and as the basis for subsequent advances in knowledge production. Knowledge circulation is expected to happen naturally to some extent, due to the mobility of knowledge holders, for example, university graduates who continue to work in industry and the comparatively low cost of the reproduction of knowledge once it is codified. However, three challenges related to specific barriers to this circulation remain and need to be addressed by the research system in this domain:

- Facilitating knowledge circulation between university, PRO and business sectors to overcome institutional barriers;
- Profiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mediate limited firm expertise and learning capabilities.

Effective knowledge-sharing is one of the main axes of the ERA green paper and significant elements of IGL 7 relate to knowledge circulation. To be effectively addressed, these require a good knowledge of the system responses to these challenges.

5.1 Analysis of system characteristics

5.1.1. Facilitating knowledge circulation between university, PRO and business sectors

Incentives and mechanisms for inter-sectoral R&D co-operation and R&D personnel circulation

The creation of academic spin-off companies is assessed as 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 DTU has founded 77 still existing firms that are based on technology from the DTU. 68 of these start-ups were founded between 1994 and 2006, since 1999 on average 7.6 start-up firms per year (DTU, 2007). There was a continuous increase after 1997, with a decline in the period 2002–2003, following the well known dot.com wave. The distribution by technology field is skewed. 25% of the companies were based on technology in informatics and mathematic modelling, 12% in communications, optics and materials and 12% in micro and nanotechnology. It is however difficult to assess whether the figures from DTU constitute a high or low performance as compared to other similar universities in other countries since there is a lack of broadly accepted and standardised indicators on measuring numbers of academic spin-offs and start-ups.

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

Private enterprises finance only in a minor degree Danish public R&D. The shares of HERD and GOVERD financed by business R&D expenditures were in 2005 2.4% and resp. 2.1% (Table 5 and see also Source: Eurostat

Table 2). Figures in Table 5 suggest that GOVERD-industry funding has diminished and the share for GOVERD is probably now much lower, because of the structural reform of the Danish research system. The EU15 shares of HERD (6.3%) and GOVERD (8.1%) financed by private enterprises are much higher. It seems that Danish business R&D expenditures are kept inside the business sector.

Table 5: Shares of R&D expenditures financed by business enterprises. 1991-2005. In per cent.

GOVERD		BERD		HERD		Non-profit		Total	
1991	2005	1991	2005	1991	2005	1991	2005	1991	2005
3.6%	2.1%	86.0%	86.0%	1.6%	2.4%	3.6%	16.4%	51.4%	59.5%

Source: Danish Centre for Studies in Research and Research Policy, Eurostat.

Private enterprises purchased R&D from Danish HEIs and PROs for €66m in 2006; of this, 43% was purchased by firms in the manufacturing sector, 20% by firms in the knowledge services & financial sector and 37% by firms in trade and other sectors (Forskningsstatistik, 2006). We assume that Danish private enterprises collaborate increasingly with Danish HEIs based on science-industry co-publishing data, but we have no other statistical evidence for this.

Business enterprise purchase of extramural R&D services has been increased from €289m (2006-prices) in 1997 to €1057m in 2006. This increase is mostly attributed to high-tech manufacturing sectors and knowledge-intensive business services (Danmark Statistik, 2008, Table 7B). We have no information on who are the knowledge providers of these purchased R&D services, but from the analysis above it appears that they mostly are other Danish or foreign business services and to a lesser extend Danish universities and research institutes.

In 2000, the Ministry of Science, Technology and Innovation established five patent consortia to deal with patenting and to create further collaboration between public research institutions and businesses. Now 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 intellectual property rights (IPR).

All the universities have technology transfer offices (TTO), but staffing and the is differently prioritised: the number of staff varies from more than ten full-time employees to less than one full-time post (DASTI, 2008). The two still independent research institutes do have TTOs each with 1–2 fulltime employees. The DTU has Denmark's first and largest university-based science park: Scion-DTU. In 2008, Scion-DTU housed 175 businesses and more than 3500 employees in high-tech areas.

Intellectual property rights 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, 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 they 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 (€7.82m 2000-2003). 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 viewed as 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.

After 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 the office has acted effectively and will be continued – in a strengthened form – for a further period until 2013 (Inhouse Consulting, 2008).

Despite these measures and as the TrendChart Report for Denmark has pointed out, 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.

While the number of patents is comparable with other European countries (see chapter 4.1.2), the commercialisation of these patents is not the focus of attention. Research organisations in Belgium, Netherlands, Switzerland and Germany produced 4 to15 times as many license agreements than the Danish institutions. The best-practice institutions in Denmark are Risø National Laboratory and the Technical University of Denmark.

5.1.2. Profiting from access to international knowledge

The Globalisation Strategy (2006) highlighted that Danish participation in the EU framework programmes is declining and therefore proposed several actions to improve the Danish access to the European knowledge networks. This declining trend has been confirmed in a recent analysis of the development of the share of Danish participation in EUFPs from the EUFP4 to EUFP6 – from 3.10% for EUFP4, to 2.67% for EUFP5 and to 2.38% for EUFP6 (DASTI, 2008a). The total number of projects and the number of projects with a Danish coordinator have decreased. However, when normalising these figures, such as provided EU budget per capita,

Denmark has achieved a rather high position, second after Sweden, followed by The Netherlands, Belgium, Finland, Switzerland and Norway.

For the improved participation in the 7th Framework programme the Danish Council for Strategic Research 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 introduced several measures and organisational changes for improving Danish participation in EUFP7: The EuroCenter has been established, and specialises in information and consulting services regarding the EUFP7. Other measures are the START-scheme and Pre-project grants for SMEs. However, national research programmes allow still limited access for foreign researchers.

Collaboration with Nordic and Baltic countries is fostered through collaboration under the Nordic Council of Ministers.

The Ministry of Science, Technology and Innovation has also 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.

In 2006, 1.3% of R&D expenditure at Danish HEIs was funded by foreign businesses, while the sector research institutes and other PROs received even smaller shares. The EU funding was highest for the sector research institutes which received 7.5% of their funding from the EU, followed by other PROs, while the HEIs received just 3.0% of the funding from this source (Table 6).

Danish firms purchased R&D from foreign public research institutions for €11m in 2006, while Danish foreign affiliates purchased R&D from Danish public research institutions for €208m. Other foreign firms purchased R&D for €370m in 2006 (Danmarks Statistik, 2008; Table 5).

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 8000 Danish students study abroad and about 12,000 foreign students study in Denmark. Of the foreign graduates stay about 60% one year after graduation still in Denmark (Ministry of Science, Technology and Innovation, Press release of the 20.8.2008).

Table 6: Shares of public R&D expenditures financed by foreign business, EU and other foreign sources. 2006. In per cent.

	Foreign businesses	EU	Other foreign funding
HEI	1.3%	3.0%	1.4%
Sector research institutes	0.8%	7.5%	3.2%
Other PROs	0.6%	3.9%	2.6%
Private non-profit	0.8%	2.5%	4.6%

Source: Dansk Center for Forskningsanalyse og Danmarks Statistik, 2008: Forskningsstatistik 2006.

5.1.3. Absorptive capacity of knowledge users

Processes enhancing SME participation in R&D

Statistics on the aggregate level imply that Danish industry has a high knowledge absorption capacity since companies invest heavily in R&D. The absorptive capacity among SMEs is quite high in Denmark compared to European averages and to other Nordic countries (see also Chapter 2.1.3). The SMEs (less than 250 employees) invest 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 have contributed to an increased absorptive capacity in the private sector. However, Denmark is suffering under a lack of engineers.

Mechanisms ensuring the availability of a highly qualified labour force

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

The Industrial PhD initiative, dating back to 1970, is aimed at enhancing research and development in the Danish business sector on the one hand by training researchers to gain insight into business related aspects of research and development, and on the other, to build 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 enhances research-based knowledge circulation between HEIs and the business sector.

5.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Danish research system in terms of knowledge circulation can be summarised as follows:

Cross-sector knowledge circulation is a policy priority in Denmark and it is targeted by several policy measures, but here we find a kind of paradox: The private sector has purchased only in a minor degree Danish public R&D, and a documented strength of the Danish R&D system is the high absorptive capacity of SMEs (measured as total firm R&D-funding). The participation of HEI in international research programmes (EU) is low compared to other EU-countries.

Main strengths	Main weaknesses
• Industry PhDs have successfully contributed to increased absorptive capacity in private firms • SMEs have high absorptive capacity • Life-long learning has long traditions • National network for technology transfer strengthens professionalization of technology transfer from public research to industry	• Private enterprises purchase only in a minor degree Danish public R&D and IPR ownership of universities may become a field for conflict of interests between firms and universities • Staffing and qualification of TTOs not prioritised by many research organisations and may endanger research commercialisation • Commercialisation of patents still modest • Modest participation of HEIs in EUFPs • National research programmes allow still limited access for foreign researchers

5.3 Analysis of recent policy changes

In Denmark, research and innovation policy is organised under one ministry, the Ministry for Science, Technology and Innovation. This is a good precondition for the coordination of activities which target knowledge circulation. Denmark's National Reform Programme as well as the progress reports have focused on the importance of knowledge-sharing. The Globalisation Strategy proposed a doubling of the number of industry PhDs and initiatives to reinforce Danish participation in EU framework programmes and other international research activities. The subsidy for enterprises and universities has increased for all new projects under the Industrial PhD Programme since November 2005.

Since 2006, the Ministry of Science, Technology and Innovation, the Trade Council and the Ministry of Foreign Affairs of Denmark, have set up three innovation centres in strong, international knowledge environments in Silicon Valley (USA), Shanghai (China) and Munich (Germany). The purpose of the innovation centres is to contribute to the internationalisation of Danish R&D and to enhance the innovative and competitive strength of Danish industry.

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

- Knowledge Voucher for SMEs:

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

- Research Voucher for SMEs

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

- Proof of concept

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

- Knowledge Pilot Initiative

The initiative was introduced in 2005, granting subsidies to companies with less than 100 employees when engaging 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 shall contribute to the graduate's salary.

With the reorganisation of the Danish universities and sectoral research institutes, the majority of sectoral research institutes have now been acquired by 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 *lack of engineers* in the Danish labour market may be threaten the absorptive capacity of Danish companies and has been addressed by a campaign which commenced in May 2007 and will end in 2008. The shortage of engineers is allegedly one of the main reasons why Danish companies move production out of Denmark: every fifth company that moved abroad has stated that as the main reason for this decision. The initiative is a collaborative effort of the Ministry of Science, Technology and Innovation, Danish Industry and the Danish Society of Engineers.

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

Challenges	Main policy changes
• Internationalisation of Danish R&D	• New policy measures to reinforce Danish participation in EU Framework Programmes • Danish innovation centres in USA, China and Germany • Agreements on research collaboration with China, India etc.
• Collaboration between Danish SMEs and public R&D organisations	• Introduction of several new policy measures, such as Knowledge vouchers and Research vouchers for SMEs
• Lack of human resources in industry	• Knowledge Pilot initiative to increase share of highly skilled employees in SMEs • Joint initiative of Ministry of Science, Technology and Innovation, Danish Industry and the Danish Society of Engineers • Introduction of subsidies for experimental courses for S&T students
• Technology transfer from public R&D	• Introduction of Proof of concept scheme

5.4 Assessment of policy opportunities and risks

The main opportunities and risks for knowledge production in Denmark arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

The introduction of several new schemes targeting at university-industry collaboration may help to overcome the highlighted weakness of university-industry links. However, they are rather small measures by funding and can contribute to a further fragmentation of the system of policy measures.

There are indications that the sectoral research institutes, in their new university environment, lost some of their dynamism and collaboration flexibility. For example, while research institutes as independent organisations frequently had many small contracts with smaller firms, the number of these contracts (and contacts) may now dramatically decrease. Despite the large number of new policy measures introduced for stimulating knowledge circulation in Denmark, a potentially less responsive public R&D sector may have negative effects on the innovation activities of the Danish SMEs. It has been pointed out by Koch (2008) that SMEs, which were the target of the traditional sector-oriented institutes, may now suffer under the reorientation towards research.

The major restructuring of the Danish research system has lead to a concentration of technology transfer activities in just a few public research institutions. Six institutions accounted for more than 90% of these activities in 2007. The restructuring has contributed to a transfer of the patent portfolio of important research institutes to the Technical University of Denmark, which in 2006 held just six patents, and at the end of 2007, thirty patents. The statistics for 2007 reveal altogether a slowdown in public research commercialisation compared to the growth rates of previous years. The number of patent applications and commercial revenues increased in comparison to 2006, but the number of license deals and new spin-out companies declined.

Main policy opportunities	Main policy-related risks
• New policy measures to support participation in EUFP7 • Strong recent policy focus on collaboration with China and other countries outside Europe • New policy instruments in place targeting university-industry collaboration	• Policy efforts insufficient to counter decreasing numbers of S&T students and engineers • Traditional good experiences with science-industry linkages at sectoral research institutes can get lost with the integration in bureaucratic structures of universities, and SMEs may suffer

5.5 *Summary of the role of the ERA dimension*

The Globalisation Strategy (2006) highlighted that Danish participation in the EU framework programmes is declining and proposed therefore several actions to improve the Danish access to the European knowledge networks. DASTI has introduced several measures and organisational changes for improving Danish participation in EUFP7. The openness of national research programmes to European and international researchers is still limited, but there are some differences. Some programmes already have the possibility also to fund foreign research groups, but according to Danish law about research, counselling must be documented that funded foreign research activities clearly strengthen Danish research groups. Foreign research groups can apply for funding also within the Strategic Network Project scheme.

The Ministry of Science, Technology and Innovation has, for this purpose, introduced a specific scheme the Pre-project grant for the 7th EU framework programme, which is a continuation of the support for projects under EUFP6. The main goal is to increase the number of applying and participating Danish SMEs in the EUFP7.

6 - Overall assessment and conclusions

6.1 Strengths and weaknesses of research system and governance

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

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

The Danish industry has a high absorptive capacity and R&D intensity compared to the European average. However, the linkages between industry and public research organisations need further strengthening. The limited purchase of R&D results from universities and the limited licensing of university patents are two indications for the same weakness.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	• Broad policy consensus on the importance of research and development (R&D) for the future of Danish economy and society. • Government policy oriented towards inclusion of stakeholders from industry and the academia in developing Danish research policy and securing the resource mobilisation.
	Securing long term investment in research	• Long-term planning for development of public R&D expenditure to meet the 1% Barcelona target in 2010.
	Dealing with barriers to private R&D investment	• Rather high share of business R&D, but 2% target will not be reached by 2010. • Purchase of R&D from higher education institutions (HEI) by industry is limited.
	Providing qualified human resources	• Relatively low numbers of PhDs and engineers. • Varying quality of PhD education, but increasing focus on the quality of PhD education.
Knowledge demand	Identifying the drivers of knowledge demand	• Common thematic orientation between public and private knowledge demand drivers. • Stakeholder involvement in public R&D priority settings and foresight exercises. • Modest degree of participation in EU Framework Programmes and ERA-NETs may weaken the influence on research priorities in the EU.
	Co-ordination and channelling knowledge demands	• Research and Innovation policy under one ministry. • Danish Council for Research Policy is an adequate instrument for co-ordination of research policy. • Research Coordination Committee allows co-ordination between the main research funding organisations. • A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge.
	Monitoring of demand fulfilment	• Broad and frequent use of international benchmarking. and systemic evaluation, but evaluation of specific R&D programmes often ad hoc and irregularly.
Knowledge production	Ensuring quality and excellence of knowledge production	• Long experience with centres of excellence. • Well-performing technical university which has been further strengthened considerably the late years. • Good funding of interdisciplinary research. • Good performance in medical science fields, plant and animal sciences, but weaker performance in natural sciences and engineering (based on bibliometric data).
	Ensuring exploitability of knowledge	• Increased focus on commercialisation of public research results and patents. • Coherence between R&D thematic focus in the public and private sector and economic specialisation – strengths in food, pharmaceuticals, instruments and energy sectors.

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	• Private enterprises purchase only in a minor degree Danish public R&D and IPR ownership of universities may become a field for conflict of interests between firms and universities. • Modest rates of commercialisation of university research. • National network for technology transfer strengthens professionalization of technology transfer from public research to industry, but staffing of technology transfer offices (TTO) and qualification of TTOs not prioritised in all organisations.
	Profiting from international knowledge	• Modest participation of Higher Education Institutions (HEIs) in the EU Framework programmes. • National research programmes with limited access (participation and funding) to foreign researchers. • Agreements on research collaboration with China, India etc.
	Enhancing absorptive capacity of knowledge users	• Small and medium sized enterprises (SME) have high absorptive capacity. • High levels and well organised Lifelong learning • Industry PhDs have successfully contributed to increased absorptive capacity in private firms.

6.2 Policy dynamics, opportunities and risks from the perspective of the Lisbon agenda and the ERA

The policy mix that is addressing research, innovation and education policy has been in the centre of attention of recent Danish policy. The Globalisation Strategy combines a boost to 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 has, however, been stagnating since 2002 (2003: 1.78%; 2005: 1.67%) and it may be difficult to achieve the 2% target for this sector. Therefore, in order to achieve the 2% target the Danish R&D policy ought to stimulate more R&D in the business sector, even if there have been introduced a broad range of new policy measures with this goal. The new policy measures provide a rather limited funding and it remains to see whether this set of policy measures is powerful enough for achieving this goal (2% target). A further strengthening of the linkages between industry and universities will also contribute to a higher share of BERD.

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

The recent policy measures attempt to strengthen the identified strongholds of the Danish research system. A policy opportunity arises from the restructuring of the Danish R&D system and the follow-up policy measures aimed at world-class universities: they shall be more competitive and entrepreneurial and more responsive

to the needs of industry. The knowledge production of universities shall be measured by bibliometric indicators and core funding given accordingly. That means, a funding mechanism shall boost research quality. However, the distribution of core funding of universities based on bibliometric indicators may lead to unintended consequences, such as changes of research priorities or even lower quality, if they are not well communicated and if they do not clearly distinguish between quality differences of different publishing channels, and are aware of different publication patterns in different science fields.

As a result of the restructuring of the public research sector most of the applied research institutes have merged with universities. These universities, with the exception of the DTU, have only limited experiences with and capacities for patenting, licensing, start-up companies and other commercialisation efforts. As for the risks, enhanced university IPR policies should not hinder university-industry collaboration and experience with knowledge transfer from the former research institutes has to be acquired and activated. Technology transfer from universities to industry will be strengthened and possible conflicts of interests are to be addressed in standard agreements on IPR and strategic collaboration agreements between universities and industry partners.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• According to Globalisation Strategy, 50% of public R&D funding shall be competitive by 2010. • Long-term funding for universities based on Welfare agreement, and introduction of new funds providing access to investment capital and improved infrastructure • Policy focus on PhD education and increasing number of PhDs Policy measures to attract foreign researchers and PhD students • Globalisation Strategy combines a boost to R&D and higher education with a tri-party agreement on life-long learning	• Limitations for immigration may endanger attraction of foreign researchers • Increased competitive funding may have a negative impact on academic freedom • Increased competitive funding will lead to an extra burden for researchers who have to apply for competitive funding • Policy decision to abandon tax incentives for business R&D in 2006
Knowledge demand	• Broad stakeholder involvement ensures good match between research policy and user needs • Energy R&D has been strengthened • Further strengthening evaluation, benchmarking and accountability culture	• A multitude of funding sources and funding organisations suggests that co-ordination and concentration of public R&D funding is still a challenge. • The identified strategic research areas may be too diverse for a small country as Denmark.
Knowledge production	• Strengthened universities based on restructuring of public R&D system • Focus on world-class universities based on development contracts and bibliometric indicators as a basis for distribution of the increased university core funding	• Distribution of core funding of universities based on bibliometric indicators may lead to unintended effects, if they are not well well-understood by the research community and combined with other output indicators.

Domain	Main policy opportunities	Main policy-related risks
Knowledge circulation	• New policy measures to support participation in EUFP7 • Strong recent policy focus on collaboration with China and other countries outside Europe • New policy instruments in place targeting university-industry collaboration	• Policy efforts insufficient to counter decreasing numbers of S&T students and engineers • Traditional good experiences with science-industry linkages at sectoral research institutes can get lost with the integration in bureaucratic structures of universities, and SMEs may suffer

6.3 System and policy dynamics from the perspective of the ERA

The European Research Area as such plays only a minor role in the current Danish research policy debate. However, the Danish government has fully adopted the Lisbon objective and its Globalisation strategy has proposed reinforcing Danish participation in EU framework programmes and other international research activities.

Regarding European mobility of researchers, the Danish participation in the Marie Curie Actions is at the same level as for all participating countries in the EUFP6, about 10% of all EUFP6 financial contributions go to these actions both for Denmark and in total.

When analysing the financial contribution of the EUFP6 to research infrastructures, Denmark received a much lower share of funding compared to the EUFP6 in total

Most national research programmes still have restricted access for foreign researchers although there are some exceptions. Generally, the entry of European and international researchers is still quite restricted.

Denmark is active in Nordic research co-operation. This involves Nordic research institutions, joint research programmes, Nordic Centres of Excellence (NCoE), grant schemes and the co-ordination and planning of major infrastructure investments.

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List of Abbreviations

AAGR	Average annual growth rate
BERD	R&D expenditure in the Business Enterprise sector
DASTI	Danish Agency for Science, Technology and Innovation (Forsknings- og Innovationsstyrelsen)
DCIR	Danish Councils for Independent Research (Det Frie Forskningsråd)
DTU	Technical University of Denmark (Danmarks Tekniske Universitet)
EIS	European Innovation Scoreboard
EPO	European Patent Organisation
EUFP	European Framework Programme
GBAORD	Government budget appropriations or outlays on R&D
GDP	Gross Domestic Product
GERD	Total intramural R&D expenditure
GEUS	Geological Survey of Denmark and Greenland (De Nationale Geologiske Undersøgelser for Danmark og Grønland – GEUS)
GOVERD	Government Intramural Expenditure on R&D
GTS-net	Network of accredited technological service institutes (Godkjente Teknologiske Serviceinstitutter)
HEI	Higher education institutions
HERD	R&D expenditure in the Higher Education Sector
ICT	Information and Communication Technology
IGL	Integrated Guidelines for Growth and Jobs
IPR	Intellectual property rights
NCoE	Nordic Centres of Excellence

NordForsk	Nordic Research Board
NORIA	Nordic Research and Innovation Area
NSIODE	National Science Indicators Deluxe Edition
PRO	Public research organisations
R&D	Research and development
SF	Structural funds
SME	Small and medium enterprises
TTO	Technology transfer office
UNIK	University Research Investment Capital (UNiversitetsforskningens InvesteringsKapital)

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Abstract

The main objective of ERAWATCH country reports 2008 is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. The reports are produced for each EU Member State to support the mutual learning process and the monitoring of Member States' efforts by DG Research in the context of the Lisbon Strategy and the European Research Area. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The reports are based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.
This report encompasses an analysis of the research system and policies in Denmark.

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