The Governance of Research and Innovation
An international comparative study

Synthesis Report

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Executive Summary

Governance of innovation tells something about what roles the various actors in the innovation system play, how the rules of the game work, how decisions are taken and how changes in the overall innovation system come into being. The European Commission's definition of governance can also be applied to science, technology and innovation (STI):

"*'Governance' means rules, processes and behaviour that affect the way in which powers are exercised …..., particularly as regards openness, participation, accountability, effectiveness and coherence.*"

This international comparative study on the governance of innovation was launched in order to see whether the Netherlands can learn from governance practices in other countries. The Dutch Ministry of Economic Affairs is particularly interested in Innovation Governance as key actors are rethinking how the Dutch innovation governance system could be improved to make innovation policy more effective.

The Synthesis Report is based on a comparative study in six countries: Canada, Denmark, Finland, Ireland, Sweden and the United Kingdom. A separate report contains the analysis per country. In addition we have looked at 14 specific cases of governance in various specific technology fields in many parts of the world.
The objective of the study is to describe the national public governance models and good practice examples.

The study found that many countries are struggling with similar governance issues as the Netherlands. A critical one is how to arrive at a coherent science, technology and innovation (STI) policy. The study identified the need for greater coherence and integration along three dimensions:

- The integration of knowledge creation (mostly basic research) and the use of knowledge for commercial exploitation, thus better integration of science and innovation policies.
- The co-ordination and attuning of different societal and economic goals of research and innovation, thus integrating STI policies across sectoral departments.
- The combination of knowledge from different science disciplines to tackle interdisciplinary research needs (e.g. bio-technology) and overarching societal problems that need such an interdisciplinary approach (e.g. climate change).

Other typical STI governance issues that we address in this study are:

- How does the governance structure deal with adaptation and change in the innovation system? What brings about change in structure and public investments in STI ?
- How are research performers (universities and public research organisations) and intermediaries (funding agencies) held accountable for their activities?
- How do national and regional actors co-ordinate their activities?

We have identified various responses to the above dilemma's in the benchmark countries. In all governance systems linear modes of operation function in parallel

with more systemic and integrative modes of operation. Partly this can be explained by path dependency and a long cultural heritage, partly since some elements of the linear model (e.g. funding mechanisms for curiosity driven research) still fulfil a function in a systemic governance model.

Countries are converging on the idea that there should be a very high level research and innovation policy function to generate overall strategy and to act as 'referee' in the system. Attempts to improve co-ordination and integration can be found in all countries. The examples provided vary from high level advisory committees providing the strategic framework (Finland, Ireland), allocating responsibility for co-ordination to one Minister or Department (Sweden, UK) to the establishment of one Ministry dealing with the entire knowledge production chain (Denmark).

Tackling the multidisciplinary issue appears to be more difficult within the existing governance structures. What we have seen in the technology case studies, is that new governance structures (e.g. dedicated task forces) arise in emerging technology areas (e.g. nano-technology, genomics), particularly if new money is poured into the system. The cases also show that co-ordination between different organisations and departments is easier with new money, in comparison with having to negotiate the allocation of existing funds.

Three examples of radical changes in STI governance have occurred in our benchmark countries. The re-allocation of massive amounts of government budgets in the favour of science and technology in Finland in the 1990s and in Ireland in 2001 and the review and part restructuring of the research and innovation system in Denmark. Each of these have very country specific backgrounds in terms of the arguments for these radical changes. The similarity between the three was a support at high political level, and from industrial leaders.

Similar to the Netherlands, there appears to be a myriad of non-academic public research centres and government labs in Canada, Denmark, Finland and Norway, whereas Ireland , Sweden and the UK rely mostly on their universities.
The influence of the New Public Management and the principles of 'good governance' for research and innovation is positive and increasing, particularly in countries such as Canada, Norway and the UK, but there are important national differences in the way it is implemented. This means that in for instance Norway and Denmark, non-academic public research centres are regularly evaluated.

Concerning the synergy between national and regional activities in STI we found that in most countries studied, the co-ordination does not work very well. The UK and Sweden have recently taken this up as a serious issue and have issued formal performance contracts between national and regional actors.

Overall the governance models in the benchmark countries can be seen as a continuous learning process of adopting organisations and practices to external and internal challenges. The snapshot view that this study has provided can not capture this nationally specific historical process in great depth. Similarly good practices can not simply be transferred from one country to another. Nevertheless the illustrations how the benchmark countries have tackled some of the key governance issues, provide food for thought to improve the efficiency of the Dutch innovation system.

Contents

1 Introduction

Innovation Governance attracts enormous interest among scholars and practitioners dealing with research and innovation policy. The drive for this renewed interest rests on questions such as: does the public governance of research and innovation really make a difference? Does the manner in which we organise our science and research affect our wealth creation? Despite the increasing internationalisation of science and technology, we see that national governance models are still very much dependent on historical patterns. There are many common challenges and issues in industrialised countries. This study looks at how different countries deal with these, and whether some models of governance are better equipped to translate a good performance in science and technology into economic wealth.

The Dutch Ministry of Economic Affairs is particularly interested in Innovation Governance as the key actors are rethinking how the Dutch governance system could be improved. This is prompted by a recent overall review of innovation policies[1] which recommended that:

1 Streamlining of current policy instruments is necessary to increase transparency for its users, to avoid overlap and diminish conflicting policy goals
2 Financial support for public research should have a stronger connection with research achievements
3 The position of applied research institutions, as bridge between fundamental research and commercial application should be improved, for instance by formulating objectives and performance indicators
4 The information on the effectiveness of innovation policies be improved
5 The co-ordination between government departments in policy design and implementation to be reinforced

A key assumption is that if overall governance is improved and sectoral Departments are more inclined to overcome their 'turf battles' to co-ordinate public efforts, the effectiveness of research and innovation policies will increase. Even in a context of tighter government budgets, an effective governance model would lead to a better impact of public investment in R&D.

This international comparative study on the governance of innovation was launched in order to see whether the Netherlands can learn from governance practices in other countries. The report is based on a comparative study in six countries: Canada, Denmark, Finland, Ireland, Sweden and the United Kingdom. In addition we have looked at 14 specific cases of governance in various specific technology fields in many parts of the world. We have taken a broad approach and included the governance of science, technology and innovation (STI). In the remainder of the document we will refer to STI unless we specifically isolate one of these three spheres.

[1] Ministerie van Financiën, Samenwerken en stroomlijnen. Opties voor een effectief innovatiebeleid. Eindrapportage IBO Technologiebeleid, 2002.

The objective of the study is to describe the national public governance models and good practice examples, particularly with regards to the questions such as:

- How are responsibilities for STI policy divided across the different ministers, departments, agencies and intermediaries? What co-ordination mechanisms are in place?
- How is decision making taking place?
- In what way are stakeholders involved?
- How is the knowledge infrastructure[2] being directed or guided and how are the funders and performers of research held accountable for their actions?
- Can national and regional efforts be co-ordinated better?

Given the already very broad scope of this assignment and the complexity of governance, we have not included further questions such as to co-ordinate innovation policies with other policy domains such as competition policy or education.

1.1 Structure of the Report

This part of the overall study synthesises the results of the empirical work done in the six benchmark countries Canada, Denmark, Finland, Ireland, Sweden and the United Kingdom. We have included some additional material on Norway which came from a similar exercise we have done for the Research Council Norway.

The report is structured as follows. In the second chapter we explore the concept of governance, which is used very loosely and for many purposes. This chapter also provides some background as to why there is so much pressure on current governance systems. In Chapter 3 we briefly introduce the six countries, their main characteristics and performance in STI. The need for a more coherent approach to STI policy, and the solutions sought for this challenge, are described in Chapter 4. Chapter 5 explores the decision making processes in STI and how external stakeholders are involved in this process. The relationship between government, STI funders and research performers is discussed in Chapter 6.
A key issue in the governance debates is the accountability of the actors in the system and the mechanisms established to assess the performance of these actors. Chapter 7 gives a synthesised account of what we have found on the relationship between national and regional policy levels. Subsequently in the final Chapter 8 we draw some conclusions from the findings of the study and highlight a number of lessons from good and bad practices elsewhere.

[2] In Dutch the term ‘knowledge infrastructure’ is used to refer to the public and semi-public organisations performing research and development. This includes the universities, the national laboratories and applied research organisations, and the laboratories attached to government departments.

2 What is governance?

2.1 A definition

Before we start providing the results of this benchmark study on STI governance, it would be beneficial to examine the term governance in more detail. Our experience is that the term is used in a loose way and for different purposes. Clarification on how we have used the term in our investigation will help further reading.

In public management literature, the term governance " … is a perspective within which the conventional boundaries between politics and administration are perhaps less significant, and which enables large social questions to be approached more directly than from within the narrower perspective of traditional public administration". These are linked with systems approaches where "the boundaries between individual institutions become less significant than the question of how the whole ensemble dances (or fails to dance) together."[3]

In Europe the concept of governance has only recently emerged in the STI policy debate. The term is used to broaden the concepts of *government* and *policy*. The concept of governance allows for a larger set of actors to have an influence on the outcome of the strategy formulation processes and the allocation of tasks and budgets. As the above quotation indicates it deals with the relationships between institutions that form an ensemble. In this study we could say the ensemble is made up of the actors in the innovation system. Thus in STI governance we do not look only at *policy*, but focus on the interplay between the various actors that together determine the priorities, strategies, activities and outcomes in research and innovation. Nevertheless, the policy arena is quite an important one, due to its major role in setting budgets and defining missions.

John de la Mothe has emphasised this inter-institutional relationship in his description of governance:

> *"Governance is about the handling of complexity and the management of dynamic flows. It is fundamentally about interdependence, linkages, networks, partnerships, co-evolution and mutual adjustment."*[4]

Thus this type of approach to research and innovation performance fits very well with the Dynamic Innovation System approach that the Ministry of Economic Affairs has now adopted.

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[3] Pollitt, C., Bouckaert, G., Public Management Reform, A comparative analysis, Oxford University Press, 2000.

[4] John de la Mothe, Knowledge Politics and Governance, in: John de la Mothe (ed), Science Technology and Governance, Continuum, London, New York, 2001.

2.2 Governance in Europe

Governance is increasingly appearing in policy debates across Europe. The European Commission identified reform of governance as one of its four key strategic objectives in early 2000. The European Union's concern with governance is mainly centred on the fear that citizens are alienated from government, and particularly from European level government. Another central issue which prompted this debate is the question of subsidiarity: what can we do best at which government level? As a result it published a White Paper on the subject of governance a year later. *"The White Paper on European Governance concerns the way in which the Union uses the powers given by its citizens."* [5] The White Paper uses the definition: "'*Governance' means rules, processes and behaviour that affect the way in which powers are exercised at European level, particularly as regards openness, participation, accountability, effectiveness and coherence.*" These five principles underpin the subsequent proposal for reform and the actions proposed to reach it.

2.3 Key issues in STI governance

Although the political context for this European report is quite different, its principles also apply to the key issues in STI governance. The issue of integrating science and innovation policy for instance is a question of achieving more coherence in tackling the questions of the knowledge society, from both the research and the economy's perspective. The principle of accountability is a key issue in the relationship between research & innovation funders and research & innovation performers, as well as between funders and political leadership (i.e. Parliament). Closely related to accountability is the issue of effectiveness: since we are dealing with public resources, we would expect that investment in the innovation system is effective in achieving the set goals. The organisations funded with public money should be held accountable, i.e. demonstrating that their efforts are effective.

The term governance is often linked with the idea of 'good government practices ' as opposed to 'bad government practices' that needs to be reformed . The OECD for instance has a project on the governance of public agencies and authorities, which the Public Management Committee considers to be a priority issue. In a report "Distributed Public Governance, Agencies, authorities and other autonomous bodies" the OECD deals with the role of the 'wider state sector' as an understudied subject.[6] It aims to provide some guidance in good practice on how this effects good governance practices. Our study also deals extensively with this wider state sector, since relatively autonomous bodies such as Research Councils, Research Institutes and intermediary agencies form a substantial part of the public governance.

From these quite broad descriptions of what governance is we first need to have an overview of the 'map' of each country to know:

- Who are the key actors involved in decision making on STI in the public and semi-public sector?

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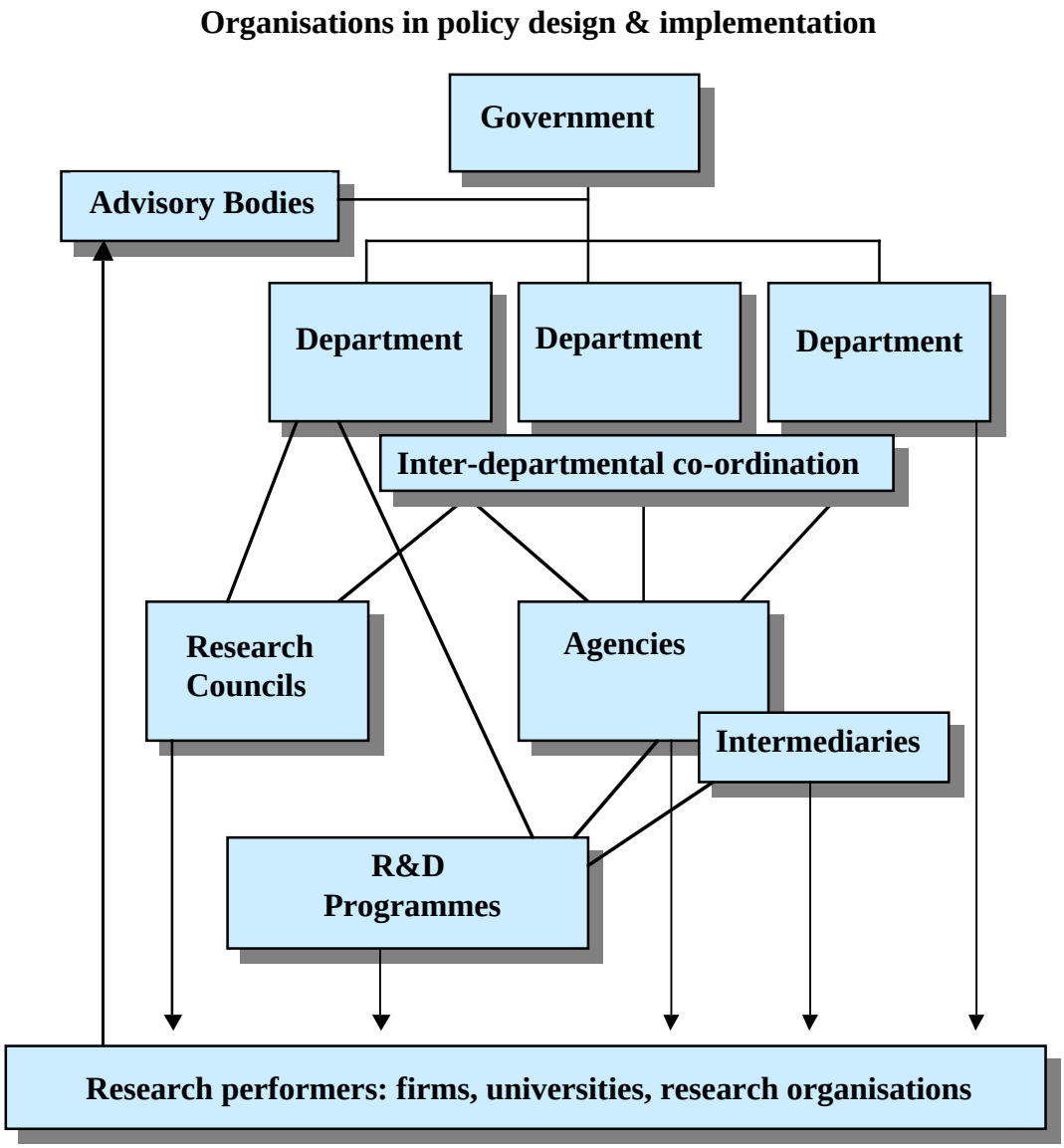
[5] Commission of the European Communities, COM (2001) 428 final, Brussels, 25.7.2001.

[6] OECD, Distributed Public Governance, Agencies, authorities and other autonomous bodies, Paris.

- How do these sets of actors determine the direction, priorities and volume of STI activities?
  - Where are responsibilities?
  - Which institutions are most powerful?
  - Which stakeholders are involved?
- What are the change agents in the system?

An 'ideal type' overview of the governance structure in a country is given in **Exhibit 1**. Nevertheless drawing up these maps in each country immediately shows the disparity between them.

Exhibit 1 Typical innovation governance structure



The most important layer for policy design and overall strategy formulation for STI lies at the level of **governments, departments** and to a varying degree **advisory bodies**. The study shows that the degree to which the national governments (Cabinet and Prime Minister) are involved in deciding on overall co-ordination and strategy formulation in innovation and research differs greatly, but can have great impact. In Finland the Prime Minister heads the co-ordinating Science and Technology Policy Council, whereas in the Netherlands, and also in Canada strategic decisions are taken by individual Ministers on their own sector domain. The status and influence of Advisory Bodies is another governance issue which shows wide variations. The composition of these bodies and the links with key decision makers decide on their importance.

Government departments are usually the key organisations in deciding on the direction of STI investments. After overall budget allocations are decided at Cabinet level, the departments usually define how these budget are spent, and what weight is given to STI. Co-ordination on this is the exception rather than the rule. We will see some examples where departmental co-ordination bodies operate above departmental level (with Ministers taking seat in these bodies) whereas other countries rather have interdepartmental co-ordination mechanisms at the level of high civil servants.

Each of the countries have an important 'middle level' consisting of research funders (typically research councils, funding institutes, and dedicated agencies) which have the responsibility for allocating funding to the research performers (universities, research organisations and laboratories, firms). The level of independence of this **middle layer** shows large variations in terms of their role in policy design and decisions on allocation of funding. Ireland for instance has a relatively thin Ministerial level and a strong position for its agency Enterprise Ireland, whereas in comparison the Netherlands has a strong Ministry of Economic Affairs and a less independent position of its agency SENTER.

The third level in the governance system consists of those **actors that perform research and innovation** and are the direct beneficiaries of public funding for R&D. This is where countries patterns vary most. The economic structure in each of the countries determines the main R&D performers in the private sector. For instance Finland, Sweden and the Netherlands have in common that private R&D is very much influenced by a limited number of large multinationals originally based in their countries. Canada and Ireland have in common that they are dependent on attracting large companies from the US, which only conduct a limited amount of R&D in their host country.

The governance study will not include research and innovation conducted in the private sector, although we will discuss:

- How the private sector influences the direction of public sector STI
- How the public and semi-public sector activities trigger private sector activities

Variations in the public R&D sector are for instance the position of public research centres alongside the university system. Sweden and the UK on the one extreme have very limited non-academic public research centres, whereas Norway and the Netherlands have a vast number of these institutes.

Within the scope and time scale of this study it was not possible to go into the details of the governance of the higher education system, which is under reform in many European countries. We have addressed the issue under the heading of accountability of the HEI sector.

2.4 Challenges for innovation governance

Why the increasing demand for good governance, and particularly the need for a more coherent systemic approach in research and innovation?

In general innovation systems are faced with important drivers for change. We see four categories of drivers, in the form of changes in

- The modes of knowledge production
- The nature of (hard and soft) technologies
- The way industry organises both knowledge acquisition and physical production
- The priorities of those who pay for knowledge production – sometimes discussed in terms of establishing a new social contract between science and society

2.4.1 Modes of Knowledge production

This is especially evident in Sweden and Finland, with their high rates of growth in Business Expenditure on R&D in recent years, where knowledge is increasingly produced outside disciplinary science, outside the universities, and in response to real-world problems rather than theoretical and experimental puzzles. One reason for this is the massive production of graduates and post-graduates stemming from the great expansion of university systems in recent decades, increasing the number of research-capable people in place across society. Knowledge production is increasingly becoming an interdisciplinary and collective process, involving teams and networks rather than lone scientists or 'heroic inventors'. The networks and collectives involved in science are becoming increasingly international, as is clear from a range of indicators including data on collaborations and co-publication.

2.4.2 Nature of Technology

The nature of certain technologies is also changing. Much technical and economic growth in recent years has been associated with the newer 'hyphen technologies' such as micro-electronics, bio-sensors, electro-optics, and so on, which involve new combinations of previously separate areas of knowledge, challenging traditional ways of organising science and technology. A recent report titled *Converging Technologies*, sponsored by the National Science Foundation in the US phrased the situation as follows:

"*Half a millenium ago, Renaissance leaders were masters of several fields simultaneously. Today, however, specialization has splintered the arts and engineering, and no one can master more than a tiny fragment of human creativity. The sciences have reached a watershed at which they must unify if they are to continue to advance rapidly*." [7]

Some technologies are 'dematerialising,' through the increased use of simulation in knowledge production and the fact that many technologies are now delivered in the form of software or other forms of disembodied know-how. Intellectual, as opposed to physical, property therefore becomes increasingly important in knowledge production and use. In some areas, such as parts of electronics and biology, intellectual property rights can be an important constraint on research activity, but also an important source of income for research-performing organisations.

This means that the governance of science and research should adapt to these changes and address the multidisciplinary character of knowledge production.

2.4.3 Industrial organisation of knowledge

Three forces are changing the way industry is generating and using knowledge: globalisation; de-integration; and acceleration.

Globalisation of production and (to a lesser extent) corporate R&D allows specialisation and scale while allowing companies to seek out the best available global knowledge. Therefore, not only is scientific competition global (it has been for a long time), but also knowledge about applications and technologies is increasingly involved in global competition.[8] Universities' network relationships are subject to competition and may be fragile.

Production and, increasingly, design in many important engineering industries relies on the idea of platforms (e.g. a car), where the final producer's key role is to integrate knowledge over many fields and to act as systems integrator. Large parts of the design and manufacturing task are delegated to 'first tier suppliers,' who provide major systems to the platform manufacturer. They in turn ask the component or sub-sub-system suppliers from whom they obtain inputs to take on aspects of design as well as manufacturing. (From the car-maker's perspective, these are 'second tier' suppliers.) This process of 'de-integration' of design and manufacture allows economies of scale and specialisation in the supply chains, but also means that knowledge buyers increasingly need packaged solutions, often spanning different disciplines or knowledge areas. In addition to their traditional style of network relations, where internal and external specialists interrelate, there is a growing need for knowledge suppliers to be able to package together different knowledges.

Development lead times have been declining in most parts of industry, and are especially short in the new electronics-related technologies. Developers have been

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[7] National Science Foundation and Department of Commerce, Converging Technologies for Improving Human Performance, Arlington , USA, June 2002.

[8] This is, of course, an over-generalisation. Specialised surface chemistry, for example, is a highly global business. Mechanical engineering and parts of metals production appear less so, with local relations and customer knowledge being more important knowledge producers' ability to serve customers

modularising designs and moving to concurrent engineering in order to reduce lead times. There is evidence that sophisticated knowledge users are incorporating more fundamental research into their plans for innovation within and between platforms. (Nokia is a concrete example.) It is therefore beginning to make sense to think of 'concurrent science' as one characteristic of the relationship between the applied sciences and other knowledge producers. This imposes new disciplines and new kinds of networking needs on those working in applied science, in addition to increasing the importance of being able to deal with long-standing questions of confidentiality, publication and intellectual property rights.

2.4.4 Social contracts between science and society

There are at least two types of change taking place in the way the state prioritises, these are found in its role as a buyer of knowledge and as a patron of research. The trend towards demanding increased 'relevance' in research is long-standing, even if it continues to be strongly contested by the basic science research community. The second movement is for issues of 'relevance' to become more important than before in relation to problems where the state is a major, direct user of knowledge. Environment (especially climate change) and health, and in the context of the ageing population, are the two obvious examples but there are a large number of other issues in the effectiveness and management of public services that are becoming critical. The growing need for knowledge in the state sector not only affects the type of customer relationships which knowledge producers have to foster, but also extend the **types** of knowledge that need to be translated from technical knowledge into the social sciences.

The role of the state as a buyer of research is one driver behind the departmentalisation of government funded research and research organisations. Departments with different sectoral interests have a long history of establishing policy oriented research centres, with which they have a close relation and often a direct governance relationship. This is one of the reasons that many countries, including the Netherlands, have a wide set of public and semi-public research and technology organisations (RTOs) under direct control of a department. As discussed below only the UK has drastically cut in these research organisations.

2.4.5 Effects of changes on the organisation of knowledge production

Even if we at this stage are not in a position to do a strict analysis, there are several trends in the organisation of knowledge production, which appear to be related to these drivers.

- Research institute systems are discussing or being driven towards larger, more generic entities. In a number of cases, where institutes have their origins in branch research associations, these links are being weakened, allowing the institutes to tackle wider markets and to offer solutions, which span more areas of knowledge. Examples include the strategies of the more successful UK research Associations, the current Swedish debate, and ongoing restructuring at TNO
- The old-fashioned 'three hump model' where universities, applied research institutes and industry have distinct and separate roles in a division of labour for knowledge production has broken down. The activities of these actors increasingly overlap, they increasingly work together, and they increasingly employ personnel (including doctoral researchers and professors) mutually.

Examples include the long-standing practices of the Fraunhofer Gesellschaft, the use of 'industrial doctorands', the established practices of certain universities with tight industrial relations (especially in the USA and UK), and the growing efforts being made by other universities to build such linkages

- Further evidence of this interpenetration comes from the trend of powerful knowledge producers in industry in locating small research laboratories or 'observatories' on campuses where they have close access to world class research. It is noticeable that companies are highly discriminating about quality, and will only invest to be close to the world's best researchers. Examples include ABB corporate research at Lund, located close to that universities excellent control theory capabilities, but there are many others
- Intellectual property rights are increasingly important, both as a constraining factor in research agendas and as a source of income for universities, which generally regard the MIT model with envy but have difficulty in imitating it
- The creation of global and continental-level markets for knowledge (and education) is one of the factors promoting the emergence of 'super-universities' – generally, but not only, built on existing advantages. Examples include, Stanford, MIT, Harvard, Cambridge UK, and potentially clusters of universities in the Öresund region and Stockholm/Uppsala corridor
- There are initial signs of additional kinds of private-public partnerships emerging at the university-industry interface. Such relationships were important, for example, in Microsoft's decision to locate major facilities in Cambridge, UK.

Apart from challenges coming from the world of science and technology, additional challenges are exerted in the political arena and the public sector itself, particularly Parliaments and Finance Departments. The public sector is held more accountable for how it spends the tax-payers money as well as how it reaches decisions. Three of the five key words in the European Commission's definition of governance refer to this: openness, accountability and effectiveness. Much of this has to do with the influence of principles of New Public Management.
Hughes (1994)[9] described three central elements of New Public Management:

1 A focus on mission, goals and strategy
2 A focus on results and performance measurement
3 Attention for external relations

In the typical/traditional innovation governance models where responsibility is decentralised and spread over many actors, addressing these central elements requires, clear agreements as to who sets the goals, what the expected results are, and in how far there is a need to involve stakeholders. The influence of the New Public Management is slowly increasing in the countries studied. This brings, *inter alia*, the ideas of

- Contractual relations between principals and agents
- Specification of agents' tasks in terms of goals, with the detail of how the goals are reached becoming the responsibility of the agent, not the principal

[9] Hughes, Owen E., (1994), Public Management and Administration, St. Martin's Press, New York, cited from Schilder, Ard, (2000), Government Failures and Institutions in Public Policy Evaluation, Van Gorcum, Assen.

- Reporting and accountability extending beyond finance to encompass limited sets of performance indicators, carefully chosen to avoid encouraging perverse behaviour (i.e. maximising the indicators, rather than the performance).

3 The benchmark countries: a brief overview

In consultation with the Ministry of Economic Affairs we have chosen six countries that:

- Were most likely to have good practice examples in terms of governance
- Had some similarity with the Netherlands in terms of population, economic structure and R&D performance (with the exception of the UK).

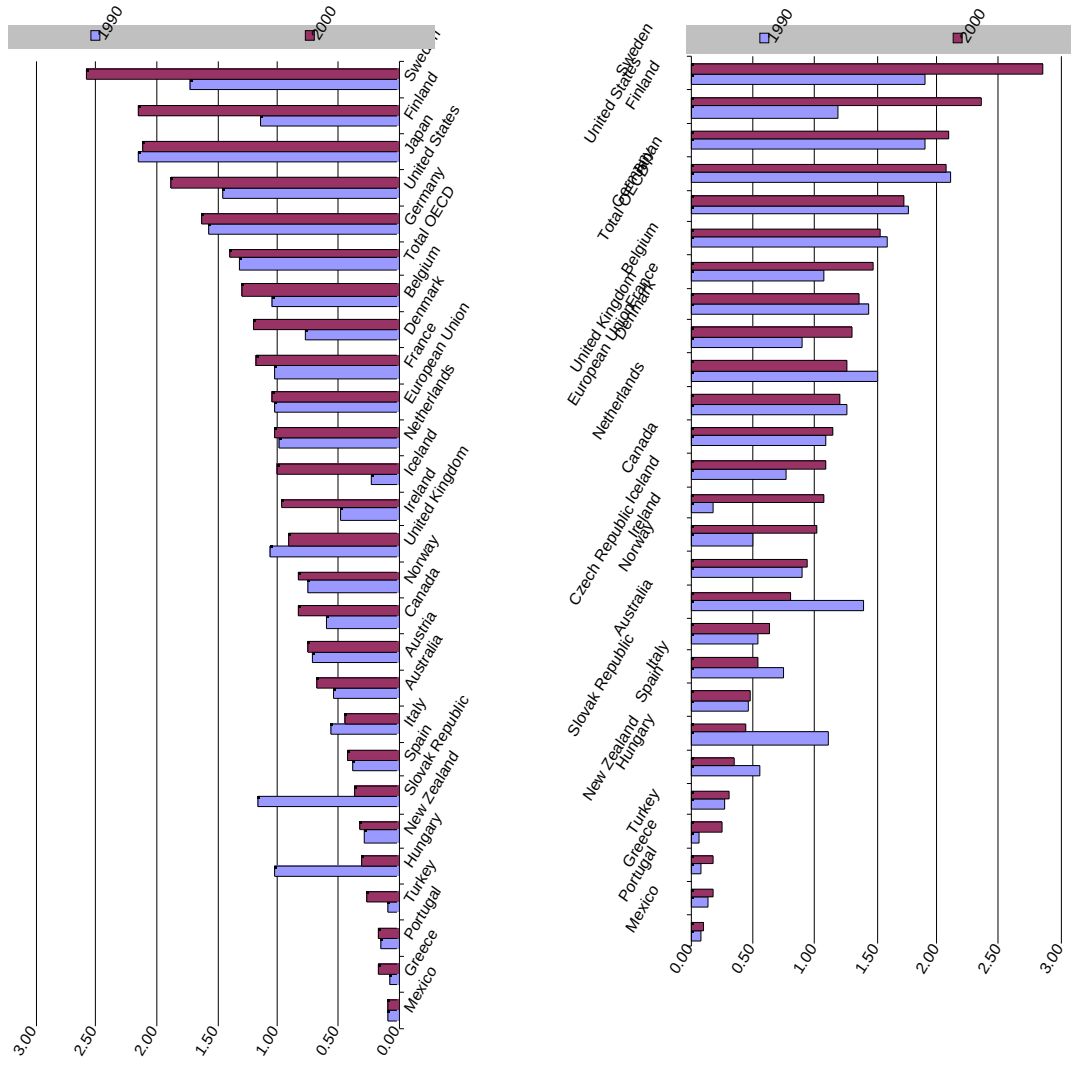
These countries are Canada, Denmark, Finland, Ireland, Sweden and the United Kingdom. We will also refer to Norway, which is not part of this study but has been analysed in parallel. Detailed accounts of these countries can be found in Part II of this report. A very brief description of each of these governance systems follows:

- Canada is highly centralised with a wide network of federal government agencies and departments taking a key role not only in steering research and innovation, but also in conducting a large part of intramural governmental research
- Denmark has a governance system where stakeholders in the research community have considerable influence on the direction of research through a mainly bottom-up process of allocating funding. The innovation part of the governance system is relatively small, in part because industry focuses on framework conditions rather than on public financial support. The governance system is currently under review
- Finland has a quite lean and well co-ordinated governance system, with a high level of commitment to research and innovation from the Cabinet. It has implemented principles of New Public Management in many parts of its system
- Norway has a relatively centralised research and innovation funding system with one powerful agency dealing with research and innovation. At the same time it has, for its population size, quite an extensive network of research institutes. It has enthusiastically embraced many ideas of the New Public Management, including the principle of management by objectives
- Sweden's governance system is very well geared to a high level of commitment to science and research. The science community is given a large amount of trust and independence to define its own direction. At the same time however, the weakness in the system is evident in its poor links with innovation, which is partly due to its governance model
- The United Kingdom has a strong central function for science and research with its Office of Science and Technology. Innovation governance has been more haphazard with little involvement of stakeholders. At the same time it has built in various checks and balances from 'watchdog' organisations such as the Audit Office. The UK has implemented New Public management principles in many parts of its system.

The following Exhibit 2 positions these benchmark countries in terms of their business R&D activities. This gives only part of the picture but in the light of recent discussions around the ambition to boost Europe's R&D figures to 3% of GDP not an unimportant one.

Exhibit 2 Business performed R&D

National trends in industry-financed and business-performed R&D relative to GDP, 1990-2000[1]



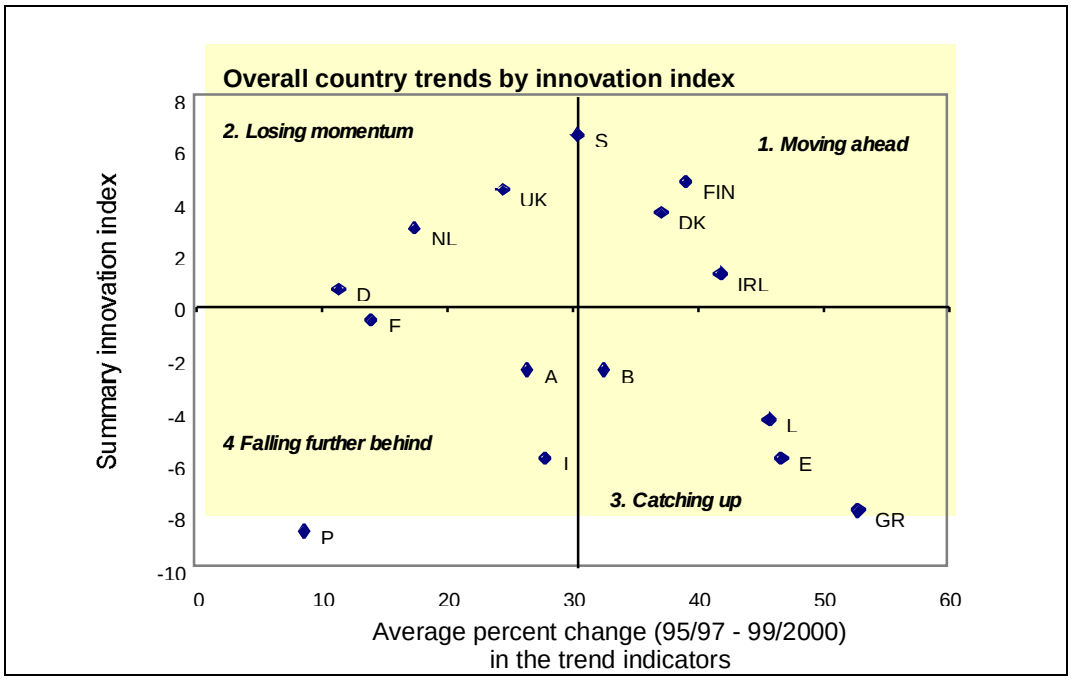
Note: 1. Nearest available year.

Source: OECD, MSTI Database, June 2002.

The figures show that Finland and Sweden have been very successful in boosting business related R&D visible in their particularly high share of BERD in GDP. Denmark shows an increase in the period since 1990, and has a relatively high BERD/GDP level, despite its SME dominated economic structure. The only country whose situation has deteriorated is the United Kingdom, where BERD/GDP rates have dropped, as well as its industry financed R&D.

A similar picture comes from the Innovation Score Board[10], which does not include Canada and Norway. The Nordic countries are all situated in the category 'moving ahead' with exceptionally high innovation scores for Sweden and positive trends for all countries apart from The Netherlands and the UK. Whether the governance of STI has influenced this level of performance is extremely difficult to establish. And whether the 'moving momentum' of the UK can be attributed to bad governance or rather to other factors such as a declining industrial basis will also be difficult to prove. But learning from those that have apparently done much better on average than others is a good starting point.

Exhibit 3 Benchmark Countries in the Innovation Scoreboard



The difficulties of establishing a link between STI governance and economic and social development are extreme. They are complicated by path dependency, which implies that successful solutions may evolve in particular times and places that are relevant in their contexts, but which are not necessarily valid in all places and at all times. Given that we investigate only a handful of examples, it would be dangerous to draw overly general conclusions. Nonetheless, we think that a number of lessons emerge, which may be useful. We (crudely!) characterise the successfulness of the innovation systems considered as follows:

- Canada is a branch-plant economy on the US periphery. Developing a stronger industrial base is a prerequisite for moving from resource- to industry-based development. It has managed to move its GERD/GDP ratio up since 1990, as well as the percentage of business R&D in some sectors. The Canadians have set themselves the target to move Canada from the 15th place to the 5th place in the

[10] European Trend Chart on Innovation, Innovation Scoreboard, www.cordis.lu/trendchart

world in terms of performance in R&D. Nevertheless, there seems to be no clear strategic response to this challenge in the Canadian STI policy community.

- Finland has been developing rapidly from a resource- to an IT-based economy, and has been making massive investments in state R&D in order to support this transition. The strategy of massive state investment in R&D during the 1990s is now being questioned – on the basis that it seems to have 'run out of steam' – and may no longer be an adequate basis for future policy.
- Norway is locked into largely low-R&D sectors, making it structurally difficult to use research as a motor for change. Sustaining present oil-supported levels of welfare in the future will not be possible without generating major new industry. There has been some recent success in setting national research priorities likely to address these issues, though reforms are likely be needed in parts of the innovation infrastructure.
- Sweden is more problematic. It has moved quickly to become the world's most R&D-intensive economy, but has been losing relative position in terms of GDP per person for a long time now. The implication is that there is something fundamentally wrong with Swedish assumptions about how the STI system works. As one of us tactlessly put the question at a recent Swedish conference on research and economic development: "If you're so clever, how come you ain't rich?"
- Ireland is regarded as the 'European Tiger' and is in the process of catching up with the more R&D intensive countries. It has succeeded in increasing BERD at a rate of 20% during the 1990s as well as the economic wealth of the country. Its main challenge now is to keep the public research sector in line with demands for higher quality research from the business sector. It has adapted its governance system to cater for these challenges, but whether this is in time to keep foreign investors in place needs to be seen.
- Denmark has been one of the high performers in R&D, as well as in creating welfare for its citizens. R&D is a key element in the governments strategies and a doubling of R&D budgets has been announced, but still not delivered. It is currently undergoing a radical reform in its entire governance system, with integration and coherence as a central objective.
- The United Kingdom is suffering from similar innovation paradoxes as Sweden. Despite its top position in the world in terms of academic science, the share of its business R&D is decreasing. Changes in the governance structure are geared to maintaining the science excellence while improving the links with industry. A declining manufacturing base might be compensated with a growth in business in new technology areas such as bio-technology and pharmaceuticals.

A summary of context and governance trends in these eight countries is shown in **Exhibit 4** in the following three pages.

Exhibit 4 Summaries of Context and Governance Trends in Countries Studied

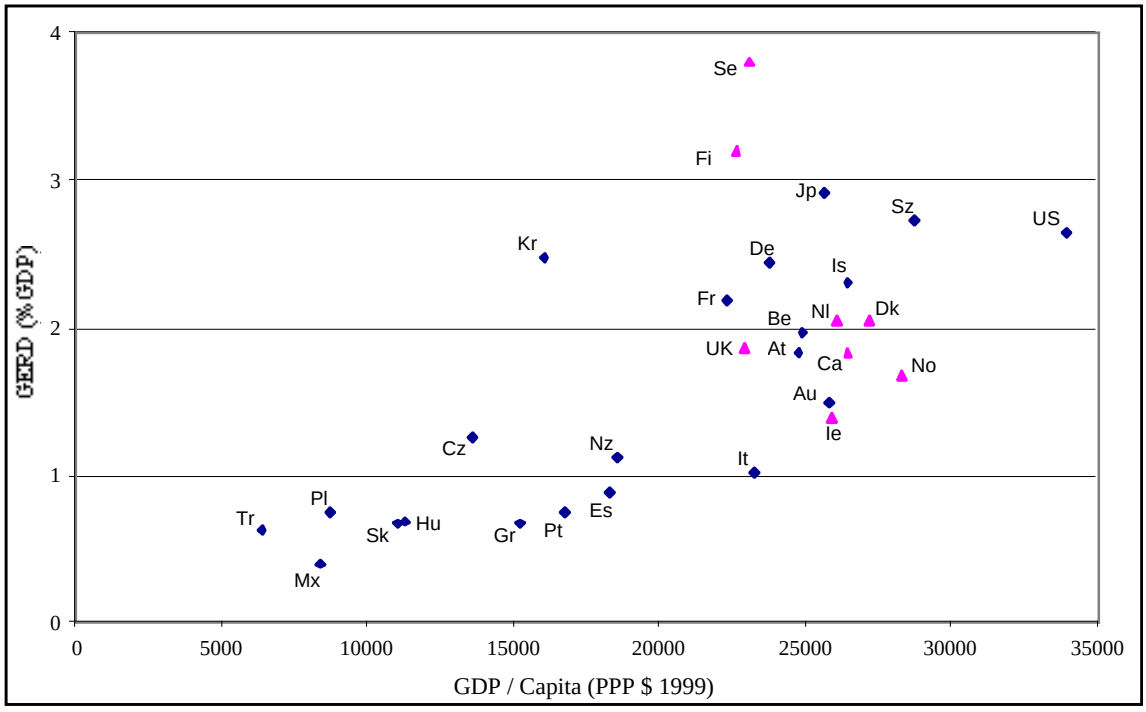
Country	Context	Governance
Canada	Canada is a branch-plant economy on the US periphery. Developing a stronger industrial base is a prerequisite for moving from resource- to industry-based development. It has managed to move its GERD/GDP ratio up since 1990, as well as the percentage of business R&D in some sectors, but industry's R&D efforts remain rather limited – especially given the amount of high-technology production in Canada. The Canada has set itself a target of moving from the 15th to the 5th place in the world in terms of expenditure on R&D. Nevertheless, there seems to be no clear strategic response to this challenge in the Canadian research and innovation policy community.	Canada is highly centralised with a wide network of federal government agencies and departments taking roles not only in steering research and innovation, but also in conducting a large amount of intramural governmental research. There have been rather frequent changes in governance and advisory structures, but the effects of these reforms appear to have been limited. Horizontal co-ordination has not been very effective. Existing advisory structures have little influence on government. Lack of continuity in government has undermined its role in developing effective governance. Effective advice essentially has a personal, not an institutional, character.
Denmark	The Danish economy is solidly SME-based, and Denmark has succeeded in creating a good level of welfare for its citizens, while making a modest overall investment in R&D. R&D is nonetheless a key element in government strategies and a doubling of R&D budgets has been announced. Basic research has especially high status and priority in Denmark – despite the industrial structure, which would normally tend to imply limited capacity in industry to absorb and exploit basic research.	Denmark is currently undergoing a radical reform in its entire governance system, with integration and coherence as central objectives. Denmark has a governance system where stakeholders in the research community have considerable influence on the direction of research through a mainly bottom-up process of allocating funding. The innovation part of the governance system is relatively small, in part because industry policy focuses on framework conditions rather than on public financial support. The governance system was being reformed during the period in which we were in the field.
Finland	Finland has been developing rapidly from a resource- to an IT-based economy, and has been making large investments in state R&D in order to support the associated growth in BERD. The strategy of massive state investment in R&D during the 1990s is now being reviewed in a series of system evaluations.	Finland has a quite lean and well co-ordinated governance system, with a high level of commitment to research and innovation from the Cabinet. The Industry and Education ministries have separate research and innovation agencies, each with considerable autonomy. However, there is a high level of both formal and informal horizontal co-ordination. The National Science and Technology Council, chaired by the Prime Minister, serves as the ultimate setter of strategic directions and arbiter.

Country	Context	Governance
Ireland	Ireland is widely regarded as the 'Celtic Tiger' and is in the process of catching up with the more R&D intensive countries in terms of GDP per head. It succeeded in increasing BERD/GDP rapidly during the early 1990s, but this growth has now tailed off. Most R&D is done by foreign multinationals, and while there are growing numbers of dynamic, Irish technology-based firms, the R&D-intensity of production overall has stagnated in the last few years. A massive investment in the state higher education and research infrastructure, and in research on ICT and biotechnology, is being implemented in the first years of the new century, which appears to be running ahead of Irish-based industry's absorptive capacity. Recognising that economic development has robbed Ireland of its historical low wage cost advantage, the intention is in the future to attract foreign direct investment in R&D rather than production.	Research and innovation have had low political priority in the past, with the main focus of development policy being on manufacturing production in high-technology industries. A comprehensive set of governance and co-ordination mechanisms was put in place in 1996, before the recent decision to increase research investment. In practice, these formal mechanisms have not been used during the period when the expansion was planned. During 2002, a government commission was appointed to analyse how to manage the overlaps and intransparencies that have apparently resulted.
Netherlands	The Netherlands' R&D-intensity tends to be little different from the OECD average, despite an industry structure that is comparatively technology-intensive. GDP per head is typical of the cluster of North European countries. There are strong national traditions of consensus building and co-operation, which may play important roles in making a rather complex governance structure successful.	Governance in the Netherlands is strongly split between a decentralised style in research (the sphere of the education ministry) and a very hands-on style by the ministry of industry. The research and innovation system has grown by accretion to become very complex, with large numbers of organisations involved. While this produces a risk of lock-in, it also means there is a good measure of de facto co-ordination. A new, high-level council (CWTI) has been created to prepare and co-ordinate policy decisions from various departments.
Norway	Norway is locked into largely low-R&D sectors, making it structurally difficult to use research as a motor for change. Raising the proportion of GDP to be spent on R&D to 3% is nonetheless a long-standing national goal. Sustaining present high, oil-supported levels of welfare in the future will not be possible without generating major new industry. There has been some recent success in setting national research priorities likely to address these issues, though reforms are likely be needed in parts of the innovation infrastructure	Norway has a relatively centralised research and innovation funding system with one powerful agency dealing with research and innovation. At the same time it has, for its population size, quite an extensive network of research institutes. It has enthusiastically embraced many ideas of the New Public Management, including the principle of management by objectives. Ministries' interests in research are strongly sectorised, and there is a tendency in some ministries towards very detailed management of the research expenditures on the single national research council. The effectiveness of horizontal co-ordination advisory mechanisms and the level of government interest in research and innovation policy have been highly dependent upon personalities.

Country	Context	Governance
Sweden	Sweden has moved quickly to become the world's most R&D-intensive economy, but has been losing relative position in terms of GDP per person for a long time now. The implication is that there is something fundamentally wrong with Swedish assumptions about how the research and innovation system works.	Sweden's governance system is very well geared to a high level of commitment to science and research. The science community is given a large amount of trust and autonomy to define its own direction. Horizontal co-ordination is achieved partly by the education minister assuming responsibility for research in the government and partly through a large number of formal and informal co-ordination mechanisms at ministry and (especially) agency level. However at the same time the weakness in the research system is its poor links with innovation, which appears to be partly due to its governance model.
UK	The United Kingdom is said to be suffering from similar innovation paradoxes to Sweden. Despite its strong position in the world in terms of academic science, the share of its business R&D is decreasing. Changes in the governance structure are geared to maintaining scientific excellence while improving links with industry. A declining manufacturing base might be compensated in a growth in business in the new technology areas such as bio-technology and pharmaceuticals.	The United Kingdom has a strong central function for science and research with its Office of Science and Technology. Innovation governance has been more haphazard with little involvement of stakeholders. Indeed, the UK lacks the strong industry-oriented R&D policy measures found in many other North European countries. It has built in various checks and balances from 'watchdog' organisations such as the Audit Office and has implemented New Public management principles in many parts of its system. A Chief Scientific Advisor with direct access to the Prime Minister oversees science policy, the use of scientific advice and science-related policy issues. However, this role focuses more on science-related policy issues (such as BSE) than on horizontal research and innovation policy co-ordination.

Exhibit 5 plots national research-intensity against wealth generated per head. While the reader should guard against over-interpretation of such a snap shot, it does provide a useful reminder that the R&D-intensive Finnish and Swedish positions may not, in the longer term reflect a good return on R&D investment. The Netherlands with its relative low level of GERD/GDP actually performs better than these two countries in terms of GDP/per capita.

Exhibit 5 Research-Intensity and Wealth, 1999



Source: OECD Main Science and Technology Indicators 2001/2. (GERD %GDP data for Au from 1998, Ie, Nz from 1997, and Sz from 1996)

While studying the benchmark countries and discussing the governance issues with The Ministry of Economic Affairs we distilled four key governance issues relevant across all countries:

1 The need for a better integrated and co-ordinated approach in the development and design of STI policies. The departmentalisation and fragmentation of policy development is a pressing problem across all countries.
2 How can the system decide on priorities, in particular when big changes are required, or new challenges arise?
3 How can the principles of New Pubic management be applied in a governance model with many actors and decentralised responsibilities? In the Dutch situation a pressing issue which was highlighted is how to steer the vast network of research funders, agencies, intermediaries and research organisations?
4 How can we make better use of the co-ordination between national and regional actors in the governance system?

The coming four chapters will go into these issues in more detail.

4 An integrative approach to science and innovation policy

4.1 Who is responsible for science and innovation policy?

A major challenge that all benchmark countries are facing is the better integration and co-ordination of research and innovation policies that are divided over various actors in the innovation system and also within public administration. As suggested in our earlier discussion, funding systems increasingly have to cope with issues that cut across individual funders' and ministries' responsibilities. Traditionally the governance system and policies dealing with long term and basic research are not co-ordinated with those geared to the exploitation and commercialisation of knowledge (innovation). This could for instance lead to a pool of knowledge which is not exploited optimally since it does not find its way to innovation. From the other perspective, ideas for new opportunities that would rely on this new knowledge are not carried out since access to critical knowledge is hampered. Although it is generally accepted that the linear approach of innovation is outdated, the elements of the 'knowledge chain', represented by different actors in the innovation system, still need to be inter-linked. Therefore there is also a need for co-ordination at the policy level. Practice in the Netherlands also shows that to really tackle issues such as intellectual property rights, encouraging university spin-offs and industry-academia collaboration, asks for science **and** innovation policies to strengthen each other.

In broad lines we can see the following pattern of decision making:

- **Decision making relating to technology and innovation policies**. The typical pattern here is a strong influence from the Ministry, usually the Ministry of Industry, on the contents of policy instruments, which are subsequently out-sourced to one or more agencies.
- **Decision making in sectoral domains** (Health, Agriculture, Environment etc….). A typical pattern here is a strong relation between the sector Ministry and some public research laboratories that work almost exclusively for them. The Scandinavian model, however, is to interpose research councils between these ministries and research performers, increasing diversity among research performers.
- **Decision making with regards to science and research policy.** The typical pattern here is a Science Ministry that has handed over considerable authority to Research Councils as funding agencies.

The following **Exhibit 6** gives an overview of the Key Ministries involved in the entire spectrum of science to innovation. It provides an approximate of the share of the total government budget they spend on R&D. The level of funding is not necessarily a direct indicator for responsibility or power. In many countries the budgets for, for instance, academic research are immediately channelled to other organisations such as Research Councils which have a variation of levels of control, as we shall discuss in Chapter 6. The exhibit does give an impression of the broad range of departments and agencies involved in the decision-making processes.

Exhibit 6 Key Ministries with SR&I budgets

	Ministries and Departments with more than 5% of total SR&I budgets
Canada* (2001)	National Research Canada (10%) Natural Sciences and Engineering Research Council (9 %) Statistics Canada (9%) Environment Canada (9%) Industry Canada (7%) Natural Resources Canada (7%) Canadian International Development Agency (6%) Canadian Institutes of Health Research (6%) Canadian Space Agency (6%) Fisheries and Oceans (6%) Agriculture Canada (6%) National Defence (5%) Canada Foundation of Innovation (5%)
Denmark* (2002)	Ministry of Science, Technology and Innovation (69%) Ministry of Food, Agriculture and Fisheries (8%) Ministry of Culture (5%)
Finland (2002)	Ministry of Education (42%) Ministry of Trade and Industry (35%) Ministry of Social Affairs and Health (9%) Ministry of Agriculture & Forestry (7%)
Ireland (2000)	Department of Enterprise, Trade & Employment (41%) Dept. of Education and Science (32%) Dept of Agriculture, Food and Rural Development (13%) Social, Community & Family Dept. (5%)
Netherlands (2001)	Ministry of Science and Education (64%) Ministry of Economic Affairs (17%) Ministry of Agriculture and Fisheries (6%) Ministry of Transport and Water Management (5%)
Sweden**	Ministry of Education and Science Ministry of Industry, Employment & Communications
United Kingdom (1999-2000) ***	Ministry of Defence (38%) Office of Science and Technology (22%) Higher Education Funding Councils (19%) Department of Health (8%) [Department of Industry (4%)]

* Canada does not have a similar departmental structure as most European countries have. Agencies are seen as independent 'departments', rather than an implementation body of a particular Ministry
** Sweden's budget is allocated by domain rather than by Ministry, therefore we have not been able to make a comparable allocation of funding to departments. The areas which receive large funding are research funding channelled through the Ministry of Education and Science and funding for Innovation and ICT channelled through the Ministry of Industry.
** If we exclude defence related research in the UK the breakdown would be OST 35%; HEFC 30%; Department of Health 12%; and DTI 6%.

As **Exhibit 6** shows most countries have the division between an Education and Science Department, the typical Industry Ministry and a number of sectoral ministries, typically Agriculture, Environment, Defence and Health. Apart from Canada, the funding in all countries is subsequently reallocated to a 'middle layer' of Funders and Agencies. The UK budget is organised somewhat differently since it allocates science funding not to one of the Departments but to the Office of Science and Technology and the Higher Education Funding Council.

We immediately see a number of striking features:

- A very fragmented structure in Canada with a multitude of Science Based Departments and Agencies which are directly in charge of their budgets. Once a budget has been allocated, it is the responsibility of the department agency or council to manage the funds
- A relatively lean departmental structure in Denmark and the Netherlands
- One department controlling more than 50% of the public STI budgets in the Netherlands (Education and Science Ministry) and Denmark (Ministry for Science, Technology and Innovation)
- A strong emphasis on defence and health related research in the UK, which have far larger budgets than for instance the Department of Trade and Industry (excluding OST funding, which mainly goes to the Research Councils). The huge funds for health research are reflected in the strong position of medical research and pharmaceuticals in the UK as the technology case shows
- Health as a sector ministry for R&D is not prominent in Denmark, Ireland or The Netherlands
- Agriculture is a prominent actor in all countries but the UK
- The Netherlands is the only country where the transport Ministry is among the bigger spenders.

4.2 Integration across three dimensions

The above describes the picture of fragmented responsibilities for innovation policy. The European Commission's White Paper on Governance identified the issue of coherence, meaning that different policy objectives and policy instruments should not work against each other, and even better still make use of synergies to strengthen the effectiveness of the whole portfolio.

In our study we have looked for governance models that encourage coherent policy approaches for research and innovation. More concretely this means we have looked for mechanisms that co-ordinate and integrate research and innovation policies in a better way.

The shift from the linear to the integrative approach of innovation can almost be considered as the accepted model in most OECD countries, even though linear thinking, practices and routines are still widespread. In all of the benchmark countries the integrated approach of innovation policy, thinking in terms of evolutionary models (national or dynamic innovation systems) has become a common goal in the policy debates and discourse. Nevertheless the question of implementation of such an integrated perspective is an issue that all countries are struggling with. The heritage of an innovation system that has been built up in an era where the linear thinking still dominanted, constitutes an obstacle to adapting the governance structure to the new challenges.

In the Netherlands, the lack of co-ordination between Ministries on research and innovation issues has also been taken up as a necessary reform in governance. The recent establishment of the Interdepartmental Committee for Science, Innovation and Informatics (CWTI) as a co-ordination body to prepare the overall policy strategies on science, research, (information) technology and innovation policy illustrates this most clearly. The Interdepartmental Investigation Innovation Policy (in Dutch known as Interdepartementaal Onderzoek Technologiebeleid (IBO)) conducted in 2002, concluded that the portfolio of policy instruments for innovation of all Ministries was departmentalised and fragmented. [11] Co-ordination and collaboration between Ministries was one of the options recommended by this government report. The CWTI is one possible response to this challenge. But an integrative approach to research and innovation policy requires more than the co-ordination between Ministries only.

In line with the changes in knowledge production as sketched above the study found the need for greater coherence and integration along three dimensions:

1 The integration of knowledge creation (mostly basic research) and the use of knowledge for innovation; In an innovation system this could involve bringing together those actors that focus on different roles in the knowledge production chain. In policy terms this involves the integration of science, research and innovation policy.
2 The co-ordination and attuning of different societal and economic goals of research and innovation; In policy terms co-ordination and attuning between SR&I policies for the stimulation of industrial growth, for improved use of information technology, environmental preservation, a healthy population, good quality food, etcetera.
3 The combination of knowledge from different science disciplines to tackle interdisciplinary research needs (e.g. bio-technology) and overarching societal problems that need such an interdisciplinary approach (e.g climate change).

The demand for a more coherent policy to address the knowledge society involves all these three integration aspects. Our study suggests that all benchmark countries have identified one or more of the above dimensions of integration as an objective for reform and improvement of governance. The solutions chosen, the type of actors dealing with the challenge and their success in having an impact differs from country to country.

The first two dimensions have mostly to do with the allocation of responsibility for science, research and innovation at departmental level.

[11] Ministerie van Financiën, Samenwerken en stroomlijnen. Opties voor een effectief innovatiebeleid. Eindrapportage IBO technologiebeleid, 2002.

4.2.1 Integration between government departments

The dominant picture in the benchmark countries is that there are 'separate' governance structures for science and research policy on the one hand and for innovation and industry oriented research on the other hand. The typical divide is a Ministry for Education and Science dealing with university research and a Ministry for Industry dealing with applied research and technology. Of the countries considered, only Denmark has a dedicated research and innovation ministry.

We have also seen in section 4.1 that, judging by the allocation of budgets, responsibility for science, research and innovation is spread across a variety of sectoral departments. It is however generally accepted that research and innovation need to be on the agenda of nearly all ministries, since they are integral to wider policy. Departments concerned with for instance health, the environment, civil engineering, and transport have very specific research needs and act as a substantial research customer. In most countries this has led them to develop their own research networks, agencies and government laboratories over many years. Further, dedicated research ministries tend to become isolated, competing with strong sector interests for funding..

Nevertheless both types of compartmentalisation (between research and innovation and between sectors) have their drawbacks when it comes to a more integrative approach to research and innovation.

What is problematic about this 'departmentalisation'?

- Some societal issues are too big to address from one sectoral perspective only
- The creation of separate, relatively closed departmental research and innovation networks has a risk of preventing government in receiving the highest quality and/or independent advice
- Some issues such as intellectual property rights, encouraging university spin-offs and industry-academia collaboration, asks for science **and** innovation policies to strengthen each other
- From the perspective of the user (industry, research) a multitude of R&D support mechanisms hinders transparency
- As we suggested at the start of this document, a growing number of key knowledge and policy challenges appear to span multiple sectoral responsibilities. (The inability of a fragmented innovation and research system to tackle this was a key reason for the reform, which set up the single Research Council of Norway in 1993)

Barriers to integration can be significant. One is the major cultural difference that developed between 'basic science' and 'research and innovation' communities in the post-War period. Arie Rip points out that the post-war social contract with (basic) science was largely stable until the 1970s. Under this regime, the state provided patronage by delegating its responsibilities to research councils, which were largely captured by the scientific community itself. As a result

> Scientists definitely acquired an entitlement attitude: it was their right to be funded, and to be funded on their own terms…. Life on the Endless Frontier was competitive, but competition was kept within bounds by new traditions of patronage [from research councils]. Scientific establishments … could reproduce themselves, and did so (up to reproduction of gender asymmetries). The incestuous element in such a set-up reinforces the risk-aversive tendencies of the funding agency as a bureaucracy… The importance of novelty is recognised and enshrined in the criterion of 'originality.' But to actually get scarce resources awarded to far out proposals is not easy in the multi-layered systems, where scientific establishments as well as bureaucratic accountability must be honoured.[12]

From the 1960s and 1970s, however, new social unease about the role of science appeared. Nuclear energy, the peaceful face of the atom bomb, turned out to be dirty and dangerous after all. The environment was more generally seen to be suffering from the effects of science-based industry, and people began asking just what scientific neutrality meant in the context of weapons development for the Vietnam War. As the Cold War receded, governments became more interested in promoting technology for competitiveness. Some governments, especially in northern Europe, began to wonder about the practical applicability of the social sciences. As a result, over the last 20–30 years, there has been a shift away from the idea that scientists should be supported as autonomous truth-seekers and towards the idea that they should orient their work rather more towards social and economic objectives. Today they have less autonomy than in the 1950s and 1960s, and are held more accountable. In effect, the nature of the social contract with the research community has changed, a fact that is deeply resented and contested in the research community, which in turn resists attempts to integrate with 'relevant' research done for explicitly social ends.

Integration of research and innovation activities across the sectoral responsibilities is also strongly resisted in most systems, due partly to legitimate concerns that individual ministries should be able to fulfil their sectoral responsibilities. Often, the risk of loss of control over activities or budgets is a key aspect – so that cross-sectoral innovation and research activities tend to become casualties in the traditional inter-ministerial turf wars.

However good the theoretical justifications, it is difficult to provide convincing **practical** arguments for integration of the two research communities or across ministry responsibilities because there are rather few successful examples.

The following **Exhibit 7** gives an overview of the solutions sought for the integration issues along the first and second dimensions. Some of these responses specifically aim to bridge the gap between science and innovation, others are mechanisms to co-ordinate along the sectoral dimension or both. We can see solutions at three levels:

- Creating a policy decision making or advisory structure on top of the Ministries (Finland, Ireland) which report directly to the government
- Reorganising the department structure, giving responsibilities to one or a few departments (Denmark)
- Strengthening co-ordination mechanisms at interdepartmental level (UK, Sweden, Canada)

[12] Arie Rip, "Aggregation machines – A political science of science approach to the future of the peer review system," (mimeo), University of Twente, 2000

Exhibit 7 Overview of governance responses to integration in policy making

Country	Integration of science, research and innovation policy	Co-ordination between departmental sectors
Canada	The Council of Science and Technology Advisors	The Science-based Department and Agency Assistant Deputy Minister's Committee
Denmark	Launch of one Ministry responsible for science research, innovation and IT	Slightly more powers to central ministry in total SRI budgets
Finland	Science and Technology Policy Council	
Ireland	Cabinet Committee on Science and Technology Interdepartmental Committee for Science Technology & Innovation	
Netherlands	Interdepartmental Committee for Science, Innovation and Informatics (CWTI)	
Norway	Creating a single Research Council, including the national innovation agency (formerly NTNF)	Government research committee (RFU). Discussions are ongoing about extending the remit to include innovation
Sweden	Education Minister overall responsibility for Research and Innovation Policy Interdepartmental Committees	
UK	Cross-departmental programmes Cross-departmental organisations such as the Office of Science and Technology One integrated Science and Innovation White Paper	

The traditional response to co-ordination is to set up *ad hoc* co-ordination groups or task forces. Swedish practice is in this respect very traditional. There is a legal requirement for inter-ministry consultation on all matters which cross ministry boundaries – a process that seems to work surprisingly well. Ministries then instruct their agencies to co-ordinate, and allocate the lead role to one of their agencies. The apparent success of this approach in Sweden probably depends in part on the high value placed on co-operation in Swedish culture. It is therefore not clear how transportable this approach is, as a universal solution.

The current Swedish research organisation uses a second co-ordination mechanism - the person of the education minister. His strong personality and political position are preconditions for success. A large part of the co-ordination involved amounts to implementing a policy of allowing the researchers to decide, so the degree of practical co-ordination involved seems rather low, and probably not threatening to existing organisations. We would therefore also question the transportability (and usefulness) of this Swedish solution in an international context.

In both **Norway and Sweden**, the education ministry plays (different) roles in creating a virtual research ministry. In Norway, this function appears largely descriptive, with the education ministry having no power over the others. In Sweden, special arrangements which place the education minister in the chair for all government discussions of research and which make all major research agencies

report to him (regardless of sector) provide a much stronger lead role for his ministry as a quasi-research ministry, without at the same time undermining the research budget.

In the **UK** the Department of Trade and Industry (DTI) has overall responsibility for the Government's science and innovation policy as a direct result of its 'ownership' of the Office of Science and Technology (OST), which has its own junior minister (Lord David Sainsbury, Minister for Science). The OST was established in 1992 within the Cabinet Office, however, since 1995 it has been part of the DTI, reflecting the government's desire to strengthen the interplay between science and economic performance. The Chief Scientific Advisor in OST is supported by the Trans-departmental Science and Technology Group within OST.

In the **UK,** horizontal co-ordination across government departments and other public bodies is an increasingly important topic and cross-departmental working groups have been founded in numerous areas to reconcile the competing pressures of a distributed system of government with the desire for concerted action across sectors and domains. Co-ordination is managed at several levels, in addition to the cohesion offered and sought through the science and innovation white paper:

- Cross-departmental research structures and organisations, such as the Office of Science and Technology or Research Councils UK or the British National Space Centre
- Cross-departmental programmes, such as Foresight, LINK, Teaching Company Scheme and Faraday Partnerships
- Cross-departmental processes, from R&D programme definition tools to science communication[13]

Activity on all three levels has been increasing. The fact that the UK Government publishes an integrated Science and Innovation Policy White Paper, with strategies for all Departments, also illustrates the will to tackle both subjects in an integrated manner.

Denmark is the exception in terms of Ministry structure and offers an interesting case for this governance study. With a new government in place since late 2001, the structure of the Ministries was drastically altered. It was exactly the poor co-ordination and integration between science, research and innovation that prompted the government to form a type of 'super ministry' responsible for science, research, innovation and information technology, called the Ministry of Science, Technology and Innovation. This 'super ministry' was formed around an existing, much smaller and weaker Ministry for Research and Information. The former Ministry of Education and Science transferred all responsibilities in relation to the universities to this new Ministry, including education issues. From the Ministry of Trade and Industry came the division that deals with innovation support to the business sector. The other ministries (Agriculture, Environment, Health etc.) have maintained their own R&D budgets.

Advantages of the creation of this "Super Ministry" are that

[13] For example, the ROAME procedure requires the public administration in question to be able to demonstrate (to an independent party or review board) the additional value of a proposed S&T initiative over and above those that exist already. And that the organisation in question is the natural administration to lead the work nationally and with that comes the responsibility to coordinate with other organisations.

- one Ministry is responsible for all aspects of research and innovation
- all university matters are integrated with research and innovation policies which makes it easier to define strategies around commercialisation of research, IPR regulation etc.
- co-ordination could in principle be more easily established under one roof

Most of our discussants in this study would see two principal disadvantages of centralising responsibility for research and innovation in this way. First, it creates a single budget for research and innovation, which then has to compete with other ministries' budget needs in the process of setting the national budget – creating an opposition between research and innovation and other types of spending. Second, it removes responsibility from other ministries for integrating research and innovation aspects into their other policies.

The merger has however been very recent and whether the integration will actually work remains to be seen. The four pillars - research, universities, IT and innovation - are now organised in four divisions. Our interviews revealed that up till now civil servants are still working in their 'old' division. Co-ordination takes place at the level of division directors ,the actual integration of cultures and modes of thinking still yet to be realised. (see Country Report Denmark).

Ireland has a typical split governance model where one department is funding collaborative and strategic R&D, with relevance to industry and one department is dealing with the basic funding for the universities, the prime organisations in the Irish knowledge infrastructure. The policy emphasis was formerly on the first type of funding. Over the years this had led to a situation where the basic funds of the universities were so low that universities struggled to develop state-of-the art research departments and keep talented researchers in the country. This was felt to be undermining the competitiveness of Ireland and the linkages between the mostly foreign firms with the other actors in the innovation system. The imbalance among science, technology and innovation led to the establishment of Science Foundation Ireland to boost investment in two technology fields: IT and bio-tech.

In 1996 a White Paper on the national strategy of **Ireland** intended three new bodies to ensure a coherent and comprehensive approach to the design, delivery and evaluation of STI policies and programmes.

At the top of the new three-tier arrangement lives the Cabinet Committee on Science and Technology. Chaired by the Taoiseach (Prime Minister) or his/her nominee, the expected role of the Cabinet Committee was to make decisions on national S&T priorities and Budget Estimates for S&T. However, the Cabinet Committee has till now met only once (summer 2002), the priorities and estimates for S&T purposes have been established in the normal course of determining government departments' budget allocations, at full meetings of the Cabinet/Government and without any particular identification of research or innovation expenditures.

Underneath the Cabinet Committee sits the Inter-Departmental Committee (IDC) for STI. Chaired by the Minister for Science and Technology, the IDC has responsibility for working towards the prioritisation of S&T spending across Government

Departments and for the preparation of an annual S&T plan for the Cabinet Committee or for Government consideration. The IDC was expected to provide a forum where the role of STI policy in the achievement of national objectives could be coherently articulated. The recommendations of the IDC would then be discussed and sanctioned by the Cabinet Committee. However, the IDC has met infrequently, so the identification of national S&T policy issues and the prioritisation of actions in relation to them have not been developing in the way envisaged in the White Paper.

The new 'three-tier' organisational arrangements were completed with the establishment of ICSTI, an independent body appointed by the Minister for Science and Technology and Forfás, which provides expert, independent advice to Government within a firm legal mandate and foundation under the powers delegated to it by Forfás.

In reality only limited progress has been made in Ireland in terms of providing a coherent and co-ordinated approach to STI prioritisation. The formal governance structure has been set up, but the actors in the system still continue to work in their traditional 'compartmentalised' manner. At the time of writing, a commission convened by ICSTI and chaired by Ed Walsh, former rector of the University of Limerick, is reviewing these issues.

Canada has made several attempts for better integration and co-ordination, which in practice have not proved successful. For instance despite a government announcement of a joint Innovation Strategy by Industry Canada and Human Resource Development Canada, an integrated policy paper was never delivered, while separate Advisory Councils report to the Minister for Industry and the Minister for Science, Research and Development. Coherence and co-ordination have still been hindered by departmental territoriality and politics.

The high level Science and Technology Council of **Finland**, chaired by the Prime Minister consists of several Ministers, as well as representatives of the science and business community. The Council is responsible for the strategic development and co-ordination of Finnish science and technology policy as well as for the national innovation system as a whole. Here strong political support from the Government has made it possible to have such a top level dealing with overarching strategic science and innovation issues.

An approach to align activities at the level of agencies and intermediaries were the Finnish Cluster programmes. The Cluster programmes were a nationally inspired initiative to bring ministries' research activities and funding into closer alignment with the activities funded by The Academy, Tekes and industry. This alignment has been achieved to some degree with sectoral ministries being invited to sit on the programme boards of the Academy and Tekes, in cases where there is a complementary interest. This has lead to an increase in the exchange of information and awareness across these communities, and even, on occasion, multilateral sponsorship of 'cluster' projects. Joint financing is not common however as most sectoral ministries have a different interest in research, being more concerned with practical outcomes, whether in addressing a parliamentary question or framing a new piece of legislation. They have an indirect interest only in the advancement of knowledge more generally or the economic health of a particular industrial cluster.

However, the level of interaction between research and innovation responsibilities and other policy fields has increased and in some cases the concerns of the sector ministries have led to the setting of new research priorities and calls for proposals directed to the academic sector.

Similar to the high level committee in Finland the **US** has its **National Science and Technology Council (NSTC).** The NSTC is a cabinet-level council and is the principal means for the President to coordinate science, space, and technology and to coordinate the diverse parts of the Federal research and development enterprise. The President chairs the NSTC. Membership consists of the Vice President, Assistant to the President for Science and technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research, to improving transportation systems and strengthening fundamental research. The Council prepares research and development strategies that are co-ordinated across Federal agencies to form an investment package aimed at accomplishing multiple national goals.

4.2.2 Dealing with multi-disciplinarity

The issue of multi-disciplinarity is mainly tackled at the level of research funders, (i.e. the Research Councils) and research performers.

In **Norway** it was decided to form one Research Council, with a strong umbrella function, out of a number of individual Research Councils and divisions that existed beforehand. The rationale for this was to promote more cross-cutting interdisciplinary research, and to loosen the ties between some sectoral Ministries and individual research councils, which previously led to 'earmarked' research funding. The recent evaluation of RCN revealed that despite the change in the structure, the divisional boundaries inside the unitary Council still remained.

The six separate **Danish** Research Councils, with a Board of Danish Research Councils as an umbrella organisation, have sought a solution by launching research programmes that overarch the boundaries of single research Councils. The Ministry of Science, Technology and Innovation is trying to act as change agent in this respect. However the amount of funding that is channelled to the research community via the Research Councils is only about 10%. Two thirds of this 10% is allocated in a bottom-up, or response mode fashion. This means that the remainder will not have a great impact on changing behaviour from a mono-disciplinary to an interdisciplinary mode of working.

A similar ad-hoc picture can be found in the **UK** and **Canada** where separate research funders and agencies join forces in addressing inter-disciplinary issues such as ethics.

Some technology cases provide a better picture of how co-ordination can be achieved when a new challenging field arises, which requires joint forces of several organisations. The manner in which nano-technology was approached in the US is an interesting example. Nano-technology had developed in open competition before 2001. Several federal agencies had become involved in nano-technology including the Department of Energy, the National Science Foundation, the Defence Department and the National Institutes of Health. The research efforts however tended to be fragmented and overlapping in terms of disciplines, areas of relevance and sources of funding. Twelve funding/research agencies established an informal group in 1996/1997 in order to enhance communications and develop partnerships. Staff members met regularly to discuss their plans and programs in nanoscale science and technology. This group continued informally until September of 1998, when it was designated as the Interagency Working Group on Nanoscience, Engineering and Technology (IWGN) under the National Science and Technology Council (NTSC) of the OSTP (Office for Science and Technology Policy). The IWGN laid the groundwork for the National Nanotechnology Initiative (NNI), which co-ordinates the Administration's strategy for investing in nanoscale. With much support from this NNI, the budget for nanoscale research increased from $225 million in 1999 to $464 million during the Clinton administration. If the President Bush' budget is approved by Congress, this will jump to $679 million. Again this is an example where collaboration works well in a situation of increasing budgets.

4.3 Success in tackling the integration issue

In summary, although integration and co-ordination are high on the agenda few countries have actually found good governance solutions to cross the boundaries between science and innovation policy, between the sectoral policy domains and between disciplinary organised funding agencies. Denmark has gone furthest in restructuring the departmental structure to lower the barriers between science research and innovation. Time will tell whether the compartmentalisation that existed at department level, will shift to the division level within the same Ministry. Finland has created a powerful co-ordination layer on top of the Ministries. In both countries a strong support for research and innovation by their Cabinets has proved instrumental in such changes. Ireland has 'on paper' created a whole three-tier system to improve coherence, but the structures have so far failed to be effective.

Co-ordination seems easier to achieve when there is extra money, or when those involved have other strong incentives to co-operate. As the Canadian experience suggests, simply calling for more co-ordination is ineffective. The Finnish Additional Appropriation for R&D and the new Norwegian Research and Innovation Fund both illustrate the way in which new resources increase co-operative behaviour.

5 Making decisions and setting priorities in the public research and innovation system

The major question in this section is how priorities for investments in research and innovation are set? Are the Ministries in charge? What freedom do the funding agencies have in defining priorities? How are actors such as the business community and the science community involved?

Section 4.1 described three general, albeit somewhat simplified, patterns of how choices about science, technology and innovation are made in the governance models. In some countries the innovation governance structure runs very much in parallel with the research governance structure (Denmark, Norway, UK). In other countries the two are much more separated from each other in terms of policy design and implementation (Canada, Finland, Ireland, Netherlands, Sweden).

In comparison with governance practices in science, the patterns of priority setting and control in industry oriented research and innovation are much more closely linked to the state level (departments and agencies). Whereas the research community has traditionally played an active role in the governance of science and research (e.g. members of the research community are typically in the granting boards and committees, and peer review is seen as a best practice evaluation method) the state has kept industry much more at arms length when it comes to governance of innovation policy. Most likely concerns about corruption, unfair competition and 'self-service' have been at the root of this. Section 5.2 discusses the role of stakeholders in more detail.

Ministries are key actors in each system but their power and the level of strategic intelligence they posses differs from country to country. The other side of this coin is the level of independence, budget and strategic intelligence possessed by the 'middle level' of funders and agencies.

The role ministry personnel play in identifying research needs and specifying research to be done in their sector varies both among types of ministries and among countries. Education ministries are less likely to be involved in the detail of these questions than others, due to the role of peer review in priority setting at lower levels. Other ministries need to more closely connect R&D priorities with policy. Among the industry ministries, we find a diversity of practice, with the Finnish exploring needs in considerable detail – down to the level of being able to specify the programmatic interventions needed. The Norwegian industry ministry works at a higher level, while the Swedish is still further from the details, and is in effect unable to specify any but the most general policy requirements - except in partnership with the innovation agency. More generally, the Swedish ministries tend to take the position that the **contents** of research policy are not their business but that of the researchers. In the Swedish culture, where research has a high status and legitimacy, this attitude tends to spill over into aspects of innovation policy.

Different countries place the boundary between basic research funding, R&D or innovation funding involving industry and wider business development at different places, as **Exhibit 8** illustrates. Modern innovation theory supports the idea that all three functions should be closely related, while the practicality of having a single organisation work so broadly to cover all three functions is widely questioned. The design issue becomes partly a choice about how to place the institutional boundaries in such a way that the grey zones and co-ordination needs are as limited as possible. The cultural difference between research and innovation communities means that many countries place a boundary between them – sometimes to such an extent that this form of organisation is seen as conventional wisdom. Our evaluation of RCN argued that there are good – and increasing – reasons to try to manage these inter-cultural difficulties. These are partly reflected in our discussion (above) of changes in the knowledge production system. The analysis here suggests that Sweden and Canada have opted for the worst of all possible worlds, creating institutional boundaries between all three funding functions. (The recent reforms in Sweden which split VINNOVA off from NUTEK to form separate innovation and business development agencies are widely regarded as having thrown away a decade's progress in policy integration.)

Exhibit 8 Intermediate Funding Agencies in Research, Innovation and Business Development

Country	Basic/ applied Research	R&D/Innovation	Business Development
Canada	4 Research Councils	Foundation for Innovation	Industry Canada, local actors
Denmark	6 Research Councils Danish Research Agency	No separate agency	No separate agency
Finland	Academy of Finland	TEKES	TEKES/KTM
Ireland	2 Research Councils Science Foundation Ireland	Enterprise Ireland Irish Development Agency (IDA)	Enterprise Ireland
Norway	RCN	RCN	SND
Netherlands	NWO	STW, SENTER	SENTER
Sweden	Research Council	VINNOVA	NUTEK/ALMI
UK	Seven Research Councils	No separate agency*	No separate agency*

* The UK has the Small Business Centres run through the regional Business Links. Although they have small budgets for some consultancy support to firms, they are not an Agency that manages the innovation and business oriented funds of the DTI. They are information portals but eventually connect firms directly to DTI. Recent customer surveys reveal criticism of DTI from the business sector, concerning the lack of a clear innovation and business agency in the UK.

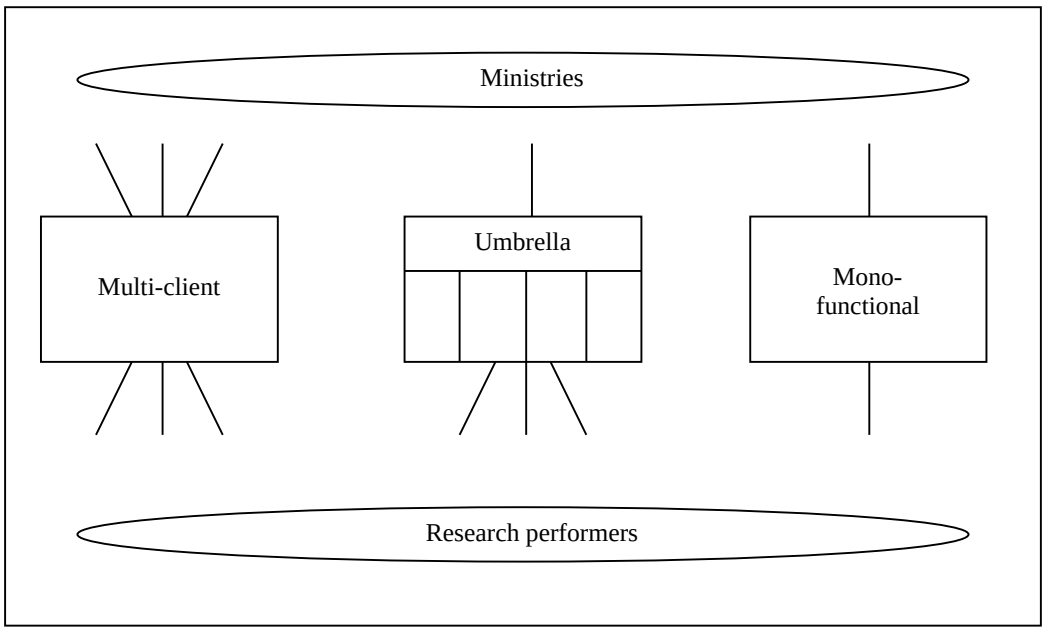
5.1 Decisions on basic science and 'strategic' research in the public knowledge infrastructure

Funding systems for basic and applied research in the public knowledge infrastructure have seen the delegation of decisions on the **contents** of research and technology mostly to intermediary funding systems (Research Councils) for academic research, or directly to the research organisations in the cases of non-academic public research laboratories. Ministries decide on the level of overall funding.

For universities the degree to which they are dependent on this 'competitive' intermediary funding system, varies from country to country. Universities in all countries have so called first tier money for which they are responsible for allocation decisions. The share of this first tier money in their total income varies considerably (for instance 63% in Denmark (66% if student fees are included), 64% in the Netherlands (70% if student fees are included), and 57% in Sweden (no fees), as opposed to only 40% in the UK (49% if student fees are included).[14] Consequently the power of intermediate research funders of changing the direction and contents of research is affected by the share of their funds in the total academic research funds.

In this study, we have been able to identify three **forms** of intermediate research funder, each of which can be governed in ways which are more or less under the influence of researchers or the state.

Exhibit 9 Three Forms of Intermediate Research Funder



[14] Jongbloed, B., Vossenstein J. , Eerste tweede en derde geldstroom in negen universitaire stelsels, Achtergrondtabel ten behoeve van de Toets op het concurrentievermogen 2001, CHEPS, Enschede 2001

The most familiar form is the **mono-functional**. An example would be FAS in Sweden, which is an agency of the ministry of health and social affairs. It receives money only from that ministry, and distributes it to various research performers in the fields of health and welfare research. TEKES, the Finnish technology agency, whose mandate comes from the industry ministry, is an example among the innovation agencies.

An increasingly common form is the **multi-client**, which acts as an intermediary for several sponsoring ministries. In the Dutch system SENTER is an example of this in the innovation field, managing programmes for multiple ministries. FORMAS is a Swedish research council of this type, which funds research for the ministries of environment, agriculture and industry. The environment ministry acts as the 'lead' agency, in this case.

The third form is the **umbrella** organisation. This has two or more distinct funding roles, overlaid by a common set of activities – which may be as minimal as the provision of overhead services, or may go well beyond this to play a strategic role. Examples include the Academy of Finland, The Danish Board of Research Councils and the Swedish Research Council, all of which focus on funding university research. The pre-2001 NUTEK in Sweden was also an example, which combined the roles of a business development and a regional development agency with a R&D and innovation funding role, now separated into VINNOVA.

There can, of course, be hybrid forms. RCN in Norway is such a hybrid: a multi-client umbrella organisation, with the apparently unique attribute of welding together the research council and innovation agency functions within a single organisation.

In each case, the co-operation of the funding recipients is essential to the funding agency's role. An analysis of the relationships in principal-agent terms[15] would suggest that the agent is likely to be co-opted by those who finally get the research grants. There is a risk that it begins to act more in these recipients' interests than in those of its own (ministry) customer. We can, for example, understand the dominance of most research council prioritisation processes by academics in these terms. The research community's co-operation in the process is rewarded by allowing that community's more senior members to distribute the money according to their own priorities and values. The argument can be extended even to the ministry principals themselves, who acquiesce in the take-over of their agents by the funding recipients is given because this gets the job done. Nor is it solely research councils that can be seen in these terms. The extensive role played by industry in most 'good practice' innovation agencies is not dissimilar, becoming involved in programme planning as well as making decisions about priority setting.

There is a real Catch-22 here. The recipient communities are actually the best placed to make good funding decisions according to prevailing criteria. The cost of their participation, however, is that the game tends to become a stable one of 'you fund my project and I'll fund yours.' The result is a lock-in, similar to the one that arises when universities use their collegial structures to allocate resources, and find themselves

[15] see especially Dietmar Braun, 'Who governs intermediary agencies? Principal-agent relations in research policy making,' *Journal of Public Policy*, 13 (2), 1993, pp135 – 162

unable to make or change university strategies. Governance and institutional structures more generally need the destabilising influence of a change agent if they are to evolve.

Each of the more complex forms gives rise to a special set of governance problems. Where the **umbrella** form is used for a research council, it gives rise to a struggle between the centre and the divisions, which was very evident in the early history of RCN. The principle of self-determination in priority setting by the research community is in conflict with almost anything the centre may try to do. The ongoing reorganisation of the Swedish Research Council appears to represent the outcome of exactly such a struggle, where the component science councils have increased their power by taking over the funds-allocation functions of the main board. In future, the main board is to focus on matters of research policy.

A key factor in the centre-division tensions in both RCN and the Swedish Science Council seems to be that the memberships of the main board and the division boards have been mutually exclusive[16]. In the Academy of Finland, the majority of the main board is made up of the chairs of the component research councils. This arrangement is more stable (as it was in the old Norwegian NAVF umbrella research council), but at the cost of inhibiting change. (One of the most interesting changes at the Academy in recent years has been the development of co-operation with TEKES. However, this has only been possible through the use of money from the 1997 Additional Appropriation for R&D, so that no existing interests or budgets were disadvantaged.) We have seen no examples of these kinds of conflicts arising in innovation agencies. These are run on a more corporate model, where the legitimacy of central management is not in question.

The Dutch NWO currently provides an example of an umbrella research council in change: from a granting organisation to an organisation for science and innovation programme management, also regarding multidisciplinary research and in terms of cross-cutting or horizontal **themes**. The recent NWO Strategy Plan puts forward nine strategic themes. For this purpose it has also joined forces with the Dutch innovation agency SENTER, in a co-operation agreement signed in June 2002. In the fields of Genomics and Catalysis this co-operative approach is being applied with apparent success.

The governance issues associated with the **multi-client** form are more external, focusing on the inter-relationships among the funding clients' (i.e. the ministries') interests. The potential tensions are well illustrated in RCN's history. During the 1990s, reduced budgets encouraged RCN's funding ministries to become increasingly specific about the way the council was to use 'their' money. Synergies obtained by the council were interpreted as losses to the individual ministries, not as gains to the system. The level of earmarking of funds by individual ministries rose through the 1990s, partly as a defence against (real or imagined) incursions by other ministries. Ministries backed up their earmarkings with memberships on programme committees, to ensure that their needs were met. To a considerable degree, the relations of trust between the ministries and RCN simply broke down. As with RCN performance

[16] It is noteworthy that the tensions between the main board and central management , on the one hand, and the division boards on the other were partly resolved by informally allowing the divisional administrative heads to observe main board meetings.

more generally, the situation started improving at the point where new money (in the form of the Research and Innovation Fund) became available.

FORMAS in Sweden provides a newer but very strong contrast with these difficulties at RCN. Given the Swedish ministries' belief that most aspects of prioritisation should be tackled by the research community itself, there is little incentive for the three ministries involved to earmark more of FORMAS' funds than is necessary to respond to unavoidable political pressures. FORMAS' history is short, and it will soon have to face significant new funding challenges in its field. However, it appears so far that the high level of trust between the ministries and the council is a precondition for continued success.

A peculiarity of the Swedish system is the presence of significant research funders outside the control of the state. These include major private foundations (which are also an important factor in larger countries such as the USA and UK), but also the 'wage earner fund' foundations, which were set up by a conservative government in 1994 using taxpayers money, and then locked up with statutes which prevent later governments from appropriating their capital or having greater control than appointing members of their Boards. As much as half of Sweden's research council type funding for university research currently comes from such foundations, which are beyond the reach of government research and innovation policy.

Denmark has six disciplinary structures (Research Councils) and one overarching Board of Danish Research Councils. The negotiations of allocation of budgets between the six councils is done by the Board. The Ministry of Science, Technology and Innovation has little influence on how the research money is spent, they only decide on the level of funding. Annually the Board reports directly to the Minister to discuss their proposal for allocation of budgets. If this is approved the Danish Research Agency implements the allocation of funds to the research community.

Ireland is an exception to all other countries. The recently established Science Foundation Ireland is to allocate €770 million to basic and strategic research in a period of six years. The system includes new SFI awards for world-class researchers who move to Ireland, for Irish and international researchers already based in Ireland, for the support of scientific conferences for scientists based in Ireland, and a requirement for collaboration among certain SFI-funded researchers and industry. The government has decided however that this should be allocated to two technology fields where Ireland has the best opportunities to improve competitiveness: information technology and bio-technology. Other areas are excluded from these huge additional funds into the research system.

The technology cases show that sometimes the more formal governance structures are being bypassed, in favour of a more pragmatic and informal arrangement between stakeholders to achieve certain goals. The Dutch Genomics Initiative is a good example where collaborations suddenly appeared to function smoothly. These collaborations between government departments and between academia and industry, normally operating in separate ways, developed in order to ensure considerable additional government funding for genomics research. The solution chosen for the implementation, a National Co-ordination Office (Regiebureau) of this Action Plan was also outside 'normal' governance structures.

We have found similar examples where joint efforts to address new challenges led to focussed coalitions. The National Nanotechnology Initiative in the US is such an example (see above).

5.2 Involvement of stakeholders in the formulation of policy

Stakeholders can be those directly involved in performing research and innovation (the research community, industrial R&D performers, high-tech starters), or those that have a direct interest in the outcomes of research (industry, policy users, societal groups).

The simplified overall picture is that:

- The research community (both academic and non-academic) is given quite some direct control over the use of funding and the direction of R&D investments. This is in part the cause of a degree of 'lock-in' of the governance of research witnessed in many countries, with reforms coming very much as a top-down decision
- The business community has mostly an indirect role through its membership of Steering boards, programme committees, advisory councils etcetera. This concerns both the role as performer and as potential user of R&D. Representatives of the big R&D performers, i.e. large R&D intensive firms, are most likely to perform these roles
- Industry Associations such as the Dutch VNO-NCW or the Canadian Council of Chief Executives, publish general statements about the level of state R&D investment, but rarely engage in a detailed debate about the direction and contents of research and technology
- Policy departments with an interest as a user of research, mostly ensure their interests through a direct customer relation with dedicated research organisations or Agencies. In Canada the majority of R&D is even performed intramural, allowing direct control over R&D direction and activities
- In countries where Advisory Boards have a really strong influence on government research and innovation decisions, there is a corresponding high level of representation from both the research community and business. In comparison with the Netherlands it is striking that the S&T Advisory Board although having business representatives, they are not the CEOs that we find in other countries.

The technology cases give various examples where the role of stakeholders is quite decisive for the success of a boost in technological performance.

The Swedish ICT case is illustrative for the close co-operation between industry, academia and government to boost the scientific and technological performance of Sweden by dedicated funding from all parties. Strong industrial interest in telecommunications (Ericsson) provided a guide for government and universities to focus funding on particular pockets of ICT research.

In Canada it was a cluster around the prominent firm Ballard Power Systems that set new research and technology investments in motion, in fact by creating the cluster. The main actors in the Canadian fuel cell cluster are members of Fuel Cell Canada, a network designed to promote the development and use of fuel cells. The membership list indicates that the domestic fuel cell business is in a pre-commercial growth phase as evidenced by the involvement of several financial institutions and other supporting organisations including lawyers, public relations and even a public opinion polling firm. It is revealing that Fuel Cell Canada promotes the idea of a "national strategic approach to fuel cell industry development" exactly because there is no Canadian strategy for fuel cells. Government organisations are certainly involved, but came in as a response of activities set up by the cluster. However, these organisations, the National Research Council and Natural Resources Canada, are supportive rather than directive and there is no centralised planning or hierarchical governance imposed by the government of Canada or any other organisation.

In the case of US nano-technology initiatives it was clearly recognised by government that this field requires a large amount of government funded research. The NNI implementation plan states: *" Private industry is unable in the usual 3-5 year industrial product time frame to effectively develop cost-competitive products based on current knowledge. Further, the necessary fundamental nanotechnology research and development is too broad, complex, expensive, long-term and risky for industry to undertake."* Thus it is not surprising that in this area, leading roles have been taken by the research community and the science and technology funding agencies. The German case on nano-technology showed a similar leading role from government, in this case the Ministry for Education, Science and Technology (BMBF).

At high level policy making the involvement of stakeholders is mainly organised through Advisory Bodies consisting of representatives of different communities, mainly the science and business communities. In most cases members' positions on the Committees are based on their private capacities.

The following overview in **Exhibit 10** shows the main Advisory Bodies in the benchmark countries.

The list includes Advisory Councils, which cover science, technology and innovation, such as the Finnish, UK and Irish Councils. In Denmark, Sweden and Canada the focus is on science and research.

It is difficult to give an objective assessment of the influence and power of these bodies. Many of these bodies would produce formal reports on certain subjects, but in how far this has altered government policy is not always easy to determine. A key determinant is the receptivity of the government to advice, coupled with the priority it assigns to research and innovation issues. There is also the important element of personal links between members of the advisory groups and their responsible Ministers. In Denmark for instance, membership of the Danish Council of Research Policy is not politically determined, but vacancies do tend to be politically filled. The influence of the council is considered particularly strong, given the direct links of individuals in the Council with the Minister.

Exhibit 10 Key Advisory bodies which report to Cabinets, Ministers, Departments, and Parliament

	Advisory Body	Comments
Canada	ACST	· Ten members in private capacity from industry, academia and an NGO · Outputs are reports on broad themes · Has not met in more than a year
Denmark	Danish Council for Research Policy	· Members in private capacity from industry and academia · Reports to both Minister and Parliament · Central in debates on system reform · Secretariat run by Ministry
Finland	Science and Technology Policy Council	· Government (include Prime Minister), science and industry members · Quite influential due to high level representation
Ireland	Irish Council for Science, Technology and Innovation (ICSTI)	· Members in private capacity from industry and academia · Advises the Minister for Science and Technology and Forfás · Is foreseen to have large influence on prioritisation of ST&I
Netherlands	CWTI AWT	· Members are senior civil servants from Ministries with R&D portfolio · Prepares policy decisions for the Cabinet · Members are scientists and people with industry affiliations in private capacity · Public Advice Reports
Sweden	Forskningsberedningen	· Academic and industrial stakeholders in private capacity · Advise the Education Minister · No public reports or outputs
UK	Council for Science and Technology	· Advises the Prime Minister and cabinet · Members are Minister for Science, the CSA and senior representatives of academia and industry

Industry or industry associations have both formal and informal positions in the governance structures. Representatives of industry, mostly CEOs or CTOs of large R&D intensive firms, have a seat on the highest advisory councils in a private capacity. This is the case in all the benchmark countries. An obvious difference with the situation in the Netherlands (AWT) is that these Advisory bodies have strong representation from the research community **and** industry.[17] In addition in the UK and Finnish cases high level members of the government are also taking part in the Advisory bodies.

[17] Although the Dutch AWT does have members with a background from industry, they are not decision makers in key R&D companies

Other informal and formal involvement of stakeholders' are channelled through numerous smaller committees and boards advising research funders and performers. Comparing the benchmark countries we could say that in Denmark, Norway and Sweden, the research community has a strong hold on the research and innovation governance system. Particularly Denmark and Norway have quite a thin innovation policy portfolio. In the United Kingdom, Ireland, Finland and Canada the business perspective has a stronger voice in the whole priority setting system, with issues around both innovation and science heard. As discussed above, the balance in Ireland has shifted too much in favour of applied research and innovation, neglecting the importance of developing a strong knowledge infrastructure.

6 Steering the knowledge infrastructures and intermediaries and accountability of the actors

From the Dutch perspective the issue of steering the 'knowledge infrastructure' and to a lesser degree the intermediaries and agencies is an important issue as it is regarded as one of the main failures in the Dutch governance system.

The overall evaluation of Dutch innovation policy (IBO) finalised in 2002 revealed that:

- A relatively large share of funding goes to non academic research institutes
- Many of them are not systematically evaluated
- There is a fragmented system of accountability where various divisions of labour between Ministries prevent an overall view on the functioning of the set of institutes

It seems that over the years in the Netherlands new institutes have been created, but very few have disappeared from the landscape. This has led to a complex network of research institutes with different missions, positioning themselves at various spots on axis from basic science to applied research and with completely different models of governance. As such this is not necessarily problematic. It becomes problematic however when there is no over-arching vision of the roles of each of these in the innovation system, and when institutionalisation leads to barriers in knowledge diffusion.

This benchmark study provides only a limited set of lessons for good practices for the Dutch situation, partly because the 'knowledge infrastructures' are quite different in the benchmark countries. Overall we can say that New Public Management ideas are applied sparsely when it comes to holding research and technology organisations and government laboratories accountable for their performance. In terms of critically reviewing the whole network of research institutes, only Denmark is currently involved in such an exercise. However Finland undertook such an exercise in the late 1990s.

A culture of accountability developed mainly at the policy programme level in all countries studied. In a previous report to the Ministry of Economic Affairs we reported, among others that fall out of the scope of this study, the state-of-the-art in Norway, Finland, Canada, and the UK.[18] A culture of accountability and reporting on effects is developed most strongly in the Anglo-Saxon countries, in our cases the UK and Canada. Canada was an early adopter of ideas from the New Public Management, and an early user of evaluation in the research and innovation context. However when it comes to evaluating the research institutes, accountability focuses for the most on financial matters. The Nordic countries are now in the process of developing more and more impact measures for their main research and innovation policy programmes.

[18] Boekholt et al., An international review of methods to measure the relative effectiveness of technology policy instruments, Technopolis, 2001

Norwegian administration was already embracing many of these principles of new Public Management in the early 1990s. However, as the evaluation of RCN, the Research Council suggests, in the field of research, these principles have often been frustrated by a practice which overlays nit-pickingly detailed instruction and earmarking on the relationship between ministries and RCN.

In the following two sections we respectively discuss accountability of the knowledge infrastructure and intermediaries.

6.1 Accountability of Universities and Public Research and Technology Organisations

While this study has looked at innovation governance mainly from a birds eye perspective, we have been able to look at some examples of how public research organisations are held accountable for their performance. To understand more deeply how these processes work would ask for more research.

As was mentioned above, universities in all countries have so called first tier money for which they are responsible for allocation decisions, and is handed over to them directly. The share of this first tier money in their total income varies considerably and is particularly high in the Netherlands (64%) as opposed to for instance only 40% in the UK.

In the Netherlands this first tier income also includes research funding. It is calculated on the basis of a set of indicators which are partly based on history (including the number of PhD certificates), and only for a small part based on research excellence. The quality control system used in universities (disciplinary peer reviews organised by the Dutch Association of Universities) which hardly ever has any consequences nor does it provide a ranking of institutions.[19]

Of our benchmark countries, the UK has a university funding system which is driven by quality and performance, more than in any other country. The Research Assessment Exercises (RAEs) introduced in the 1980s form a nation wide university research evaluation. Contrary to the Dutch evaluation system these exercises do have a consequence for allocation of research funding, particularly for funding from the Higher Education Funding Council for England (HEFCE).[20] Most of HEFCE's research budget - £868 million in 2001-02 out of a total of £888 million - has been allocated as quality-related research (QR) funding, which is informed by the Research Assessment Exercise (RAE). The purpose of the RAE (the 2001 exercise was the third of these four-yearly reviews) is to produce ratings of research quality to be used by the UK higher education funding bodies to determine the main grant for research to institutions they fund.[21] The results of the RAE are used to allocate the Funding

[19] CPB, CHEPS, 2001, Higher Education Reform: Getting the Incentives Right, The Hague.

[20] ibid.

[21] The RAE was conducted jointly by the Higher Education Funding Council for England (HEFCE), the Scottish Higher Education Funding Council (SHEFC), the Higher Education Funding Council for Wales (HEFCW), and the Department for Employment and Learning,

Councils' £1 billion of research support for each of the subsequent four years. The funding impact of the 2001 exercise has been a consolidation of research funding, which will be distributed more selectively. On average, the highest quality research, awarded 5* (five star) in the RAE will receive a cash increase of 2.5 per cent (funding will be provided for departments rated at 3a and above).

The landscape of non-academic, public research and technology organisations (RTOs) is like most issues that we reported on, very country specific. There are countries with a vast network of public laboratories and research institutes (Canada, Norway, Denmark, and Finland) and those that have only few (UK, Ireland, and Sweden). There is a distinction between contract research organisations, specialised in certain technological fields or working for particular sectors, and government laboratories that work closely and almost exclusively for a certain government department. In the scope of this study it was not possible to develop a complete overview of the RTO landscapes in each of the benchmarks. We have concentrated on governance issues such as in how far RTOs in general can develop their own strategies and whether they undergo regular evaluation. Sweden and Ireland hardly have any RTOs nor government research laboratories, and are therefore not so relevant as a benchmark.

The UK was very early in adopting new public management principles to research and development almost 30 years ago. In the UK the process of putting the independent research laboratories at arms length started in the early 1970s as a result of the Rothschild Report[22], which proposed that applied scientific research should be governed by the 'customer-contractor principle'. This offers a far more commercial approach that places government in the role of a project-based customer rather than a block funding agency. This change moved RTOs away from research programmes which suited their own aims and made them focus on customer needs, in effect adopting a 'bottom-up' approach.

Further more serious reforms started in the 1980s with Prime Minister Margaret Thatcher's Conservative government. The process of putting the Government owned laboratories at arms length was taken a step further by their privatisation. The laboratories that have remained in government ownership after the period of privatisation are those that were deemed difficult to privatise, such as those dealing with police forensic science or top secret military technology. Many of the privatised government laboratories are now run as government agencies. Examples are the National Physical Laboratory and the National Engineering Laboratory. They are closely tied to government sector departments. These Agencies work almost exclusively for government departments on the basis of tendered contracts, retaining the governments' strong controlling interest, both in terms of actual ownership and the research undertaken.

In **Finland** the Council for Science and Technology Policy's Review recommended that all State Research Institutes (20) be evaluated before the end of 1999. This had previously not been done in a systematic way. This recommendation was implemented in full with ministries reporting that these reviews have helped to

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Northern Ireland (DEL). The RAE team, based at the HEFCE offices in Bristol, managed the exercise on behalf of the four funding bodies.

22 The organisation and management of Government R&D, in A Framework for Government Research and Development (The Rothschild Report), (1971), HMSO.

improve the process of negotiations between the laboratories and their host ministry, with a clearer delineation of responsibilities and performance targets.

In **Denmark** the network of approximately 25 Research Institutes, often attached to a particular Ministry, has become an issue of heated political debate. The new government is very critical of the blurred demarcation lines which have developed between the research institutes and their respective parent Ministries, during previous governments. Particularly in politically contested areas such as the environment, the research institutes were said not to have provided objective scientific advice, but instead were considered to have been politically biased. When the new Cabinet first came in power they were in favour of a radical abolishment of all Research Institutes. In a dialogue with the stakeholders this was toned down and it was decided they should be evaluated first. The vast network of government related research institutes and laboratories is now under review and it is expected that the system will undergo considerable reforms. This will most likely mean the abolishment of some of them and possibly some mergers between others. At the timethis report was written no one was able to comment on the possible outcome of this review process.

If we look at some examples in detail, this perceived 'bad practice' does not seem justified. For innovation governance the most relevant example is the relationship between the Ministry of Science Technology and Innovation and the Technical Service Institutes (GTS). Despite the critical attitude of the new government, the relation between the Ministry and the GTS have always been set on clear contractual terms. For a start these GTSs receive about 10% of their funding from these government grants. The remainder is earned through contracts with the private sector. Every year the Ministry and the GST draw up a contract containing what is to be undertaken with the government subsidy, although not described in great detail. In their Annual report the GSTs have to give an account of their activities and following the annual contract the Ministry can assess whether the government money was well spent. The GSTs are also required to analyse the impact of their activities.

However, there is not one governance model for the Research Institutes. Some are very independent (for example the Risø Laboratory) and define their own strategy, while others have very little free money and work under direction of their parent Ministry. The new governance structure will most likely address this.

In **Canada** a substantial amount of departmental R&D expenditures goes to intramural work. This work is carried out within an extensive network of departmental and research institutes. The departmental labs are inside government departments such as Health Canada. This means that the distinction between government departments and research labs hardly exists, researchers are federal civil servants. The second type of lab are similar to the National Research Council and the Communications Research Centre which have numerous labs and institutes but which do not fall under the 'direction' of the Minister or the Government. They establish priorities, which are approved or not through the government budget process, oversight however is left to the body itself with accountability being reviewed occasionally by the Auditor General or other such bodies.

A problematic area in those countries that have strong public research laboratories is the definition of their goals and measurement of their performance. In Denmark the

whole system of Government Research Laboratories is under scrutiny, being judged by some politicians to have grown too close to their respective funding Ministries, thus compromising their scientific independence. The government has launched a broad evaluation exercise to assess the many laboratories, which until now has not been systematically performed. The outcome of this evaluation exercise will form an input to a major reform of the Government Laboratory system, which will be publicly announced in the next few months.

Summing up:

- With very few RTOS, Sweden, Ireland and the UK do not have similar governance issues as found in the Netherlands with its wide network of RTOs. The UK model has drastically reshaped the landscape, but has in turn left the innovation system with a greater need to develop academia-industry linkages, and a gap in the system for applied research
- The Canadian situation, where much of the government research is done intramural within the civil service, and where labs are part of government Departments, is also not a model applicable to the Dutch situation. Putting research organisation at arms length would be seen as a reverse movement
- A case of good practice is the annual performance contracts agreed between the Ministry and the GSTs in Denmark. It makes clear what is expected of the institute and provides a baseline for evaluating performance. Contrary to the Dutch situation GST relies much more on contract research income than the Dutch research organisations
- Another possible good practice from Denmark is the overall review of the entire network of Research Institutes. This exercise however seems to be highly politicised and executed in a very short time. A comparable exercise in Germany was where the entire research network, from the Max Planck to Frauenhofer-Gesellschaft was evaluated, a better example for such an extensive and profound exercise. This so-called system evaluation was conducted over a period of two years (1997-1999). Despite some minor reorganisations and mergers, this exercise did not radically shake the German system, and has in fact been a worthwhile exercise looking deeper into the mission statements of all actors involved. The Finish example of such an overall research institutes review is an other good practice example which is worthwhile applying to the Netherlands.

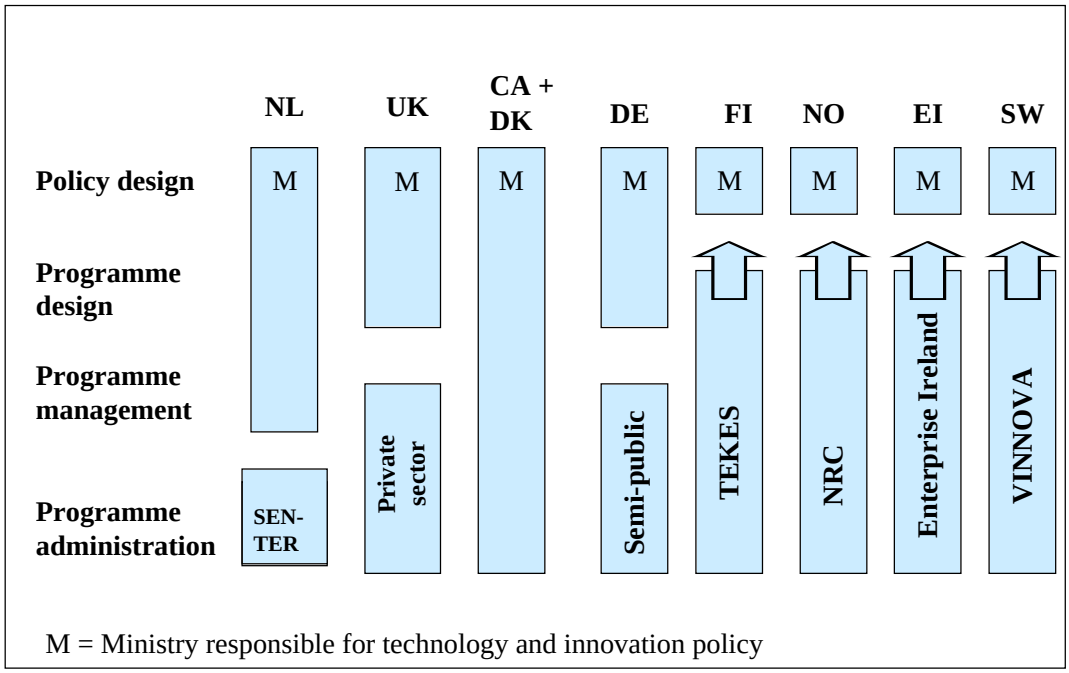
6.2 Accountability of Agencies and Intermediaries

The manner in which agencies and intermediaries are held accountable and report to their ‘masters’, (mostly the Ministries), depends on their mission and tasks.

Exhibit 11 illustrates that per country, the division of labour between Ministries and agencies varies considerably. We distinguish between policy development (define broad priorities and objectives), programme development (develop the instruments to reach the objectives), programme management (monitor the programme’s progress) and programme administration (handle the practical issues with the programme’s clientele). The comparison reveals a large variety in the level of ‘intelligence’ which is transferred to the agency level. In Sweden, Norway, Ireland and Finland, the agencies have a large influence on defining the programme design and on launching

new programmes. These are mostly prepared by the agencies and fed back to the Ministries who usually follow the recommendations of the agencies. Therefore the agencies are very much the 'owner' of their programmes and possess most experience with policy design. They would also deal with the 'low level' administration of the programme, i.e. they operate the practical aspects with the clientele of the programme (selection of applications, payments etc.). Consequently the Ministries are relatively thin in human resources and 'programme design intelligence'.

Exhibit 11 The division on labour between Ministries/Departments and agencies in delivering innovation programmes



The Netherlands forms the other end of the scale: here policy design, programme design, and most of the programme management is the responsibility of the Ministry. The programme administration is the only function which is delegated to the agencies (SENTER, NOVEM), who act as the main client interface. The advantage is that the Ministry has most of the policy intelligence in-house. In addition the Ministry can give quite clear instructions to these agencies as to what performance is expected. A disadvantage is that it is more difficult to transfer feedback from the client base on a particular programme design, back to those who design the programmes.

There are some models which deviate from the previous two divisions of labour. In the UK, programme management is out-sourced to private organisations after public tender procedures. An advantage of this could be that it is cost effective in the short-term, since competitive tenderers will lower their cost estimations. The disadvantage is that programme management knowledge and feedback on programme design by the client base is fragmented over many organisations. A constant change of contractors will also limit learning effects.

Especially in research, the principle of allocating high-level goals to agents and leaving them to 'get on with the job' has a long historyin Sweden. This is one reason why evaluation is so well established in Sweden, even if the more routine reporting of results implied by the 'management by objectives' approach is under-developed. In both Sweden and Finland, a comparatively 'hands off' relationship between ministries and research and innovation agencies seems to be built on a much higher level of trust than is present in for instance the **Norwegian** funding system.

TEKES has probably gone furthest in developing performance criteria and impact monitoring systems for its programmes. Over the years the effect of its programmes, as well as its own functioning as an Agency have been evaluated by national and international expert teams.

In **Sweden** the relationship between the Ministry of Industry and VINNOVA is defined quite precisely. VINNOVA's letter of instruction from the industry ministry for 2002 contains, in addition to the standard overall goal, 13 subsidiary goals, each with reporting requirements. It is allocated eight specific tasks, plus about the same number of earmarkings – most of which are intended to ensure the continuation of activities initiated by its predecessors. The complexity of these instructions is greater than was the case during the 1990s, and the reporting requirements are considerably more onerous. At the same time, these requirements are still felt to be insufficiently quantitative.

The official responsible for VINNOVA meets with the management about every six weeks, and there are bi-annual meetings between the permanent principal secretary and the director of VINNOVA. These meetings are seen as opportunities to exchange information, rather than to apply any control to VINNOVA. Control is strictly limited to the formal mechanisms centred on the letter of instruction.

NUTEK, which has recently de-merged from VINNOVA, has this year received four letters of instruction from the industry ministry (covering 32 pages), relating to various parts of its complex set of tasks. These letters relate to a mixture of its mainstream work, its use as a channel for sending regional development funds from the central state to the regional authorities and the channelling of EU regional development funds. In this latter role, it has to deal not only with the industry ministry but also with the European Commission.

Another example of the strong accountability culture in the **UK** is the way the Regional Development Agencies (RDAs) operate their economic development and innovation funds. From April 2002, the RDAs have been funded from a 'single pot,' with the volume of funding being determined by each RDA itself (through an annual planning process and business plan). In this new regime, the DTI and Treasury agree plans, budgets and performance targets in negotiation with the respective RDAs, and do not dictate policies or priorities. Accountability and control is exercised through a performance monitoring system and through monthly meetings between the chair people of the nine RDAs and the Minister of State for Industry and the Regions (and sometimes the Secretary of State themself).[23] The nine chair people meet on a

[23] In addition, DTI staff descend on one RDA twice a year and spend several weeks going through all the systems and operations with the chief executive and his or her senior managers.

quarterly basis in a star chamber to exchange information, share experiences and to seek common ground on major policy questions. There are in addition to this many informal groups that meet to develop guidelines on good practice and share experiences, such as the monthly meeting of the economic development managers.

Nevertheless, all the countries we looked at were struggling with the methodological and practical difficulties of developing meaningful and useful performance indicators for research and innovation agencies.

7 The co-ordination between national and regional actors

Regional actors are becoming an increasingly strong force in research and innovation. Their level of authority, their scope of action and their resources differ enormously from country to country.[24] We can not compare for instance a German Land with its own fiscal authority and large responsibility for both research and innovation, with a Swedish County which has hardly any authority nor budgets for research and innovation. So the co-ordination mechanisms and governance issues are nationally bound.

The European Structural Funds have encouraged regional actors to develop more activities in STI. In the whole of Europe the trend is that an increasing share of these Structural Funds is deployed for economic development and innovation policies.

In the Netherlands we see a similar picture: STI was traditionally a policy domain for the national state. The regional delivery of innovation services by Syntens is the main national designed policy mechanisms operating in the regions, but without much influence on the centres by regional authorities. Ireland has a similar governance pattern with regional centres of Enterprise Ireland, under strong control by their central office. Increasingly Dutch Provinces and cities, are supporting regional innovation projects and programmes, often backed up by financial resources from Europe. For the largest part these activities focus on innovation of SMEs and supporting clusters, but to an increasing extent Dutch regions support activities around local research centres, for instance Science Parks. The activities tend to be small in scale and sub-critical. Nevertheless there is very little co-ordination of these activities between regions or between regions and the national authorities. None of the benchmark countries however have tackled the issue in such a manner that we could say that there is co-ordination and synergy between national and regional STI activities. What all countries have in common is that regions tend to focus on innovation of SMEs , technology transfer and cluster development. The research side of the governance system is left to the national actors. Germany is an exception to this typical division of labour, as the Länder are also responsible for funding and regulation of the Higher Education Institutes.

The picture on the co-ordination between regional and national policies is quite diverse. **Exhibit 12** gives an overview of the situation in the benchmark countries.

[24] See for instance Cooke, Boekholt and Tödtling, 2000, The governance of Innovation in Europe, Regional perspectives on Global Competitiveness, Pinter, London.

Exhibit 12 Co-ordination national – regional research and innovation strategies

	Co-ordination national / regional
Canada	– Strong State involvement in ST&I but concentrated in the provinces of Ontario and Quebeq – Little co-ordination federal and regional policies
Denmark	– Activities of regional actors dispersed over counties and local communities and often sub-critical (small budgets) – National level attempts to help co-ordinate within and between counties
Finland	– R&D heavily concentrated in few areas (Helsinki, Tampere, Olou) – Activities of regional actors dispersed over counties and local communities and often sub-critical (small budgets) – ST&I responsibilities very centralised at national level
Ireland	– ST&I responsibilities very centralised at national level and implemented by regionally allocated agencies
Netherlands	– Provinces active players, particularly those with European Structural Funds and national development funds – No effective co-ordination of wide variety of projects among regions nor between national and regional actors
Sweden	– Strong co-ordination national regional research and innovation strategies due to strong role central state – Regions newcomers in this field – Regional Performance contracts
United Kingdom	– The Regional Development Agencies are a relatively new actor (apart from those in Wales and Scotland) with increasing innovation budgets – Aimed to deliver research and innovation services from DTI – Strong interaction with DTI – In Wales and Scotland strong Development Agencies who work quite independently from Central Government

This overview shows that there are only two countries with a really strong interaction between the national and regional levels: Sweden and the UK. In both cases this has been identified very recently as a critical issue which requires new forms of governance. In Sweden the entry of the county as a regional actor is quite new, and at the same time these counties have little powers and funding. The picture in the UK is more complicated, with some regions (Scotland and Wales) with a long history of independence and active position in innovation, whereas the English regions are newcomers to this field.

7.1 Two examples of new governance

In 1998, the **Swedish** Government introduced a new regional industrial policy. Based on the prevailing conditions of each individual region, the aim of the policy is to stimulate sustainable economic development that will spawn more companies and help existing enterprises expand. At the same time regional 'growth agreements' were introduced to facilitate implementation of the new policy.

The county administrative boards and the regional councils in those counties which are involved in the experiment to change the way responsibility is allocated on the regional level will initiate, pursue and co-ordinate work within the agreements. The aim of the growth agreements is to enhance more efficient co-ordination and collaboration among sectors and actors whose task it is to promote growth and employment. The business sector is being invited to take an active role and exert considerable influence on the wording of the agreements. The intention is to increase local and regional influence on national policy and to allow state resources earmarked for growth and employment to be used more flexibly. Research and innovation are just one element in these Growth Agreements. We have not been able to identify how central they are in the various regional strategies.

A growth agreement must be primarily based on a fundamental analysis of the business development prerequisites in the region. Based on the analysis, a development programme is formulated aimed at utilising the identified opportunities and satisfying the need for measures to promote business sector growth.

According to the Swedish Ministry of Industry the encouragement of a cross-sectoral approach to regional growth and development means that multi-sectoral collaboration should also be intensified between the various Swedish ministries. For this reason a special committee consisting primarily of the state secretaries from various ministries has been set up. Most of the ministries are represented on this committee, which has the overall responsibility for co-ordinating issues relating to growth and employment policies within the Government Offices.

When the new **UK** government came into office in 1997, part of its manifesto was to create a new level of regional administration across England to emulate the economic success achieved in Wales and Scotland. And in addition to provide some psychological balance to offset the creation of the regional assemblies in NI, Scotland and Wales. The new regional development agencies (RDAs) were given an economic development brief by London. Over time, the RDAs have seen their 'innovation' budget grow. A series of national innovation funds (Competitiveness Development Fund, Innovation Clusters Fund, Regional Innovation Fund) has been launched, each one larger than the last, and each one more open in terms of the conditions set by the Treasury and DTI (the source of the funding).

As the RDA innovation budgets have increased, the central DTI budget has been squeezed to the point that its enterprise budget (£330 million) is almost entirely expended through regional delivery channels. In practice, central government expects

a growing share of innovation support activities to be determined and delivered locally (most RDAs now have a Science Council)

The Innovation Liaison group (meets quarterly), which is coordinated by the DTI and involves officials from London and the regional Government Offices, discusses policy needs and instruments (to minimise overlaps and underlaps), and has been opened up to the RDAs. This has proved popular and there is talk of strengthening the mechanism through the creation of a high-level steering group with its own budget.

These two quite recent initiatives to formalise the responsibilities of national and regional actors are interesting governance processes to keep following in the near future.

8 Conclusion: what best practices can we learn from?

The six country studies and fourteen technology cases have given us a clearer picture of how governance works in practice. To start with a formal picture of how things operate, based on established procedures and formal organisational charts – although telling only part of the story. Much of the interaction between key actors and stakeholders takes place informally and outside formal structures. Nevertheless the backbone of each governance model is based upon the way in which organisations are structured, the power that each of these organisations have through for instance budgets, and formal rules on decision making.

The set of countries examined in this rapid study is limited, clearly limiting the validity and generalisability of our findings. Nonetheless, a number of conclusions emerge, which should be useful in the continuing discussion of research and innovation governance in the Netherlands. However, we need to be cautious about the idea of 'best practice.' We have pointed out some of the cultural and historical path dependencies in the countries studied. Practice should not uncritically be transferred from one context to another, because context is usually one of the factors that make practices successful or not. Foreign experience should therefore be seen as a basis for learning, and not for (uncritical) copying.

The study discussed (and is structured around) a number of central governance issues. The conclusions presented here will follow the line of these issues, reflecting outcomes presented in the report.

1 *Has any country managed to overcome the gap between science and innovation policy, and developed practices for better policy integration?*

In all governance systems linear modes of operation function in parallel with more systemic and integrative modes of operation. This can partly be explained by path dependency and cultural heritage, evident in the fact that some elements of the linear model (e.g. funding mechanisms for curiosity driven research) still fulfil a function in a systemic governance model

Countries are converging on the idea that there should be a high level research and innovation policy function to generate overall strategy and to act as 'referee' in the system. Attempts to improve co-ordination and integration can be found in all countries, varying from cross-departmental committees to high level co-ordination councils. Some examples with elements that we can learn from are:

- The Danish example of an integrated Ministry dealing with science, technology, innovation and IT is quite unique in its kind. It is too early to decide whether this model will be successful. Its great advantage is that the entire chain of knowledge production falls under the responsibility of one Minister. We have also pointed to a number of possible drawbacks:
  - The barriers could still pursue, now between divisions in the department instead of between ministries
  - The business sector, and particularly the traditional industries, might not consider the Ministry as a natural 'partner'
  - The Minister will have to negotiate with sector Ministries for sufficient budgets

- Other countries (Finland, and to a lesser degree the UK and US) have chosen for integration 'at the top' through high level co-ordination or advisory councils. The integrated Science and Innovation White Paper (2000) of the UK government is another example that the integration is taken seriously. A high level advisory group is also present in Canada and Ireland but these two examples highlight that formal arrangements to set these up do not necessarily mean they are actually taken up in a serious manner. **The main lesson here is that new arrangements will only have a real effect if decision makers at the top want to listen, and more so support the proposed actions.** We observed that research and innovation has a high visibility at the highest political levels in countries in all our benchmark countries. This is much less the case in the Netherlands.
- Finnish practice is considered good, and is to some extent being adopted with local variations. In those examples seen to have had a real impact, a critical factor seems to be support at the highest levels: across Cabinet Ministers and including even the Prime Minister (Finland, UK). This is a major weakness in the Dutch governance system, where research and innovation do not have a prominent place in the current government's strategies.[25]
- On the implementation level the increased co-operation between TEKES and the Academy of Finland in setting up joint programmes is a good example of how interaction can be achieved at the level of intermediaries. The Cluster programmes where several Ministries, TEKES and the Academy work together designing cross-departmental research areas is another good example.
- Despite the need for integration and co-ordination, the governance system should take into account the different dynamics and incentives in the science and research system on the one hand and the innovation system in the other. This requires finding the right balance between funding mechanisms that allow bottom-up ideas, and funding mechanisms that have a clear problem-solving objective. Trying to impose the same funding mechanisms rules to all actors in the innovation system will alienate either the research or the innovation community.
- Very few good examples have emerged in relation to co-ordination between sectoral Ministries. Again co-ordination above Ministries by a high level board, is one form of tackling this. Sweden showed a good working Interdepartmental consultation process between Ministries, but at the same time similar procedures work more ad-hoc in for instance the UK. Both Sweden and the UK have one Minister (in Sweden the minister of Science and Education) or one department (in the UK the Office of Science and Technology) that formally have the role to co-ordinate research policies of all other departments.

2 *Can the governance models deal with the multi-disciplinary challenges?*

From the country cases at national level we mainly found examples where a change in governance (merging the Norwegian Research Council) for the sake of tackling multidisciplinary did not work. **However the technology case studies showed that cross-disciplines can be brought together, but often with more success when outside the existing formal structures, and with new additional money**.

[25] In fact the Government Agreement (Regeerakkoord tussen CDA,VVD en LPF) of summer 2002 did not contain the word innovation and did not discuss the role of science and technology in Dutch society!

- The US and German nano-technology cases illustrate that when new challenging areas arise forces can be joined. In the case of the US an informal working group between agencies turned into a co-ordinating body with formal status and a huge budget to distribute. In Germany the Ministry BMBF was the change agent, facilitating multiple nano-technology networks. Nano-technology is typically an example where industry (currently) lacks leading actors, and the research community is too dispersed to achieve the clustering of disciplines themselves. The Dutch Genomics Initiative has similar features.

One drawback of this observation (working practice) is that this 'going beyond existing structures' tends to add new elements to the existing governance structure, making it even more complex.

3 *Does the manner in which priorities are set and decisions made allow for broad changes and adaptation to new challenges?*

In the Netherlands the governance of STI and the structure of the innovation system has rarely undergone any radical changes. It has adapted incrementally to new challenges by increasing the number of actors and initiatives, without abolishing existing structures. This has led to a complex and extensive set of actors. From year to year the level of public funding of STI has showed minimal variations. Not all benchmark countries showed a similar incrementalism in their system.

Three examples of radical changes have occurred in our benchmark countries: The re-allocation of massive amounts of government budgets in the favour of science and technology in Finland in the 1990s and in Ireland in 2001, and the review and part restructuring of the research and innovation system in Denmark. Each of these had very country specific backgrounds in terms of the arguments laid down for these radical changes. The similarity between the three was support both at high political level and from industrial leaders. Only in the case of Finland which faced a deep economic crisis was there a commonly felt 'sense of urgency' to redirect economic development. In Ireland and Denmark influence of individual opinion leaders and receptiveness on the side of key policy makers, rather than urgency allowed the shift.

Exactly where decisions are made in the governance structure differs from country to country. The intermediary level of agencies appears to be quite strong in setting agenda's in Canada, Finland, Ireland, Norway and Sweden. In Denmark agenda's are set in a very decentralised manner, with the stakeholders having much influence. In the Netherlands the innovation part of the governance system does not have a particularly strong 'agenda setting' intermediary level, whereas this is much stronger in the area of science and research. **In general the availability of additional funding makes such a shift of paradigms and locked in structures much more easy.**

The Netherlands significantly differs from other countries in its lack of a strong formal representation of industrial stakeholders in the debate on science and technology, which in our view is a problematic feature of the Dutch governance system. We have seen in practically every high level advisory body in other countries, that representation of leading R&D firms exists, and participation in the debate is at the executive level. Very recently however, the CEO's of some major Dutch firms have started to raise the point of under-investment in R&D, universities

and education in the public media, stressing the damage this has on the competitiveness of The Netherlands.

In addition to governance at national level, the technology case studies illustrate that new directions can be taken in challenging technology areas, directions outside the dominant national governance patterns, which can be led by a group of stakeholders. These often take the form of dedicated task forces or mega-programmes.

- Examples such as the Swedish IT and Bio-technology, and the UK Medical Research cases show how close informal consultation between industry, academia and government agencies, bypassing formal structures, can redirect efforts in a focussed way
- The Canadian Fuel Cells case is a good example where bottom-up industry driven clustering activities led the way for the government to adapt its strategy
- The US nano-technology initiative is another example where joint initiatives were taken outside existing structures, leading to large additional investments in this technology area

The case studies from Japan (mechatronics and materials), Korea (broadband and mobile phones) and Germany (nano-technology and materials) show, on the contrary, an instance where the leading role is taken by the public sector. In particular the practice where Ministries launch large public programmes in dedicated science and technology areas, in order to provide incentives for private and public sector researchers to enter into upcoming fields.

4 *Do other countries have good practices to steer their research institutes?*

Overall there appears to be a myriad of non-academic public research centres and government labs in Canada, Denmark, Finland and Norway, whereas Ireland, Sweden and the UK rely mostly on their universities. Institutes that have the government as their main customer, tend to be parented by a Ministry or Agency and to a large extent are directed by them. Contract research organisations operating on the market are, on the other hand, given much more room for manoeuvre in developing their own strategy. The influence of the New Public Management and the principles of 'good governance' on research and innovation has been positive and is increasing, but there are important national differences in the way it is implemented.

We have observed three practices that can be viewed as a good lesson for the Dutch situation:

· Firstly a **review of the overall research system** and its research institutes which has been carried out in Finland, Denmark and Germany. Such an exercise provides the opportunity to review the mission statements of institutes, while at the same time assessing their performance against broader goals. A review such as this only makes sense if the political body or bodies commissioning the exercise are prepared to act upon the conclusions and recommendations. Denmark has gone furthest in its review of the entire research institute system, in parallel with the university system and the Research Councils. Here political-will at the top to 'shake the tree' so to speak, made it possible for such an undertaking without the consent of most of the stakeholders. The Finnish and German exercises have been implemented with higher levels of consent from the stakeholders, who were closely involved in the evaluation process. In these two countries the review did not lead to radical changes to the research system.

- Secondly a **regular evaluation of the research institutes based on clear mission statements, objectives and agreed performance indicators** is a matter of practice in only a few countries (Norway and Finland). Nevertheless in most cases governments and institutes struggle in the definition of meaningful performance indicators.
- Thirdly the **linking of public funding to clear defined targets**. In Denmark the Ministry has annual performance contracts with the GSTs institutes, even though they only receive public funding of 10%. In Germany the Fraunhofer institutes need to match grant funding with external contracts.

5 *What can the Netherlands learn from the relation between Ministries and Agencies?*

- The comparison shows that the Dutch agencies, in particular SENTER, have far less programme design and programme management responsibilities in comparison with their counterparts in other countries. This implies that most programme intelligence is situated inside the Ministry. One major drawback of this governance structure is the distance between those who design and manage programmes and the customer groups using the programmes. Feedback from the user group might not enter the learning curve as directly as it does with agencies who 'design and deliver'.
- Multi-client and umbrella organisations are becoming more common for research and innovation funding, but are complex to govern.

6 *Are synergies between national and regional governance levels optimally utilised?*

The answer here is that in most cases the co-ordination does not work very well. The regional actors are relative newcomers in this policy area, with national actors often reluctant to distribute budgets and power to the regional levels. New working practices with the Regional Development Agencies in the UK and the Regional Growth Agreement in Sweden are interesting from a governance perspective. Whether they will be successful and deemed 'good practice', is at this point in time undecided. In these two very recent examples, solution have been sought through 'formal' contracts between national and regional actors. In both cases central government acted as a catalyst for such a shift in governance.

Whatever governance and advice forms are chosen, effectiveness depends considerably on the personalities with which they are populated and the level of trust between both people and organisations. Rivalry in governance appears to be dysfunctional. Structural changes and co-operative behaviour appear (with exceptions) most easily achieved when resources are increasing.

7 *And finally, has governance really made a difference in achieving better innovation performance?*

At the overall national level the direct relation between governance and performance is, as said, very difficult to establish. The technology cases more than the national studies give insight into how governance has helped shift the direction of path dependent approaches. Examples to be noted here are:

- A strong government choice in the UK for centralising medical research in the National Health Service, substantial and long term investments from the NHS, and strong academic hospitals which provide support for clinical research, together with strong linkages with pharmaceutical industries have put the UK high on the world map in terms of competitiveness in medical bio-technology. This was not however the result of a deliberate innovation policy strategy, but a result from the governance of health policy instead
- In the US the combined forces of several agencies to launch a National Nano-technology Initiative has boosted the level of research. Whether this will lead to increased industrial competitiveness this will only be seen in the long term
- In Sweden a bottom-up process from the key stakeholders in science and industry to boost research efforts in bio-technology and in particular bio-medicine, combined with dedicated actions to support start-ups, has made Sweden one of the leading scientific performers in this field. This has happened mostly without an active involvement of public agencies or government strategies. Whether this translates into a growing new industry remains to be seen, perhaps a change agent is required.

What is important to point out is that in none of these examples have achievements been realised without existing strengths in research and industry present. Informal networks and consultation structures helped in shaping new forms of formal governance.

Lessons from bad practices can be as useful as good practice lessons. What our study suggests is that:

- The governance system should avoid that decision making structures become too decentralised, with a result that no party keeps an overview of who is responsible for which task in the innovation system. In various research governance systems we have also seen that decentralised and bottom-up funding, where the stakeholders have great control over the contents of research, can lead to lock-in situations and fragmentation of research efforts. Without a change agent or 'referee' in the system, path dependency will only increase
- The case of the Norwegian Research Council where separate disciplinary councils were merged into one organisation, shows that organisational restructuring alone is not sufficient if the culture between parts of that new organisation don't change, resulting in little deviation away from 'linear' thinking.

8 *What additional research is needed on this topic?*

We have seen that despite empirical investigations of innovation governance, there are many elements of this broad concept which still need deeper understanding and analysis. This study has taken a birds eye view on the subject and set out to look at the governance and inter-linkages of the whole innovation system in a limited set of countries. The main reason governance is so complex and difficult to grasp is that we are seeing snapshots of historical learning processes. In a sense, the *real* process is how a country learns to understand and internalise STI and its role in wider policies. The organisational structures are just reflections of the stage it's reached and especially the elements of the system that are learning and changing. A deeper understanding would involve identifying 2-4 potentially rich (from the Netherlands' perspective) countries and conducting a deeper and more historical analysis. Developing some indicators of the learning, as opposed to the organisational structure, would be interesting, but again rather a deep question

In addition to looking at the overall system in specific countries, it could be considered to focus on specific governance issues in a wider set of countries.
In the Dutch context there are a number of aspects of innovation governance that should be looked at in more detail:

- The ways in which non-academic public research and technology organisations (RTOs) define objectives, agree on targets and performance indicators with their funders, and subsequently evaluate their performance, is a subject which needs a more detailed approach. In the light of increased internationalisation of R&D, their room for manoeuvre to work with foreign partners or in foreign markets could be included in such a review. This would require looking at other countries where these type of management practices are in place
- The national – regional co-ordination in the Netherlands is not developed very well as we have seen in this study. Initiatives in the benchmark countries (particularly UK and Sweden) are very young but interesting enough to follow progress. What good practice examples could be found in countries that have a longer history of federal – regional collaboration?
- In the Netherlands the main innovation agency SENTER has relatively little responsibility for policy design and management, compared to its counterparts in countries like Sweden, Norway, Finland and Ireland. Does this make the Netherlands less effective in policy learning (i.e. translating feedback from the customers in better policy designs)? How do these agencies adjust their policy instruments?
- The co-ordination between research and innovation policy objectives with wider policy domains such as competition policy, social policy, and education is yet another layer of co-ordination that needs further exploring
- What forms of stakeholder involvement can be organised avoiding the problem of empowering mainly “old-boy networks”?

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ABBREVIATIONS

AWT	Adviesraad voor Wetenschap en Technologie (NL)
BERD	Business Expenditure on R&D
BMBF	Bundes Ministerie für Bildung und Forschung (Germany)
CWTI	Interdepartmental Committee for Science, Innovation and Informatics (NL)
DTI	Department of Trade and Industry (UK)
GERD	Gross Expenditure on R&D
GDP	Gross Domestic Product
HEFCE	Higher Education Funding Council for England
IBO	Interdepartementaal Beleidsonderzoek (NL)
ICSTI	Interdepartmental Committee for Science Technology & Innovation (Ireland)
ICT	Information and communications technology
IDC	Inter-Departmental Committee (Ireland)
IWGN	Interagency Working Group on Nanoscience, Engineering and Technology (USA)
NNI	National Nanotechnology Initiative (USA)
NSTC	National Science and Technology Council (USA)
NWO	Netherlands Organisation for Scientific Research
OECD	Organisation for Economic Co-operation and Development
OST	Office of Science and Technology (UK)
OSTP	Office for Science and Technology Policy (USA)
R&D	Research and development
RAE	Research Assessment Exercise
RCN	Research Council Norway
RDA	Regional Development Agencies (UK)
RTOs	Research and Technology Organisations
SND	Norwegian Development Fund
STI	Science, technology and innovation
STW	Stichting Technische Wetenschappen (NL)
TNO	The Netherlands Organisation for Applied Research

List of interviewees for Innovation Governance

Denmark

Name	Organisation
Dan Jensen	Deputy Secretary, Ministry of Science, Technology and Innovation
Gurli Martinussen	Director Innovation Department, Ministry of Science, Technology and Innovation
Birgit Kjølby	Head of Research Policy Division, Ministry of Science, Technology and Innovation
Johny Mogensen	Ministry of Science, Technology and Innovation
Merete Reuss	Ministry of Science, Technology and Innovation
Stein Larsen	Head of Secretariat, Danish Council for Research Policy
Karin Dahl-Jørgensen	Board of Danish Research Councils
Lars Klüver	Director, Danish Board of Technology

Finland

Name	Organisation
Esko-Olavi Seppala	Secretary of the national S&T Policy Council, located at the Ministry of Education
Jari Romanainen	Expert member of Tekes Council
Martti.Makela	Director of R&D, at the Ministry of Transport and Communications
Sakari Karjalainen	Ministry of Education
Kari Tilli	Tekes, Head of ICT

Ireland

Name	Organisation and function
Michael Fitzgibbon	Forfás
Bill Hogan	Forfás

Sweden

Name	Organisation
Sune Halvarsson	deputy director , NUTEK
Per Eriksson	director general VINNOVA
Christer Heinegård	SLU
Sture Blomgren	FORMAS
Carl Jacobsson	Swedish Science Council
Matthias Jarl	Education Ministry
Catherina Stenborg-Blom	Agriculture Ministry
Erik Arnberg	Environment Ministry
Lena Kaijsa Sidén	Swedish Foundation of Strategic Research
Olof Lindgren	Swedish Foundation of Strategic Research
Conny Bogentoft	Karolinska Innovation AB
Anna Sandström	Royal Academy of Engineering Sciences
Henrik Blomgren	Royal Academy of Engineering Sciences
Peter Holmstedt	Electrum

United Kingdom

Name	Organisation and function
Peter Bunn	Director, Regional Policy Directorate, DTI
Alisdair Wotherspoon	Head of Technology Transfer Group, Biotechnology Directorate, DTI
Beccy Egleton	Assistant Director, Regional Clusters and Innovation, DTI
Martin Ridge	Deputy Director, Strategic Planning, DTI
Jim Thomas	Assistant Director, BNSC, DTI
Rob Lang	Head of Technology Transfer, Medical Research Council (MRC)
Anthony Horn	Assistant Director, R&D, Department of Health