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PRIORITIES IN SCIENCE & TECHNOLOGY POLICY - AN INTERNATIONAL COMPARISON

PROJECT REPORT

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1 Executive Summary

Priority-setting in RTD-policy has become an issue of major concern in most OECD countries, and in particular in the EU where the emergence of the European Research Area has triggered a debate on the (re-)focusing of national research and technology portfolios. However, the outcomes and processes of priority-setting differ significantly across countries, and most governments are in search of good practices of priority-setting. Often, as in the Austrian case, the national councils for science and technology or similar bodies are key drivers behind this search.

The perspectives for identifying common principles of priority-setting across countries are not too bad. The practices in terms of policies, instruments and institutions may differ considerably due to national cultures and historically grown characteristics, and the rigidities of the institutional framework and of organisational settings are such that path-dependencies can hardly be avoided. Still, one can observe an overall convergence of guiding concepts underlying research and technology policy, concentrating on the approach of National Innovation Systems (NIS), and these common grounds in terms of understanding of and dealing with research and innovation facilitate the mutual learning from other countries' experiences. Therefore, and in view of the importance of the debate on priority-setting in Austria, a comparative analysis of current practices of priority-setting in key OECD countries was commissioned by the Austrian Council for Research and Technology Development in order to strengthen the foundations of this debate in Austria. Screening in a first phase a fairly broad set of fifteen countries the study concentrated on deeper case-studies of six countries in its second phase (Gassler et al, 2004): Canada, Ireland, Korea, the Netherlands, New Zealand and the United Kingdom. This choice was grounded in the desire to avoid focussing on the "usual suspects" and at the same time achieve a good balance between different models of priority-setting.

Recent trends in priority-setting

From a historical perspective, one can observe very first steps towards scientific and technological priority-setting in the immediate post war period. Using a science push approach broad scientific and technological 'missions' were targeted (e.g. nuclear technologies, aero-space). During this first phase institutions of so-called 'big science' have been created (e.g. in physics etc.). In a next step priority setting aimed at identifying very specific strategic priority areas or technologies in a top-down manner, often motivated by 'old style', sometimes even protectionist industrial policies. In a third phase in the 1980s, more differentiated approaches became common, adopting principles of strategic planning and decentralising priority-setting to newly established intermediary institutions like funding bodies, or to research centres and universities.

The current phase is characterised by a more functionalist approach, reflecting the growing influence of the NIS concept. 'Functional' priorities were added to thematic ones, in order to concentrate efforts on the improvement of generic and structural characteristics of the innovation systems, for instance by strengthening science-industry relations and stimulating the setting up of new technology-based firms. However, the emphasis on functional priorities was perceived by policy as somewhat too strong, so that in recent years the balance has swung back to take thematic priorities on board again. Moreover, thematic priorities do not necessarily have to be restricted to

S&T priorities. Increasingly, we can observe an interest in and a need for priorities that are determined by societal needs and opportunities, i.e. so-called new mission-oriented priorities.

The attention paid to priority-setting is also due to its tight embedding in increasingly systematic approaches of strategy formulation in public policy, which in turn is driven by principles of New Public Management. This is also reflected in the growing number of actors with competence and capacity for priority formulation, even down to the intermediate and operational levels. This raises new questions regarding an appropriate division of tasks between these levels, with the policy level being in charge of the broad strategic orientations and budget allocations, and the more operational levels concretising thematic and functional priorities. A key role is played in this respect by programme formulation in science and technology policy, where a good balance needs to be found between bottom-up application-driven research and top-down priority-driven funding of R&D even in the countries most geared towards programmes.

These general trends are mirrored to varying degrees in the different countries studied, even if it is important to stress the major differences between them. Subsequently, some of the key features of these countries' priority-setting as well as the specific difficulties they are facing are synthesized.

Canada: struggling with coherence

The Canadian government has launched some very important programme and budgetary initiatives in the last six or seven years, but is still struggling with the problem of lending the whole apparatus a greater degree of coherence. A comparatively high degree of fragmentation and a predominance of single issue focusing seem to characterize Canadian S&T policy.

The tendency to focus on single aspects of the innovation process rather than on the innovation systems as a whole seems to characterize Canadian S&T policy in general. For example, cluster initiatives, commercialisation support, and investment in universities are often addressed in isolation from each other. Most of the initiatives from 1997 onwards were targeting S&T infrastructure (i.e. funding basic or university research). Recently, a shift was made to technology commercialisation, with new measures introduced in the budget and a new Director General put in charge of it at the National Research Council.

The structure of S&T policy making in Canada looks more coherent than it actually operates. In practice, there is a pretty strict division between those bodies that deal with science issues internal to the government and those that deal with broader S&T agendas. With respect to the Advisory Council on Science & Technology (ACST), it has tended to focus almost exclusively on single issues, such as commercialisation, high tech skills, etc and less so at the big picture. The Council of Science and Technology Advisors (CSTA) provides an overall evaluation of governmental departments and agencies performance in S&T areas.

These observations indicate that Canadian S&T policy would benefit in particular from efforts to achieve greater coherence between the policy initiatives of its various bodies and agencies and from adopting a broader view of the innovation process.

Ireland: stabilising the institutional context

Ireland is among the countries which have put science, technology and innovation policy high on the political agenda and which have drastically increased R&D spending in recent years (though starting from a low level). In the course of these years, a number of attempts to set priorities were undertaken. Before, there were no developed attempts to set priorities; they were rather a "by-product" of the significant flows of the European Structural Funds. With the decreasing importance of EU funding, Ireland set out to establish priorities on her own, even if the EU continues to play a role.

Priority and target stetting is done both on the thematic and functional level, recently with more emphasis on the functional side (increasing R&D spending and number of R&D performers, strengthening the science base, increasing the attractiveness of Ireland as a location for R&D, fostering industry-science linkages etc.) than on the thematic side (the so-called Programmes for Advanced Technology (PATs) which were set up in the 1990ies were discontinued).

The thematic priorities that were set at the national level were (loosely) based on a foresight exercise that was carried out at the end of the 1990ies. Moreover, they remained very broad and focused finally on Biotechnology (especially food) and ICT. These broad priority areas should be transformed into more concrete actions at the level of intermediary institutions (the newly created research councils for Humanities and Social Sciences and for Science, Engineering and Technology, or by Forfas (the main technology funding agency) and its affiliated institutions (Enterprise Ireland, Ireland Development Agency and the like).

While at the national level, the ‚National Development Plan' (currently set for the years 2000-2006) ensures some degree of guidance in terms of overarching goals, a systematic mechanism for the coherent setting of priorities in S&T policy is still lacking. This is partly due to the great flux of the institutional landscape in S&T policy in recent years and partly due to the fact that each institution is called upon to formulated their own strategy. Thus, there is an abundance of strategy documents at the various levels, which often do not seem to be sufficiently relating to each other. The establishment of an institutional framework for coherent priority setting thus is a major task for Irish S&T policy, and it should be addressed before injecting large increases of spending into the system.

New Zealand: matching goals and instruments

The science, research and technology system is regarded as a key element for ensuring a sustained economic development of New Zealand. Given the still well below average resource allocation to R&D activities in New Zealand, it is a stated aim of S&T policy to increase the amount of resources allocated to R&D, both publicly and privately funded.

The S&T policy system of New Zealand is organized around four general long-term goals (relating to knowledge, economy, environment, society), which are defined at the top-level of government. Two of those long-term goals (environmental and social goal) may be characterized as "mission orientated". The concretisation of these goals is achieved by means of dedicated and thematically orientated funding schemes (e.g. for environmental research, social and health research) with a given amount of funding attached to each of those schemes. Explicit thematic and functional priorities at various levels of aggregation are specified in these schemes. Although in general functional aspects seem to attract more attention, thematic priorities exist in areas that are supposed to be the prominent generic growth technologies in the near future as well as in areas in which New Zealand does have comparative advantages and strengths (e.g. agro-business). Thematic priorities are also reflected in the existence of some specialized public science and research establishments (i.e. Crown Research Institutes dealing with specific thematic fields).

The priority setting process comprises a broad range of elements of instruments. A series of evaluations in the 90ies led to a policy strategy discussion channelled into a Foresight programme in 1998-99 involving some 140 different sector groups. It further strengthened the already well-established communication and advisory channels between the actors and stakeholders of the innovation system. The policy strategy discussion led to the aforementioned multi-layer system of priorities, that all make reference to the four overarching policy goals. The priorities set are very influential because they are directly tied to specific instruments and funding schemes to which a given amount of monetary resources is allocated. The realization of objectives and the coherence of implemented measures is regularly evaluated.

New Zealand can thus be regarded as a small, but very instructive example of how a clear and consistent system of priority-setting can be established, implemented and monitored.

Korea: top-down priority-planning

Korea is characterized by strongly formalized and government-driven STI priority setting processes. The S&T Framework Law (2001) defines the basic institutional settings of the policy field. Long-term plans like the current „Vision 2025" define the S&T policy strategy for the period 2000 to 2025. It is operationalised by means of regular short-terms plans that usually cover a five-year time frame.

Priorities: An important factor influencing S&T priority setting in Korea must be seen in the past focus on the rapid commercialisation and imitation of foreign technologies. In order to become more innovation-oriented, functional priorities such as the promotion of basic-research, the development of core technologies and the promotion of innovations with a ten-year horizon have been given high priority in recent years. In July 2003, Korea selected ten STI priority industries and eighty target technologies in order to promote industrial growth. The selected thematic priorities are at a much lower aggregation level than those in most other countries. In addition, Korea promotes some S&T priorities with a clear mission-orientation relating to national security, nuclear energy and a healthy society.

Korea is an example of a highly technocratic priority-setting process involving a wide range of actors. The main players in STI-priority setting are the national science and technology council (NSTC), the Ministry of Science and Technology (MOST) and a few other, but less important ministries. The national science and technology council is a political board that consists of several ministers and is led by the prime minister. In principle the NSTC is the highest authority in S&T priority setting, but the ministries also have significant power. The government supported research institutes (GRI) carry out a major portion of the publicly funded R&D, however their role in decentralized priority-setting has weakened over the past years. Industry and research institutions are involved in consultations for priority-selection including foresight exercises and roadmaps, which are regularly used for the identification of thematic priorities.

The Korean case certainly represents an extreme example of priority setting, as it is the only country studied where the process is almost entirely driven by top-down policy planning. While this approach was quite successful over the past twenty years of catching up technologically with the most advanced industrial economies, it is uncertain whether this approach is well suited for staying at the forefront of technological development in the future. In order to stimulate the creative and innovative potential, a stronger focus on the combination of functional and thematic priorities, either by using functional elements in thematic programmes or through thematic focus mechanisms in functional programmes is recommended.

The Netherlands: coping with complexity

The Dutch governance system for STI policy is rather complex but with well differentiated levels. Priority setting involves aspects of all three kinds of priority setting, however with different impact. On the highest policy level (Cross-cutting policy level), the definition of functional priorities tends to dominate. New and old mission-oriented coordination and priority-setting is taking place at the level of ministries. More detailed policy development and coordination is taking place within a large number of executive agencies. As a means to focus resources, they are engaged in processes of thematic priority setting, though varying significantly across agencies.

Functional priority setting draws heavily on the support of professional consultancies, specialising in policy design and strategic policy intelligence. Activities to initiate research on key functionalities of dynamic innovation system have started only recently. In the past thematic priorities were set using foresight processes involving a large number of actors. Today foresight is used in a less binding way and the impact on thematic priorities set by government is rather indirect. For instance, the expert-based technology foresight “Technology Radar” is used for creating vision that shall guide priority setting at the level of enterprises and SMEs.

In science policy priority setting is mainly based on bottom up processes. Universities are considered as autonomous bodies deciding on their own thematic priorities. As an instrument to transfer these priorities to the level of executive agencies, expressions of interest are used as a means of priority formulation.

Similar to the Canadian case, the Netherlands seem to be struggling with the high complexity of multi-level and multi-actor priority-setting processes, though based on already very advanced practices at all these levels. Ensuring the coherence of the diversity of priority-setting initiatives is thus the main challenge for the future.

United Kingdom: re-orienting the research landscape

The UK has seen a large number of White Papers and other strategic documents on science and innovation policy on the highest policy level over the past ten years. This can be interpreted as an indicator of the growing importance of S&T policy making for the ministries in charge of formulating these policies, i.e. the Department for trade and industry (DTI), the Department for Skills and Education (DfSE) and the Department of Finance (HM Treasury). Priority-setting has also become a major issue at regional level, where foresight initiatives now seem to play a more prominent role than at national level.

British S&T policy is traditionally more science-oriented than in most other European countries. Disciplinary thematic priority setting is done by Research Councils in a bottom up process. In recent years, government has stimulated cooperation between the independent Research Councils in order to initiate multi-council programmes focussing on problems and opportunities that society is facing. There is a growing tendency to concentrate resources in large, collaborative, interdisciplinary programmes with a mission-oriented flavour, dealing with as diverse subjects as genomics, stem cells, e-science, sustainable energy, and rural economy and land use.

Only recently industry-oriented technology and innovation policy has attracted more attention. The funding for LINK, a programme to improve the cooperation between public and industrial R&D as well as for other support programmes for technology development in industry has been increased. At the same time, the number of topics is being reduced from about 100 to 10 major lines of applied research and development. Funding will be coordinated with regional agencies to promote knowledge-intensive business clusters.

The coming years will have to show whether these two main strategic initiatives (i.e. interdisciplinary programmes across research councils and a limited number of cooperative applied research initiatives) will indeed lead to the expected emergence of priorities that distinguish the British research and innovation system.

Some lessons learnt

Priority setting should not be regarded in isolation from the wider S&T policy context. As evidenced by most countries studied, priority-setting is just a part of more comprehensive S&T policy strategy development processes. Such strategy processes seem to become formally or informally compulsory in most countries, a development that is driven by the growing importance of New Public Management principles since the late 1990s. It is not only reflected in the proliferation of strategy documents and White Papers (examples being UK, Ireland, Korea and New Zealand) but also in the institutionalization of S&T strategy bodies (which can now be found in all countries studied). In the UK, even separate White Papers co-exist (White Paper on Science and Innovation 2000, White Paper on Enterprise, Skills and Innovation 2001, Science Strategy 2002, Higher Education White Paper 2003). Normally, these strategy documents and bodies also address priority setting as one of their main tasks.

Priority-setting is not an issue at the level of S&T policy alone, but rather a task that is equally of concern for funding bodies, research organizations, universities and other key actors in the innovation system. As a consequence, ensuring coherence between the various strategic levels and actors becomes an increasingly difficult and at the same time crucial task. S&T policy actors often formulate their strategies without clear reference and linkage to the overarching policy strategy documents, and even the time-scales of the different strategy processes do not fit together (e.g. the multiple strategy formulation processes at the various levels in the Netherlands and in Ireland). Some countries therefore have established institutions that aim at achieving greater coherence in the strategy and priority setting process, for instance specific councils or advisory bodies for STI policy, inter-ministerial coordination groups or chief scientific advisers to the government or the prime minister. Rather than dealing with individual priorities, their main task consists of overseeing the overall coherence of the priority-setting mechanisms throughout the innovation system.

A clear division of tasks is crucial for achieving coherent priority-setting. The countries studied show that there is no single model regarding the appropriate degree of centralization or decentralization of priority-setting processes, but that it is important to have a clear and transparent division of labor. Still, the experiences seem to indicate that the national policy level is best left with three main tasks: (a) the determination of the overall degree of priority given to science and technology in the context of the overall public policies, also reflected in the S&T budget (by the way: only a small number of countries actually has a „S&T budget“, (b) the determination of ‚system-wide’ issues (ISR, SMEs, regulations, etc.), and (c) the identification of general priority areas (both functional and thematic), in which there is need and scope for policy action. In practice, these key policy tasks require identifying a market or systems failure hampering the development of the NIS or setting societal needs as S&T policy missions (e.g. environmental and health research) in order to justify policy action, while leaving it then to the level of intermediaries (funding agencies, technology transfer institutions, etc.) and the research performers (universities, research centres, enterprises) to translate these general policy orientation into concrete actions and operational priorities.

Coherence is not only a matter of formally agreeing on priorities and dividing tasks, but requires that the decisions taken by the full range of actors in the innovation systems actually give rise to a priority. The experiences from the countries studied (with Korea being an exception from the general rule) indicate that priority-setting needs to be supported by converging mindsets and coherent decisions of the different actors in research, industry, policy and society that contribute to the shaping of a priority. Principles of transparency and participation have turned out to be crucial for priority-setting processes to become effective throughout the innovation system, and they are reflected in the proliferation of a new generation of foresight and other similar exercises that have been started in recent years in support of priority-setting.

A strategic approach to priority-setting requires the ability to change course if the context conditions for key priority areas change. Past and present experiences with priority-setting show that priorities are often reflected in new institutional settings (e.g. nuclear or environmental technology agencies, new funding bodies, etc.) that impose path-dependencies, bind resources and thus constrain the room for maneuver to adapt policy strategies in the course of time. This problem is most severe, when institutions are very much sector/technology specific (e.g. dedicated research centres, specific research councils etc.). In order to increase flexibility (and thus the degrees of freedom for priority setting) greater emphasis is being put in almost all countries on programme funding instead of institutional (‚block grant') funding.

In order to improve the quality of their strategy processes, systematic forms of ‚strategic policy intelligence' are increasingly used in a number of countries. With respect to S&T policy and priority-setting, they include, for instance, technology foresight exercises, technology monitoring and roadmapping, evaluation of programmes, institutions and sometimes policies. The use of such practices is not confined to the level of policy making at the national level but has spread and is often linked to strategy formulation processes at the level of individual organisations (research councils, funding agencies, research institutes). The role of and the reliance on these forms of strategic policy intelligence in actual policy making varies considerably between countries and types of actors. The experiences in the different countries show that the impact of the results of such exercises on policy making at the national level seems to be rather loose, whereas they can be highly effective at the level of individual institutions and organisations (research councils, funding agencies, dedicated/specialised research institutions).

Finally, one needs to be aware of some of the limitations of priority-setting. In thematic terms, a general pattern has emerged across all countries studied, reflecting some common "future" technologies like biotechnology, ICT, nanotechnology and all their derivatives. These common future technologies are at least in some countries accompanied by additional priorities which are based upon perceived country-specific strength or special endowments (i.e. wood cluster in Finland, agri-business complex in New Zealand). However, in most countries (with the notable exception of Korea), the level of aggregation of these thematic priorities is relatively high and hence their degree of discrimination should be not overstressed. The international alignment of overarching priority domains thus tends to leave little room for unique priorities of individual countries, and if, then they need to be defined at a more specific level than that of general headlines. In addition, it is important to mention, that thematic priority programme tend be rather small as compared to the broad non-discriminatory funds (both with respect to basic science as well as to more applied research). The latter still outweigh the former in terms of allocated resources. Hence, when comparing the countries examined for this study the common denominator may be best characterised as being the concurrence of functional, systems-orientated approaches (inherently non-discriminatory with respect to thematic orientation) and specific, thematic targeted (and sometimes even narrow) themes. The all-embracing common ground is to foster innovation and to smoothen relations within the innovation system, thus accepting the fact that the inherent complexity does not allow for simple-minded fixes.

2 Introduction

The discussion of technology policy during the last years was characterised by two major lines of arguments. On the on hand, the innovation systems approach, which became the dominant theoretical foundation for technology policy throughout the 90ies (e.g. Lundvall 1992, Edquist, 1997, OECD, 2002), highlights “generic” (or functional) aspects, which determine the framework in which innovation processes take place. On the other hand, recently the pivotal and growing significance of priority setting (mainly in applied research, but to a somewhat growing degree in basic research as well) has been increasingly acknowledged as critical for the guidance of (public) resource allocation. Additionally, we have seen a shift from bottom-up/curiosity driven processes of submitting research proposals towards a more top-down orientation of research. This shift can be observed for applied research as well as for basic research (“targeted basic research”). This general trend can be observed in Austria as well as in many other European countries and at the level of EU institutions.

The background of this increasing discussion about the need for priority setting are to be found in changes in the context conditions under which each national innovation system and the corresponding technology policy operate:

- The promotion of the ‘European Research Area” has led to the recognition that further integration of European research and technology may lead to a distinct pattern of re-specialisation based upon comparative strengths of regional/national innovation systems in which “critical masses” of research efforts and technological activities can be achieved.
- The struggle to increase national competitiveness leads to the need for specialization in areas in which (i) absolute or relative national strengths exist and (ii) in technological areas which are perceived as ‘generic” and/or fundamental (due to their growth potential, their expected technological/economic spill-overs etc.) for the future techno-economic development (see Dachs et al, 2003, for a detailed discussion concerning specialisation and priority setting).
- The tremendous technological push through new, path-breaking developments in fields like ICT or bio-technology has increased the incentive for national policy actors to re-focus the respective national innovation system towards these fields. Increased R&D investments in these technological areas are regarded as a necessary condition to keep abreast with the pace of new developments. Hence, in almost all countries at least some reference to these technologies can be observed. Thus, besides the strive to distinguish a country’s technological profile from its competitors, all countries seem to have a similar set of priorities, at least at a general level. We can observe a recurrence of subjects such as ICT, biotechnology, new materials, nanotechnology, but also some more broad topics like sustainability, transport, etc.

However, underlying this general observation, we can nevertheless see a number of differences, especially concerning the scope and procedure of the respective priority setting processes. In order to understand where the differences lie and what the underlying trends at this more fine-grained level are, we will suggest a conceptual framework that will be illustrated by means of a set of case-studies.

The conceptual framework to analyse priority-setting in a comparative way applied throughout this study is based upon a three-dimensional analysis along following lines:

- Differentiating between types of priorities, namely (i) mission-oriented, (ii) functional, and (iii) thematic priorities.
- Differentiating between levels or layers of priority setting concerning the hierarchical position of the different priority setting actors and/or institutions within the respective national innovation system.
- Differentiating the nature of the priority setting process (i.e. top-down/expert-based vs. bottom-up/participatory).

This differentiated way of looking at priority setting at different levels will allow comparing countries in terms of the location of different aspects of priority-setting at these levels. This approach provides a new perspective on the structural patterns that underlie priority-setting. Furthermore, this three-dimensional framework takes into account that priority setting usually takes place at different levels in most countries, ranging from national S&T portfolios to regional and sectoral priorities within individual research programmes and/or funding schemes. In addition, it is interesting to compare not only the types of priorities as such, but rather what types of priorities are defined at which levels and what types of processes are used respectively. For example, broad mission-orientated priorities are often defined at a very high institutional level within the national innovation system, whereas specific and more narrowly defined thematic priorities are to be observed often within programmes of funding institutions at a lower institutional layer.

One drawback of this approach is that it allows - due to budgetary constraints - only a limited number of countries to be chosen for a detailed analysis. Hence, a selection process concerning the countries to be analysed is necessary. In order to select the final sample of countries, the procedure was as follows:

(i) Fifteen OECD-countries were chosen to be screened regarding the principle guiding questions concerning priority settings, which are
   - Existence of explicit priorities,
   - Nature of existing priorities (mission oriented, functional, thematic),
   - Description of priorities (if there are any),
   - Institutions responsible for priority setting,
   - Methods of implementation (e.g. white-books, legislation).

   The screening of these 15 countries was based mainly on OECD-reports accompanied with selected national reports/governmental papers and internet based desk research. The results of this screening are documented in a special interim report (Gassler et al, 2004).

(ii) Based upon this screening a sample of six countries has been chosen by an interactive discussion process between the project team and the Austrian Council for Research and Technology Development. The selection criteria were chosen each as to guarantee that countries with a high degree of diversity concerning their innovation system, their policy measures etc. were included. The final sample of countries analysed consists of Canada, Ireland, Korea, Netherlands, New Zealand and the United Kingdom.

For each country case study the same set of guiding questions have been applied, which are as follows:

- Existence of explicit priorities in science, technology and innovation policy and, if yes, of what kind (based upon the three dimension discussed above i.e. 'mission', 'thematic' and/or 'functional') ?
- Frequency of adoption, re-formulation etc. of priorities, i.e. are priorities formulated and/or re-formulated and adapted in a frequent process or is this process more or less random over time ?
- The very nature of the priority-setting process itself: The process of priority setting may vary significantly between different country. One extreme case may be a very broad process based upon a detailed foresight process integrating huge number of different actors and stake-holders from policy, economy, science & technology as well as society as a whole (e.g. non-governmental organizations etc.). On the other hand the process of priority setting may be based upon a more narrow expert-orientated approach. In addition, the connex of the priority-setting process to overall strategic S&T-policy discussions is of interest. Also, the various hierarchical layers responsible for the priority setting process have to be identified and it has to be analysed which layer dominates which type of priorities.
- Aggregate level, scale and scope of priorities: At which aggregate level are priorities to be chosen? E.g. broad technology fields like ICT, biotechnology, new materials, nanotechnology or more narrow scientific-technological paths like e.g. high-temperature super conductor.
- Degree of formalisation and mechanism of implementation: How are the chosen priorities actually implemented? Are they implemented in a more or less formal way (e.g. by governmental decrees) or are they more or less informal or intentional?
- Evaluation Procedures: Are there any evaluation procedures of chosen priorities implemented? If yes, what evaluation time horizons and methods are used?

The results of this detailed country-based analysis, using the conceptual framework discussed above, are presented in Chapter 3 of this report. Chapter 4 will draw some conclusions from this analysis, first by suggesting a typology of countries, and second by highlighting basic strategies of priority-setting that seem appropriate for these different types of countries. This latter step being an exploratory one, it is evident that further research will have to be done in order to substantiate the hypotheses formulated. However, the framework and first empirical evidence should help policy makers identify and learn systematically from other countries strategies.

3 Country Case Studies

3.1. Canada

Sami Mahroum (systems research)

3.1.1 The Canadian Innovation System – some stylized facts

Canada is one the G7 economies and the only major advanced economy that neighbours the U.S. The latter gives Canada both many advantages and challenges, which may be summed up by the need to find the delicate balance between finding synergies with the US and averting dependency on it. In terms of research, technology and innovation (RT&I), Canada looks very small compared to its neighbour to the south, in a way similar to the position Austria *vis a vis* Germany. Among OECD economies, Canada, like Austria, falls behind the OECD average in terms of its R&D intensity, spending almost 1.9% of its GDP on R&D in 2002, (Austria's expenditure on R&D in 2002 was also around 1.9% of its GDP). Governments in both countries has pledged to close the gap in R&D spending between them and the OECD average - 2.3% of GDP. In Canada the pledge is to double government's expenditure on R&D by 2010. The nature of the R&D performed by the federal government has changed in emphasis over the past five years. Changes show an increased emphasis on public health, industrial production and technology, and non-oriented (or basic) research.

Canada's GERD/GDP ratio has grown from 1.76 in 1990 to 1.93 in 2001. The industrial R&D has grown considerably in telecom equipment (23%), aircraft and parts (13%) and engineering and scientific services (10%), although overall levels of industrial R&D expenditure as a percentage of GERD have been declining since 1997. Canadian patenting activity in the U.S. has also increased over the same period, particularly in telecommunications (8.5% of total Canadian patents granted), pharmaceuticals (5%), computers and peripherals (5.5%), and biotechnology (3%). The average annual growth in Canada (1980-1997) exceeded that of the U.S. and the world in high-technology manufacturing and total manufacturing, while it stayed abreast in knowledge-based services.

Recent Discussions of Strengths and Weaknesses

The Government of Canada has set an ambitious goal for Canada to meet by 2010 which is to become one of the top five countries in the OECD in terms of proportional R&D spending. In order to reach that goal the government has committed to double its expenditure on R&D and has set a broad plan outlining its goals and on how it seeks to achieve them. This broad plan is known as *Canada's Innovation Strategy* and it sets the priorities and objectives for government in the area of RT&I. In general, it can be said that Canada's approach has not been to 'pick' winning sectors or institutions but to 'back' leading sectors and to support research and innovation that addresses what are perceived as being key social and economic objectives.

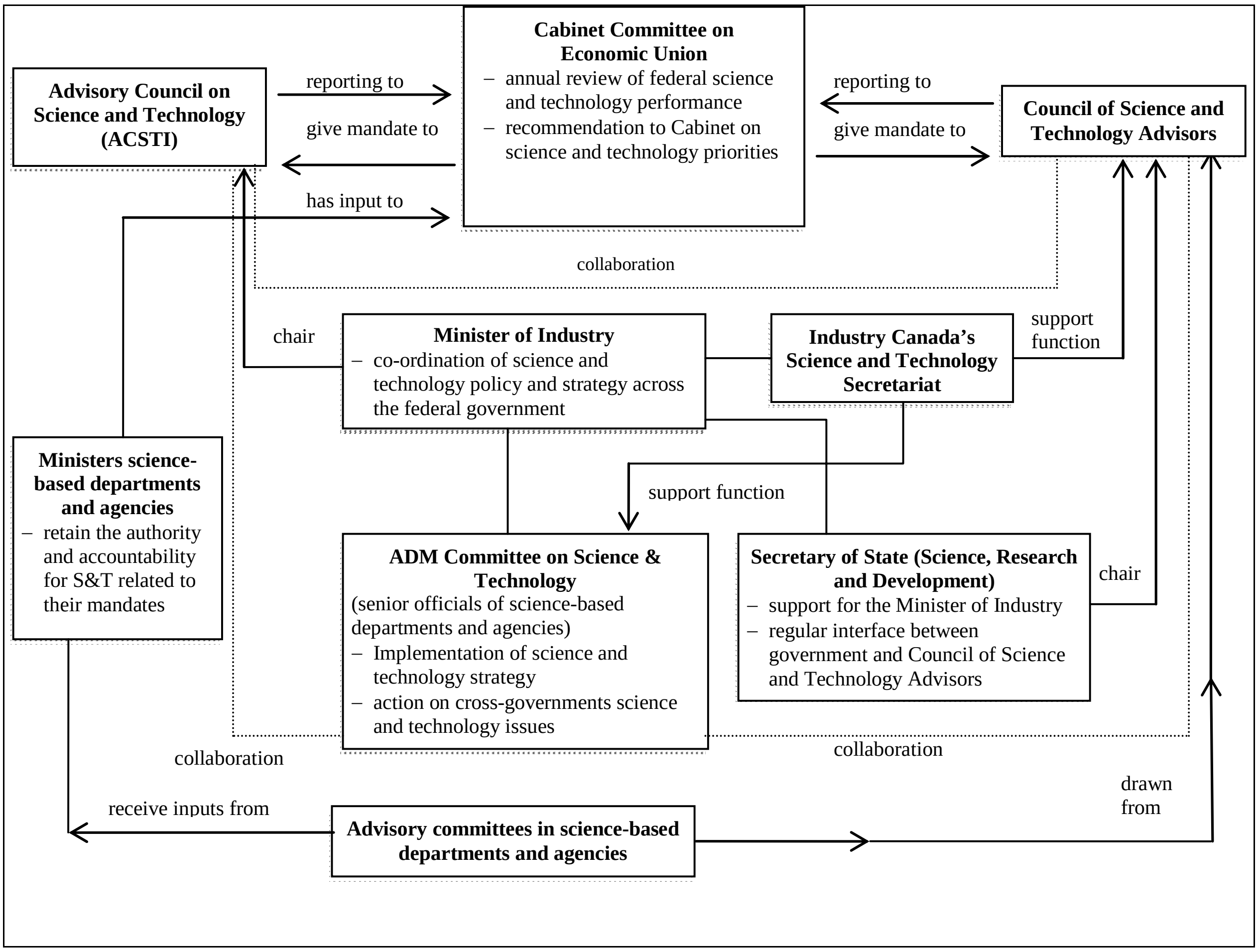
The government's strategy is focused on four inter-related priorities:

- Create and use knowledge strategically to benefit Canadians: promote the creation, adoption and commercialization of knowledge.
- Increase the supply of highly qualified people: ensure the supply of people who create and use knowledge.

- Work toward a better innovation environment: build an environment of trust and confidence, where the public interest is protected and marketplace policies provide incentives to innovate.
- Strengthen communities: support innovation at the local level so our communities continue to be magnets for investment and opportunity.

Institutional Structure & Development

Figure 3.1: Institutional Structure for Priority Setting



Source: 1998 Annual Report of the Auditor General of Canada.

Two top advisory bodies, the ACST and the CSTA provide support to the Cabinet Committee on Economic Union which itself conducts annual reviews of federal S&T performance and makes recommendations to the Cabinet on S&T priorities (see Figure 3.1).

The Cabinet Committees review proposals from individual ministers and then send their recommendations forward to the full Cabinet for discussion or ratification, are organized around the economic union, the social union, Treasury Board, and government communications.

The Advisory Council for Science & Technology (ACST) has as a role to review Canada's performance in research and innovation and to identify emerging issues of national concern, and advise on a forward-looking agenda with a view to positioning Canada in an international context. The Council of Science and Technology Advisors (CSTA) provides advice to the federal Cabinet on the management of the government's science and technology enterprise. Thus, the ACST has its focus the country as a whole, while the CSTA focuses mainly on government related S&T activities.

The ACST is considered an advisory body at the highest level equivalent in its status to the Austrian Council for Research and Technology Development. In 1996, the Prime Minister's Advisory Council on Science and Technology (ACST) was created with the role to review Canada's performance in research and innovation, identify emerging issues of national concern, and advise on a forward-looking agenda with a view to positioning Canada in an international context.

The members of the Council are eminent Canadians representing different sectors of business, academia, and research institutions, and come from across Canada. In carrying out their role, the members provide expert, non-partisan advice to the Prime Minister.

The ACST's role is to:

- advise on Canada's transition to a knowledge-based economy
- contribute to identifying the necessary adjustments on how to increase the number of Canadians with the skills necessary for a knowledge-based economy
- advise on how government, industry, and academia can work in partnership to commercialise research and new technologies into new products, processes, and services
- provide advice on science and technology issues to the Cabinet Committee for the Economic Union
- respond to specific questions and requests from the Prime Minister.

3.1.2 Existence and kind of priorities in STI

The Government of Canada unveiled its Innovation Strategy in January 2001. Two complementary papers, *Achieving Excellence* and *Knowledge Matters*, were written to "focus on what Canada must do to ensure equality of opportunity and economic innovation in the knowledge society." *Achieving Excellence*, the paper written by Industry Canada, which is the federal ministry for industry, identified several goals and strategies for government, the private sector, and educational institutions with respect to developing innovation capacity and output. The commercialisation of university research featured prominently in the goals and targets in *Achieving Excellence*.

From the targets declared above, it is obvious that generally speaking the explicit priorities of the Canadian government lean more towards being of the **'functional'** type. More specifically, the government has committed to:

- at least doubling federal expenditures on R&D
- strengthening the research capacity of Canadian universities and government laboratories and institutions
- accelerating Canada's ability to commercialise research discoveries
- pursuing a global strategy for Canadian science and technology (S&T).

An important principle is that government should be supporting excellence in Canadian R&D. However, some '**thematic**' priorities have also been mentioned such as:

- strategically targeting new investments in research (e.g. in life sciences) and
- increasing support for the development of new technologies to assist Canadians with disabilities.

When thematic objectives are spelt out, they are mentioned as **'mission oriented'** priorities such as health and environment, industrial technology, space, and basic (or non-oriented) research, which often are part of social and economic objectives.

The frequency of adoption and re-formulation of priorities

In 1996 a strategy document was released entitled *S&T for the New Century* followed in 2001 (5 years later) by another strategy document called *Canada's Innovation Strategy*. A major review of S&T policy and institutions began in 1994 and culminated in the release of the innovation strategy in 2001. There is no official timeline for the issuing of new S&T strategies or new priorities, however, such priorities are usually revised before new budget releases and expressed in the 'Throne Speech'[1]in a rather formalized procedure.

Ministries develop new programmes and services to reflect the priorities of the government as outlined in the 'Speech from the Throne' (by the Governor General, the Queen's representative in Canada). These priorities are quietly developed and circulated around senior civil servants through contact with the Privy Council Office in the months leading up to the budget cycle.

The communication of new activities is typically achieved through press releases from the office of the Minister or the Secretary of State. Co-ordination of R&D mechanisms is most typically found in the research councils. Here strategies, objectives and proposals are discussed at the level of council, developed at the level of staff and executive, and lobbied for to Parliament through standing committees, letters to members of parliament, etc. Once funds are announced in the budget, they are co-coordinated by Grant Selection Committees (GSC) for each programme (such as strategic grants, matching grants, operating grants, infrastructure grants, etc). This tends to be a function of fairly large degrees of responsibility and trust being transferred implicitly from government to the senior management of the various bodies. Also, this is a function of the government preferring to strike a balance between funding education and basic research as well as stimulating the commercialisation of innovation and technology.

The nature of the priority-setting process

The broad lines for the 2001 Canadian S&T strategy were drawn in a relatively wide consultative process that lasted 9 months. The aim was to develop a concrete plan by which the government will be guided in meeting its commitment to double R&D investment by the year 2010. The process culminated in the 'National Summit on Innovation & Learning'. Delegates to the summit were broken out into working groups and asked to vote for their top three priorities from lists of about 15 recommendations in each of the five thematic areas. The Prime Minister's Advisory Council on S&T (ACST) was charged with identifying priority areas of future Canadian research.

[1] The Speech from the Throne officially opens every new session of Parliament. It sets out the broad goals and directions of the government.

The ACST will also be asked to identify whether, at this moment in time, Canada should be favouring broad areas of life sciences, information and communication technology, aerospace so as to achieve a competitive international advantage or critical mass within a discipline.

However, **most priority-setting** exercises still take place **at the level of the granting councils and executive agencies**. In fact, the establishment and/or restructuring of external S&T advisory boards and technical review panels has been a key mechanism used by departments and agencies to ensure the relevance of their S&T programmes and activities to the overall national objectives set at the federal level.

The merit principle drives the examination of applications for funds as they are brought forth, whether to the National Research Council or Natural Sciences & Engineering Research Council (NSERC) or the centres of excellence programme or to the Canadian Foundation for Innovation (CFI). All of the decisions on all of these programmes are made at arm's length from the government and from the Parliament. Whenever there is a block of funds, an expert panel is involved in the priority setting for how it should be spent.

Target areas in strategic programmes in the federal granting agencies are generally proposed by multi-stakeholder committees and decided upon (whether to approve or not) by the agencies' governing councils. In the case of *Genome Canada*, a panel from outside the country — 150 international experts give their advice on where this strategic investment across Canada should go. The same procedure was repeated in the space program, or the neutron facility. So the government makes use of consultative and outreach exercises to draw the broad line while leaving the details to expert panels and advisory boards that are attached to the individual institutes and agencies to draw the priorities at the organisational level.

Recently, the National Research Council (based in Ottawa but with institutes across the country) launched a pilot project for a **foresight exercise**. The NRC made a proposal to the community of federal Science-Based Departments and Agencies (SBDA) in March 2002 to launch a collaborative pilot project to explore the application of foresight tools. The foresight project had the following objectives:

- Exploring prospective impacts on society of S&T developments.
- Identifying emerging factors driving change.
- Identifying areas of scientific research and technological development likely to influence change and yield the greatest economic, environmental and social benefits over the next 10-25 years.
- Developing a foresight context for potential application to policies, agendas and investment strategies for S&T and R&D.
- Improving horizontality through better understanding of where and how to collaborate among departments, agencies and other stakeholders.
- Creating robust networks of collaboration among Canadian and international experts in selected S&T domains and prospective future sectors of national concern.
- Providing a collaborative learning environment for strengthening the inclusion of S&T input to the policy process.

Box 1: Technology Roadmaps

Industry Canada acts as a catalyst and facilitator, through increased collaboration, shared knowledge, and new partnerships, in identifying the technologies required to meet future market demands. Eight Roadmaps have been completed (Aircraft, Aluminum, Electric power, Forestry, Geomatics, Lumber and Value-Added Products, Metalcasting and Wood-Based Panel Products).

Four Roadmaps are being developed (Biopharmaceutical, Intelligent Buildings, Medical, Imaging, and Photonics). Five Roadmaps are under discussion (Logistics, Biomass and Biofuels, Fuel Sources for Fuel Cells, Ocean technologies, and Nanotechnology).

Aggregation Level - the scale and scope of priorities

Since the introduction of the S&T strategy in 1996, R&D priority-setting has taken on new levels of importance within the federal government. They are generally set at the broad fields' level. The 1996 strategy document set out three inter-related goals for building that innovation system:

- sustainable job creation and economic growth;
- improved quality of life;
- and advancement of knowledge.

In the Speech from the Throne of 2001 the government set similar broad objectives namely:

- continue to pursue excellence in Canadian research by strengthening the research capacity of Canadian universities and government laboratories and institutions;
- accelerate Canada's ability to commercialise research discoveries, turning them into new products and services; and
- pursue a global strategy for Canadian science and technology, supporting more collaborative international research at the frontiers of knowledge.

These priorities are rather too general, for directing economic development or social capital. However, there was reference to investments in areas such as **health, water quality, the environment, natural resources management and oceans research**. The importance of research in **the life sciences**, which will benefit all of Canada, was a major theme in the speech. It stressed the role that research plays not only in major centres, but also its importance for agricultural and rural economies.

In 2003, the new Canadian PM, Mr. Paul Martin, spelt out Canada's S&T priorities like the following "it is the transformative technologies: "this is where the true new economy is to be found in the transformative cascade of new technologies" — wave after wave after wave of new technologies." He then gave more details naming information technology and biotechnology, fuel cells, nanotechnology, and genomics.

A recent report[2] by an S&T parliamentary committee stated that Committee believes that **a stronger federal S&T advisory framework** is necessary to ensure that the government is receiving appropriate and adequate advice for setting federal research priorities and policy. However, the Committee said it was encouraged to see that the issue of decision making and

[2] In October 1997, the House of Commons Standing Committee on Industry began a long-term study leading to a series of reports on innovation, productivity and industrial competitiveness. This study was initiated in response to Sustaining Canada as an Innovative Society: An Action Agenda, a document written by several research groups for the Government of Canada and which had raised important questions on the quantity and quality of scientific research being undertaken in this country.

priority setting is mentioned in the federal government's *Innovation Strategy*, and that the government will consider establishing a national, arm's length science organization (the *Canadian Academies of Science*) to provide independent assessments on science-based issues of national importance. Indeed the new government has started acting on its promise and has established a National Science Advisor position to provide part of that advisory function on national S&T priorities.

Some critics point to the lack of clear research priorities at the federal level to explain the recurring debate that relates to the subject of the allocation of research funds. As a consequence, the government tries to fund all fields of research and thus cuts a small pie into even smaller pieces. The government has tried to remedy this situation by setting up special funds, programmes and even institutions to focus scarce research funds in specific areas.

Formalisation of prioritisation and subsequent implementation

The central department in Canada, in terms of research and innovation, is **Industry Canada**, i.e. the Ministry for Industry. Several research councils effectively report to parliament through the Minister for Industry. These include the Natural Sciences and Engineering Research Council, the National Research Council, the Canadian Foundation for Innovation, and the Social Sciences and Humanities Research Council. The Minister for **Health Canada** performs similar duties for the Canadian Institutes for Health Research. Other ministries conduct research and stimulate innovation, such the **Environment Canada**, **Natural Resources Canada**, and **Atomic Energy of Canada Limited**, but the majority of their R&D is performed intramural. Each of these departments has a priority setting mechanism that comprises internal and external advisory processes. To ensure that departments and agencies act together to reach S&T goals, the S&T strategy adopted a common framework of operating principles. The government-wide framework guides departments and agencies in preparing and implementing their S&T plans. External S&T Advisory Boards (SAB) in particular have been effective in providing assistance.

At the level of the government as a whole, in the course of its S&T review, which began in 1994, the federal government decided to make a number of changes to the structure and processes of its decision-making. The Cabinet Committee on Economic Union (CCEU) was given the mandate to review the performance of federal S&T activities on an annual basis and to recommend priorities to Cabinet. To facilitate its review of S&T priorities, the CCEU is to receive advice from a new body, the Advisory Council on Science and Technology. The Council — which is composed of 12 eminent Canadians who represent academic, the voluntary/charity sector, and industry stakeholders — replaces the National Advisory Board on Science and Technology that was disbanded at the beginning of the 1990s.

The government also recognized that an improvement in the management of its investment would also be required, which, first and foremost, necessitated more coordination of intramural S&T activities among federal agencies, as well as greater collaboration on major horizontal issues — those that cut across departmental and agency boundaries. This coordination function resides with the Minister of Industry and the Secretary of State (Science, Research and Development), who are supported by another new body, the Council of Science and Technology Advisors, comprising 22 advisors from outside government and chaired by the Secretary of State.

Evaluation Procedures: Which evaluation procedures do exist?

At the top of the federal policy-making structure, the Council of Science and Technology Advisors (CSTA) provides an overall evaluation of governmental departments and agencies performance in S&T areas. CSTA members are drawn from the academic, private and not-for-profit sectors. The CSTA is tasked by, and reports to, the Federal Cabinet. Its goal is to improve federal S&T management by examining issues common to a number of government departments and agencies and highlighting opportunities for synergy and joint action. CSTA reports cover a variety of science and technology management topics, from the role of the federal government in S&T, to the effective use of science advice in policy and regulatory decision-making, to the key elements of S&T excellence.

In response to the government's S&T strategy- **Science and Technology for the New Century-** CSTA has recently called for the need to improve the management and coordination of the large federal investment in S&T and called for greater government reliance on external advice. The Strategy recognized the need to better integrate the diverse array of expert, external advice received by Science Based Departments & Agencies and draw these advisors into one body to provide advice on internal, horizontal, federal government S&T issues.

Science-based departments and agencies too have started to make active use of R&D impact analysis to assess the outcomes and results of federal S&T. The R&D Impact Network and the Programme of Energy Research and Development’s implementation of results-based performance measurement are two examples of how government is adopting these mechanisms to ensure relevance and value for money.

In March 1996, the Minister of Industry funded the implementation of one of the recommendations of the Working Group on Science and Technology Statistics: The Information System for Science and Technology Project at Statistics Canada. The initial three-year project was extended to March 2003, with the support of the federal Policy Research Initiative (PRI). The indicators that the project has developed or improved since 1996 provide a background against which federal government departments and agencies can measure how effectively they are applying the operating principles of the federal S&T strategy.

3.2. Ireland

Wolfgang Polt (Joanneum Research)

3.2.1 The Irish Innovation System –some stylised facts

Ireland has experienced rapid economic growth in past decades, propelling it from one of the poorer European countries to income levels well above the European average. Most recent figures of GDP in PPP[3] even rank Ireland among the richest countries. This success has largely been based on attracting substantial amounts of FDI[4] and was aided considerably by monies from the European Union. Growth was especially strong in the ICT industries, with Ireland and Finland being the countries with the most pronounced change in specialisation pattern of the economy towards ICT (see Dachs et al. 2003). Irish policy-makers and experts recognise, though, that this growth trajectory might be exhausted soon and have put an up-grading of the Irish Innovation System on top of the policy agenda (see e.g. the national development plans). Crucial elements of this up-grad are seen in education, science and technology.

Starting from a low level, Ireland has substantially increased its R&D spending in recent years, but even though the level of business R&D expenditures has already been on the rise throughout the 1990ies (at growth rates of approximately 15 percent between 1993 and 1999), R&D intensity grew very little if at all, because GDP and GNP also experienced very rapid growth in this period. Recently (2001), R&D intensity was 1.4 percent, still well below the EU average of 1.9 percent. Business expenditure on R&D accounted for some 0.9 percent of GNP (EU average: 1.25 percent), while R&D spend in higher education and public research sector equalled 0.4 percent of GNP (EU average: 0.66 percent) (FORFAS and OST, 2004). While the enterprise sector spends two-thirds of all R&D expenditures, multinational co-operations account for two-thirds of all business R&D, of which again two-thirds stem from just 19 firms. Of indigenous firms, only a small number has significant R&D expenditures.

Policy has tried to counterbalance by markedly increasing public spending on R&D, which was especially low at the start – and still is below EU average in terms of GBAORD [5] (share in GDP, share in GOVEXP[6]). Especially HERD[7] has grown at a rapid pace, more than doubling between 1997 to 2001 from 140 m € to 300 m € (constant prices). Also, the share of S&E graduates is higher in Ireland then in most EU (15) and OECD countries, which is mainly due to the high share of science graduates. Yet, the most pronounced change in recent years was the doubling of government intramural expenditure on R&D between 1999 and 2001 – but only to bring it back to the relative levels of the beginning of the 1990s. Conversely, the importance of funding from the EU (Structural funds, Framework Programme) declined.

Thus, with respect to S&T expenditures, Ireland can be seen as a country which strives to rapidly catching up, with a strong increase in business expenditure on R&D upfront, which is now thought to be matched by an equally string rise in public R&D. As the latter is happening at a much higher

[3] Purchasing Power Parities
[4] Foreign Direct Investments
[5] Government budget appropriation on R&D
[6] Government Expenditures
[7] Higher Education R&D

speed, the strain on the Irish system of S&T policy formulation and delivery is considerable. Such a rapid increase in public R&D spending needs a well laid out strategy and institutions well in place to be absorbed in a sensible way.

Against the above described background, Irish STI policy reacted in the following way: A strategic decision was taken to heavily invest into ‘building Ireland’s knowledge economy’ (**Inter Departmental Committee - IDC**, 2004), epitomized in the **National Development Plan** (**NDP**)[8] for the period 2000-2006, which sets the target to increase Government spending on R&D from 0,5 bn € over the previous period (1994-1999) to 2,5 bn €. (**Irish Council for Science, Technology and Innovation - ICSTI**, 1999). In this plan, as well as in a number of other policy documents (see e.g. **Department of Enterprise, Trade and Employment - DETE** 2002, **IDC** 2004), R&D and innovation was given highest priority for future development in Ireland. This went along with a general re-orientation of state-aid, which saw a significant re-orientation from sectoral to horizontal objectives, among which R&D figures prominently.

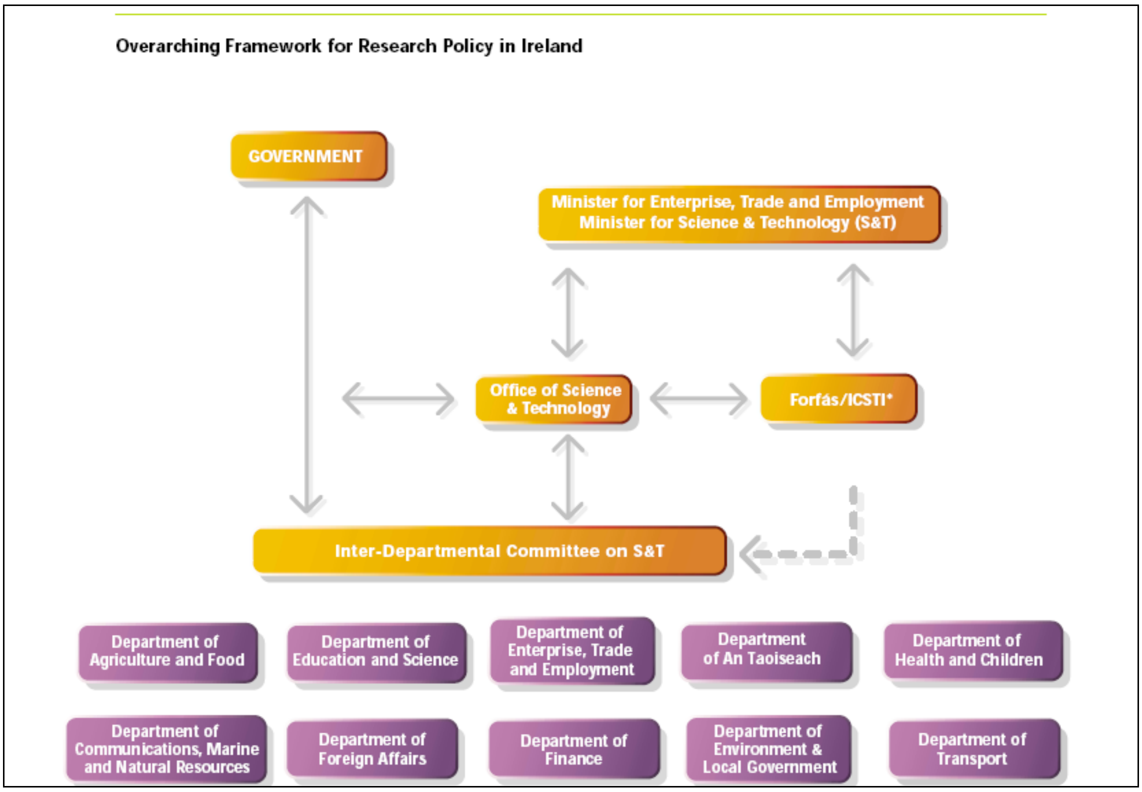
3.2.2 Priority setting in S&T policy in Ireland

The Institutional Framework for S&T Policy in Ireland

In 1996, following the first ever Irish Government White Paper on Science, Technology and Innovation, the Government set out an institutional framework for the formulation of STI[9] policy entitled ‘Overarching Framework for Research Policy in Ireland’, the main parts of which are illustrated in Figure 3.2.

[8] The national development plan sets out development targets for all areas of economic policy, including R&D.
[9] Science, Technology and Innovation

Figure 3.2: Institutional structure of the Irish S&T policy system



*Note: *ICSTI-Irish Council for Science, Technology and Innovation*
Department of An Taoiseach: Department of the Irish Prime-Minister

Source: Forfás

The various elements of this Framework are:

- The individual Ministries: The departments with the strongest role in STI policy (and budget allocations) are the **Departments of Education and Science (EDS)**, of **Enterprise, Trade and Employment (ETE)**, and of **Agriculture and Food (AGF)** respectively, the latter due to the large role of agriculture and related industry in the Irish innovation system. In 1997, the Government decided to rename the Department of Education as the Department of Education and Science. It appointed a Minister for Science and Technology to the Department of Enterprise, Trade and Employment and the Department of Education and Science. Following the Government elections in 2002, the Tánaiste (Deputy Prime Minister) and Minister for Enterprise, Trade and Employment assumed responsibility for the science and technology portfolio.
- The **Inter-Departmental Committee (IDC) for Science, Technology and Innovation,** which is chaired by the Minister for Enterprise, Trade and Employment. The IDC has responsibility for working towards the prioritisation of STI spending across Government Departments. While the respective Ministries are supposed to play a larger role in STI policy than in many European countries (Ireland resembling more the ‚R&D by department' organisation of the US), the Inter-departmental Committee on S&T is expected to coordinate between the Departments. In reality, it has only met occasionally and has no strong coordinative powers. In the same vein, the overall S&T budget is little more than a compilation on the budget plans of the respective departments. As a

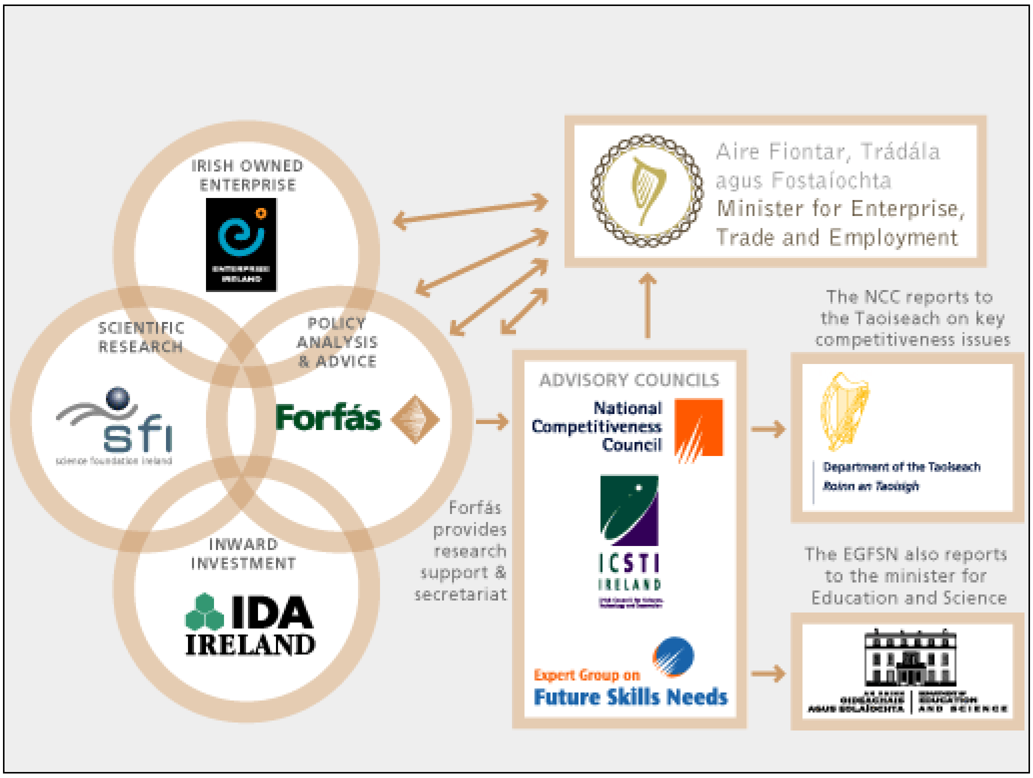
comprehensive document, the S&T budget is only presented with about 2 years time lag afterwards by Forfás (see Forfás, 2001, 2002 for the latest issues).

- The **Irish Council for Science, Technology and Innovation (ICSTI)**, which was established in 1997, is an independent body appointed by the Minister for Science and Technology and Forfás. The Council provides expert, independent advice to Government within a firm legal mandate and foundation under the powers delegated to it by Forfás. Its membership comprises 25 experts from industry, academia and public sector organisations.
- The **Office of Science and Technology (OST)**, within the Department of Enterprise, Trade and Employment, which is responsible for the development, promotion and national co-ordination of STI policy. It is responsible for the science and technology budget, including EU funding, promoting research and technological development in industry and developing and coordinating Ireland's policy in international research activities. This includes the EU Framework Programmes for RTD&D[10] and the development of the European Research Area.
- **Forfás** is the national Board responsible for providing policy advice to Government on enterprise, trade, science, technology and innovation in Ireland and the promotion of investment in enterprises and in S&T. Legal responsibility for the promotion and development of indigenous and overseas enterprise and the promotion of science and technology in Ireland is vested by the State, through the Department of Trade, Enterprise and Employment, in Forfás. The Board fulfils its mandate either directly (by running programmes), or by delegating responsibility to associated agencies with which it has close working relationships. These agencies include **Enterprise Ireland** for promotion of indigenous industry, **IDA Ireland** for attraction of inward investment and **Science Foundation Ireland** for funding basic research (see Figure 3.3). Though the main purpose of these agencies is to implement funding programmes, they also have in-house capacity for strategy formulation and are asked to regularly issue strategic planning documents (see list of references for the latest ones).
- In the realm of support to scientific research, **Science Foundation Ireland (SFI)** was established in 2001, became independent in 2003 and funds 'excellent' research, mainly in ICT and Biotech. In these areas, SFI has created centers for Science, Technology and Industry to foster scientific excellence and industry science-cooperation.
- In addition, two research councils were created - one for Humanities and Social Sciences (in 2000) and one for Sciences, Engineering and Technology (in 2001). In 2000 and 2001 the Minister for Education and Science created the **Irish Research Council for the Humanities and Social Sciences (IRCHSS)**. It was established to fund the development of local research capabilities and skills and the **Irish Research Council for Science, Engineering and Technology (IRCSET)**, to promote excellence in research in the wide areas of sciences, engineering and technology.
- Apart from the above mentioned institutions, a number of others with broader political remit also issue statements addressing in part S&T policy, e.g. the **National Competitiveness Council (NCC)** or **the Expert Group on Future Skills Needs**

[10] Research, Technological Development & Demonstration

(**EGFSN)**, again, also these institutions regularly issue strategy documents in which policy priorities are set.

Figure 3.3: The role of FORFAS vis a vis other actors



Source: Forfás

The main characteristics of the current institutional framework for S&T policy in Ireland could be summarized as follows:

- The *institutional system* is quite *young* (as is the importance of the S&T policy area for the Irish innovation system). Most of the institutions have only been established recently (see Table 3.1) and the institutional landscape still seems to be in flux, with responsibilities often not quite clear and existing structures often not well incorporated when new ones are created.
- Also, the institutional system also seems quite *complex and heterogeneous* in terms of number of actors and responsibilities.
- Overarching and coherent strategy formulation is not eased by the fact that most of the *institutions* mentioned above are called *to formulate their own strategy documents*. These documents are issued at different points in time, sometimes with little reference to each other. In the absence of a strong overarching strategy or a strong coordinative body, this could lead to a 'coherence gap' in S&T policy.
- In recognition of the difficulties inherent in the current institutional system, a forthcoming plan for further institutional reform – based on the recommendations of a report produced under the aegis of ICSTI (the so-called ‚Wilson commission') - is waging again

institutional changes for better policy coordination, e.g. the instalment of a ‚chief science adviser’. It remains to be seen, whether such an adviser (even when directly attached to the highest political ranks) can actually fulfil the task of creating policy coherence or whether there is a need for further structural streamlining in the Irish system.

Table 3.1: Years of foundation of important Irish S&T policy institutions

IDA-Ireland	1957
NAB - The National Accreditation Board -	1985
FÁS - Training and Employment Authority	1988
Forfás	1994
ICSTI - Irish Council for Science, Technology and Innovation	1997
National Competitiveness Council	1997
EGFSN - Expert-Group on Future skills needs	1997
Enterprise Ireland	1998
SFI - Science Foundation Ireland -	2000

Source: compilation by Joanneum Research

The history and processes of priority setting in Irish S&T policy

Priority setting can take place implicitly or explicitly, it can be arrived at heteronymous or autonomously, it can be done with an emphasis more on thematic or on functional priorities. In the late 1980s and the early 1990s, Ireland started from a rather high degree of implicit, heteronymous and thematically oriented priority setting to arrive at a much more explicit, increasingly autonomous and to a large extent functionally oriented priority setting at the beginning of this century. In the following, a very brief account of the development and the main characteristics of priority setting processes in Irish S&T policy is given.

The need for priority setting and to establish appropriate policy mechanism was recognized quite early: the availability of significantly increased levels of Structural Funds *“[...] led to a certain level of thematic priority setting“* (ICSTI 1998, 16) – especially in the National Plan (1989) that responded to the Structural Funds targets and in the **Community Support Framework (CSF)** (1989-93). In this period, a number of thematic national technology programmes in ‚advanced technologies’ were established (biotechnology, advanced manufacturing, optoelectronic, material technology, software, telecommunications and power electronics), the selection of which was mainly inspired by the structure of the priorities at the EU level: *„The methodology by which these priority areas were identified was not, perhaps, particularly sophisticated but the areas chosen did represent what is generally accepted by most countries as being areas of prime technological importance“* (ICSTI, 1998, 16).

It has to be mentioned, though that even at this time, these thematic priority areas were accompanied by ‚functional’ ones, namely (i) strengthening the technological capabilities of firms, (ii) improving industry / third level (education) links, (iii) strengthening the regional infrastructure.

The need to administer the CSF gave rise to multi-annual allocations and the systematic use of performance indicators and evaluation. With the launch of the second CSF, distinct priority setting activities began to emerge *within* departments and agencies. This was especially important for S&T, as a considerable share of Irish S&T expenditure in the 1990s originated from EU funds. As the EU funding did not address basic research, this was large left out from STI strategy formulation – a neglect to be compensated only in recent years.

With the growing awareness of the importance of S&T for the development of the Irish innovation system and the diminishing role of the EU funding, the strive towards priority setting that should be based on genuinely national development priorities became stronger. The first major approach in this vein was the White Paper on Science, Technology and Innovation of 1996, which was based on an earlier recognition of by the **Science, Technology and Innovation Advisory Council (STIAC)** in 1995. The White Paper outlined a series of government actions which would put in place the necessary institutional structures to provide a coherent national S&T strategy and determine national priorities. It observed the absence of a coherent budgetary process for determining ex-ante the overall amount the Government expenditures on STI and the allocation between different expenditure programmes. The White Paper also advised for a government planning process with a long-term vision of the country's S&T requirements. It emphasised the need clearly to link S&T policy and programmes with industrial policy and wider economic and national development.

In relation to the issue of prioritisation the following Government decisions were announced in the White Paper (see ICSTI 1998, 9/10, in brackets and italics our remarks):

- The Government would develop an integrated procedure for the prioritisation of S&T spending, based on the Forfás annual Science Budget […] and draft spending plans of Departments. The process would form an integral part of the annual Estimates and Budget cycle *(led to prioritisation statements from ICSTI for specific years and for the periods of the national development plan, but not – as of yet – to a coherent science budget formulation process).*
- The process would be conducted by an Interdepartmental Committee under the direction of a Cabinet Committee *(IDC established, but not really fulfilling this role).*
- Forfás would make proposals on the function, scope and appropriate approach for a technology foresight or alternative process for generating techno-economic scenarios as an input to the prioritisation process *(large scale Technology Foresight was carried out, some of its recommendation were taken up – see below).*
- Each Department would designate an Assistant Secretary (or equivalent rank) with responsibility for promoting and co-ordinating its science and technology policy and budgets *(by and large not implemented).*
- The Office of Science and Technology would have responsibility for national co-ordination of STI policy, which function would remain as part of the Department of Enterprise and Employment *(established).*
- A permanent STI Advisory Council, representative of wide-ranging interests, would be established *(established in the form of ICSTI)*.
- Funding for science and technology, on a programme basis, would increase in line with priorities, when a proven requirement is demonstrated and as resources permit*(programme based spending has indeed gained importance)*.

Though this document gave a major impulse for S&T policy making, both in terms of priorities to be addressed and in setting up new institutions which would have major responsibilities in the process of priority setting, a critical review of its implementation and the state of the policy process for prioritisation by ICSTI (ICSTI, 1998) concluded that these processes were still far from being up to the task: „Despite the significant levels of public money invested in STI, and the detailed description of it available in the published estimates and the Science Budget, it is difficult to discern any systematic and comprehensive approach in relating this expenditure to national priorities for either STI itself or, importantly, for the sectoral functional areas of Government activity.“ (ICSTI, 1998, 31)

According to expert judgement, most of the criticism is still valid today, though awareness to the problem seems to have risen, not least because of the recent considerable increases in the monies involved (see for an account of the increase in Irish S&T spending Falk et al, 2004):

The main findings from an examination of the existing system for funding and activities in science, technology and innovation in Ireland are as follows:

- Spending on S&T within government departments is 'derived' from wider policy objectives of the departments and no clear system is discernible in relating STI expenditure to these policy objectives.
- In general, there is a weak focus on STI within departments and particularly across departments.
- As a percentage of GDP the level of State expenditure on R&D undertaken directly within the public sector is less than half of that which is found across EU Member States on average.

The Council makes the following recommendations for action to Government:

- Government should make an explicit strategic commitment to STI to be reflected in a national mission statement and this commitment should be recognised in the overall strategy statements prepared by each Government Department as part of the Strategic Management Initiative.
- Each Government Department should draw up an STI Statement, covering its STI activities and objectives based on a three-year framework within the overall context of the Department's functions and objectives. The Statement should address any proposals for change in the STI component of its activities coming from analyses undertaken by ICSTI or other sources and should take account of those key technologies emerging from the Council's Technology Foresight Initiative.
- Each Government Department with responsibility for significant STI activity should appoint a Scientific Adviser to improve the linkage between the Department's policy objectives and the contribution of STI activities to their achievement.
- In order to facilitate the rapid implementation of the new approach the initial focus of the STI Statements of Government Departments should be on R&D activities, which tend to be more discretionary and adaptable.
- The STI Statements of Government Departments should be synthesised by the Interdepartmental Committee on Science and Technology into a National STI Plan. Consultation with ICSTI on the Plan, which should be published and laid before the Oireachtas, is desirable.

- The R&D components of the Forfás Science Budget should be separately extracted and published with an associated evaluative commentary.
- Given the significant contribution which EU Structural Funds makes to the STI system in Ireland, it would greatly facilitate co-ordination and prioritisation of spending if, in a future round of Structural Funds, all of the activities were encompassed under a single programme.

The new National Innovation Investment Fund should be increased substantially and utilised to encourage Departments to reallocate resources and activities to areas of emerging national priority. The Interdepartmental Committee, which has ultimate responsibility for the Fund, should establish these priorities in consultation with ICSTI and should allocate funding accordingly, on a competitive basis.“ (ICSTI, 1998, p. 5).

The current phase

Again, a number of these recommendations have been taking up and have fed into the so-called National Development Plan 2000-2006, which is the current basis for priority setting, most notably the recommendation to substantially increase public R&D funding. The recommendations regarding the institutional framework were implemented to a lesser degree.

The ‚National Development Plan 2000-2006' addresses the whole range of policy areas. Basically, it is an investment plan designed to underpin ‚the development of Ireland as a dynamic, competitive economy' over that period. The Plan provides for a total investment of € 51.5 bn, in 1999 prices, of which some € 2.5 bn is allocated to research, technology, development and innovation (RTDI). The scale of this allocation represents a major upward step-change in the funding available to implement science and technology policy in Ireland, from approximately € 0.5 bn over the period of the previous Plan 1994-1999. The Plan's objective is to invest substantially in the research, technological development and innovation base of the country as a means of enhancing innovation and competitiveness by

- strengthening the research capability in the third-level education and state research institutes
- to meet RTDI and skills' needs of the economy
- strengthening supports to researchers and research students
- increasing RTDI linkages between institutions and companies
- helping companies to develop innovative products, services and processes
- increasing the number of companies performing effective R&D
- increasing the scale of RTDI investment by companies in Ireland
- promoting research and development (R&D) and technology transfer
- embedding the culture of R&D in small and medium sized enterprises
- providing substantial public investment in niche technologies and
- promoting balanced regional development.

As can be seen from this list of priorities, there was a major shift toward functional priorities, addressing what was perceived as weak points in the Irish innovation system. Reference to specific technologies is – at this level – only made to Biotechnology and ICT as the outcomes of the Foresight exercise which was carried out in 1999. Apart from the definition of these two broad technology areas, the specific formulation was left to other actors.

The plan did – in contrast to earlier priority settings – also put basic research, the performance of the university system and industry-science linkages into the picture. A main part of the additional investment goes to **Science Foundation Ireland (SFI**), which was established only in 2000. SFI has also set up a competence centre programme (**Centres for Science, Engineering and Technology**), accruing for 67 m € over 5 years (out of a total of 646 m € for the whole period; = 10% approx.).

The substantial increases for public S&T spending foreseen in the NDP 2000-2006 have fed into a number of programmes (see for an overview Falk et al., 2004). These programmes are basically functionally oriented. The remaining thematically oriented programmes have a very broad focus on Biotechnology and ICT. Policy documents do trace the establishment of these tow thematic areas back to the Foresight exercises, but the link – at least seen from the outside – does not appear very strong, as a number of other technologies having been mentioned in the foresight process have not been taken up and one would hardly need a Foresight process to arrive at these two broad technology areas which figure prominently in the technology policy portfolios of practically all countries (see Rammer et al 2004 for a comparison of thematic priority settings in major OECD countries). The targets in these programmes are to establish research capacities (which by and large did not exist in Ireland) and thus, there is a strong focus on academic research and on industry science linkages in both. In the case of ICT, the prime task is to encourage the ICT manufacturers already established in Ireland to engage also in R&D and to set up respective facilities. In the case of Biotech, there is also a strong emphasis on attracting foreign direct investment, but there is also an indigenous industrial base (especially in the food and dairy sector) which is addressed.

With targets only very broadly defined and with the proliferation of bodies at the same time responsible for the implementation of these programmes and increasingly with the task to set priorities in their own realm (e.g. SFI, the research councils), this makes up for a growing role of these institutions in the setting of concrete priorities, a shift that can also be observed in other countries as well. In Ireland, this process is still in the beginning.

While some evaluations do exist with respect to some functionally oriented programmes, there has been no evaluation of the thematically oriented ones (for the current ones this would be premature). A few evaluations are available which shed some light on whether the targets of the NDP are met and the implementation is functioning smoothly. The whole of the implementation of the NDP has been subject to a mid-term evaluation (see Indecon, 2003), while some of the specific programmes (e.g. PRTLI and the RTDI for collaboration Programme – see HEA 2004 and Technopolis, 2004 respectively) also have been evaluated. By and large, these evaluations only allow for a first tentative assessment of whole of the implementation and the effects of the increased RTDI spending.

The main results from the overall evaluation is that, overall, the NDP had a slow start due to administrative problems and the need to obtain approval from the EU. Thus, only parts of the monies that should have been spent on RTDI in the first 3 years of the plan were really made available. Spending in the education sector was much closer to the target than spending in industry, probably pointing to the fact that public research institutions are more easy to identify and address as clients for support measures. That, despite the slow start, the NDP had positive effects on GDP, employment and labour migration, but negative effects on inflation, the level of debt and the balance of payments (Indecon 2003).

Judging also from assessments in the administration, it seems that the rapid increase of public R&D spending has put the Irish 'system of policy delivery' under stress. Slower than anticipated uptake of spending and the proliferation of institutions and support measures can be seen as an indication for this stress. It also appears that not all measures have been designed according to 'good/best' international practice. Further evaluations will have to look into the effectiveness not only of the single measures, but also on their portfolio. As they have not been designed in a coherent way (i.e. on the basis of a 'concerted political action' by the stakeholders), but rather by the individual players, it might turn out that this portfolio needs to be streamlined in the future.

The new 'action plan on innovation' (Interdepartmental Committee 2004) again sets very ambitious targets for R&D spending (Interdepartmental Committee 2004, p 2-3):

- *"Business investment in R&D should increase from €917 million in 2001 (0.9% GNP) to € 2.5 bn in 2010 or 1.7% GNP;*
- *the number of indigenous companies with minimum scale R&D activity (in excess of € 100,000) should double, from 525 in 2001 to 1,050 in 2010;*
- *the number of indigenous enterprises performing significant R&D (in excess of € 2 million) should increase from 26, currently, to 100 by 2010;*
- *the number of foreign affiliates companies with minimum scale R&D activity (in excess of € 100,000) should double, from 239 in 2001 to at least 520 in 2010;*
- *the number of foreign affiliates performing significant levels of R&D (in excess of € 2 million) should increase from 47 in 2001 to 150 by 2010;*
- *R&D performance in the higher education and public sectors should increase from € 422 million in 2001 (0.4% GNP) to € 1.1 bn in 2010 or 0.8% GNP;*
- *The combined increases in performance in business, higher education and public sector R&D should result in gross expenditure on R&D increasing to 2.5% of GNP by 2010;*
- *Consequently, the number of researchers should reach 9.3 per 1,000 of total employment by 2010, from approximately 5.1 per 1,000 in 2001."*

These ambitious targets – if to be met - are likely increase to the pressure on the Irish policy system. There seems to be continuous need for institutional changes to arrive at more coherent ways of priority setting. While the overarching documents cited above (White Paper, National Development Plan) provide for some frame, there seems to be too little capacity in the system to ensure coherent policy making between the departments and between the different actors on the operational level. This is probably the main challenge for the Irish S&T policy system if the further increases in public R&D spendings are to be spent wisely.

3.2.3 Conclusions and policy lessons from the Irish case

Ireland is among the countries which have put Science, technology and Innovation policy high on the political agenda and which have drastically increased R&D spending in recent years (though starting from a low level). In the course of this increase, a number of attempts to set priorities were undertaken. Before, there were no developed attempts to priority setting. Priorities were rather set ‚heteronymous' by the Structural Funds of the EU, which led to a certain level of thematic priority setting. With the decreasing importance of EU funding, Ireland set out to establish priorities on her own, but EU continues to play a role.

Priority and target stetting is done both on the thematic and functional level, recently with more emphasis on the functional side (overall increase of R&D spending, increasing number of R&D performers, strengthening the science base, increasing the attractiveness of Ireland as a location for R&D, fostering industry-science linkages etc.) than on the thematic side (the so-called Progammes for Advanced Technology (PATs) which were set up in the 1990ies were discontinued).

The thematic priorities that were set at the national level were (loosely) based on a foresight exercise which was carried out at the end of the 1990ies. On the national level, the thematic priorities remained very broad: basically the focus finally was on Biotechnology (especially food) and ICT. These broad priority areas should be transformed into more concrete actions at the level of intermediary institutions (the newly created research councils for Humanities and Social Sciences and for Science, Engineering and Technology, or by Forfàs (the main technology funding agency) and its affiliated institutions (Enterprise Ireland, Ireland Development Agency and the like). Apart from the priority setting in the realm of the Department of Education and Science and the Department of Enterprise, Trade and Employment, a number of other departments do have their internal priorities for S&T.

While at the national level, the framework of the so-called ‚National Development Plan' (currently set for the years 2000-2006) ensures some level of coherence for the overarching goals, a mechanism for the coherent setting of priorities in S&T policy is lacking. This is partly due to the great flux of the institutional landscape in S&T policy in recent years and partly due to the fact that each institution is called upon to formulated her own strategy. Thus, there is an abundance of strategy documents at the various levels, which often seem to be not sufficiently relating to each other. The establishment of an institutional framework for coherent priority setting thus is a mayor task for Irish S&T policy. A major lesson would be to get the institutional framework and the priority setting processes right before injecting large increases of spending into the system.

3.3. Korea

Julia Schindler (Joanneum Research)[11]

3.3.1 The Korean Innovation System – some stylised facts

In Korea, research and development activities in the 1960's and 1970's focused on the imitation and import of technologies from developed countries. In the 1980's, a national R&D funding mechanism was developed to promote industrial restructuring through domestic innovation. As a result, the Ministry of Science of Technology developed specific national R&D Programmes. In the 1990's public R&D was expanded with the aim of increasing private R&D investment and increasing collaborative R&D among industries, universities, and government-supported research institutes (GRIs). The HAN Project, a large-scale R&D project with funding from government and industry, was designed and launched in 1992 as an inter-ministerial programme

In 1999 a long term plan for Korean S&T development was established, the "Vision 2025". It is a roadmap for achieving the aim of becoming the world's seventh power in science and technology by the year 2025. Short term S&T plans were also created: the Five-Year Plan for S&T Innovation (1997-2002) and the follow-up plan for 2002 until 2006. In 2001 the "Science and Technology Framework Law" was established. It sets the institutional framework governing S&T.

Since 2000 increased emphasis is placed on high-tech and high-value industries. Thematic priority areas were selected: biotechnology, information technology, nanotechnology, aeronautics, and conventional industrial technologies (textile and shipbuilding). Important issues include building a creative R&D environment and transparent R&D management systems.

In Korea the share of R&D performed by the public sector has fallen continuously, that of the private sector growing. Until the early 1980s, the government's share was higher than that of the private sector, but after 1982, the trend was reversed. In recent years, roughly one quarter of gross R&D expenditure came from the government, and the rest from the private sector. As a consequence of the financial crisis in 1997, the share of private industries in total R&D investments declined to 73%, while the public sector's share increased to 27% in 1998. This new balance was maintained over the past years.

Table 3.2: Korea Government R&D

	1970	1980	1990	2000	2001	2002
Government R&D (as % of total)	71	64	19	26	26	26
GERD (US$ millions)	33	428	4,676	12,693	14,140	15,238
R&D/GDP	0.38	0.77	1.87	2.65	2.92	2.91
Researchers (persons)	5,628	18,434	70,503	159,973	178,937	189,888

Source: Ministry of Science and Technology

The balance between universities and government research institutions has changed considerably in the past years. The share of universities in the public sector R&D expenditures increased from

[11] We would like to thank Joonghae Suh from the Korean Development Institute for his helpful comments and suggestions.

38% in 1997 to 44% in 2000. The amount of R&D investment into basic research is low compared to other advanced nations. The absolute expenditure on basic research has risen, but the share of R&D invested into basic research has remained relatively stable in the past years.

Table 3.3: Basic Research, applied research and development as % of total R&D investment

	1999	2000	2001	2002	2003
% Basic Research	13.6	12.6	12.6	13.7	12,6
% Applied Research	25.7	24.3	25.3	21.7	25,3
% Exp. Development	60.7	63.1	62.1	64.6	62,1

Source: KOSEF (2003)[12]

The efficiency of the Korean STI system has been criticized in that the output measured by patents, publications and citations is relatively low compared to the inputs. Another important development is the launching of the government's 21st Century Frontier Programme The programme is a large public R&D initiative with the aim of developing core technologies with a time horizon of 10 years. It is the follow-up initiative of the HAN-programme.

One of the most important challenges of the Korean NIS is to transform the imitation and catch-up oriented NIS into an innovation-oriented NIS. Although changes are being made, the private sector still focuses on the rapid commercialization of foreign technologies and the imitation of global technology leaders. To achieve the long-term aims of he Korean S&T strategy, it is considered necessary to transform the national innovation system from a government-initiated, development-oriented system into a market-driven, diffusion-oriented system, and also from an inward-looking S&T system into a globally networked system. More immediate challenges that are addressed with respect to the National Innovation System are, (1) to strengthen the role and authority of the National Science and Technology Council, (2) to improve the system of planning, management, evaluation, outcome diffusion of R&D projects and (3) to improve the performance of the government supported research institutes.

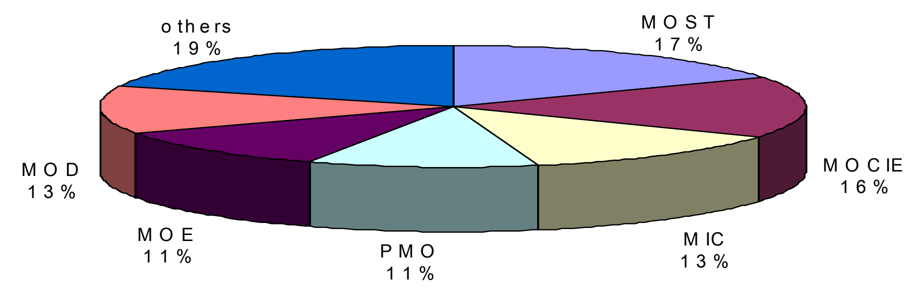
Institutional structure & development

The "Science and Technology Framework Law" established in 2001 defines the basic framework for technology support and R&D institute funding in Korea. The Science and Technology Framework Law in 2001 brought about several important changes in STI policy in Korea. It provides the legal basis for the National Science and Technology Council (NSTC), which is in charge of coordinating national science and technology policies and is responsible for priority setting with respect to S&T policy and with respect to the R&D investments of the government. Nevertheless Korea has a decentralized government R&D policy structure. Ministries set priorities within their programmes. The MOST (Ministry for Science and Technology), MOCIE (Ministry of Commerce, Industry and Energy) and MIC (Ministry of Information and Communications) are the most important S&T ministries in terms of R&D budget. The expenditure structure in Figure 3.4 shows the "decentralized" government R&D system. The total amount of government R&D investment amounts to 6,146.6 bn Won[13] (5,158.3 bn from the R&D budget, 983.3 bn from other

[12] http://www.most.go.kr/most/english/activies_01_5.jsp
[13] 1 € = about 1,420 KRW (South Korean WON)

sources). MOST has the highest R&D expenditure, but the shares and importance of other ministries, especially MOCIE, MIC are almost equally high as those of MOST. MOE's money mainly goes to universities, that of the Prime Minister's Office is allocated to the GRI. The Ministry of Defence is treated special, since its R&D activities are heavily focus on weapon and defence matters.

Figure 3.4: The distribution of the government's R&D investment, 2002

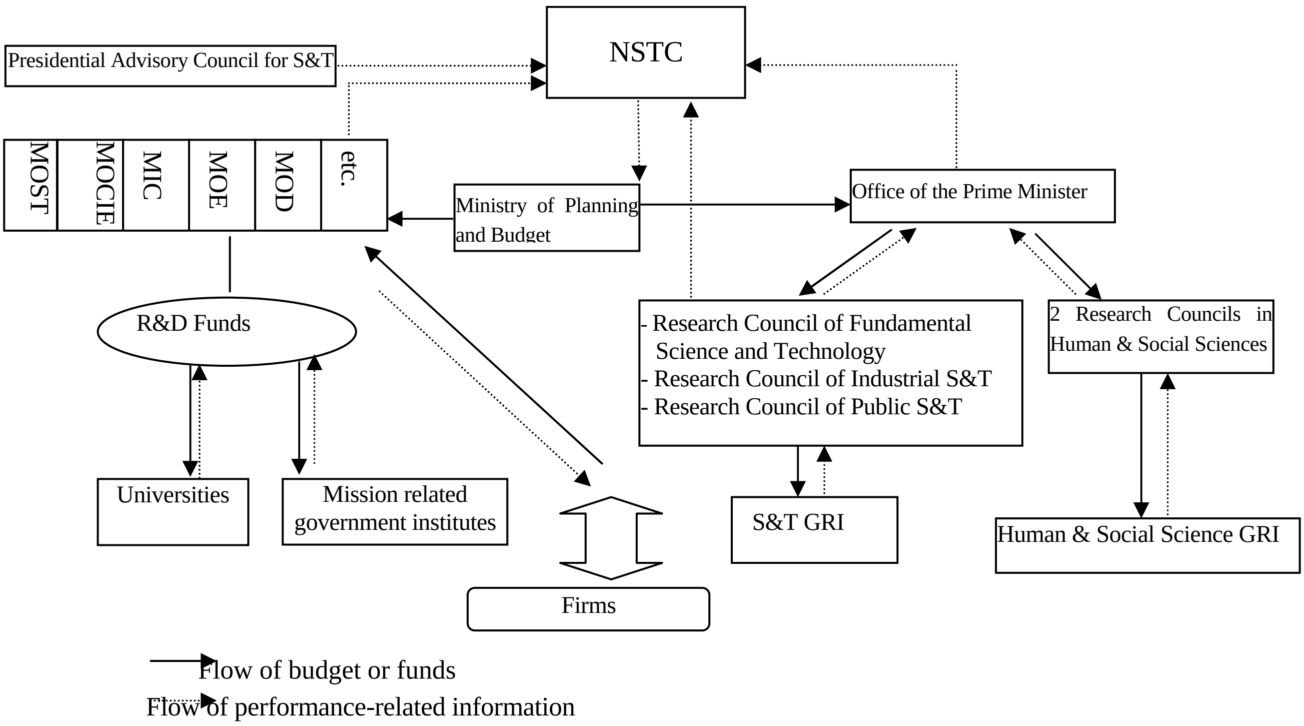


Source: Suh, Joonhae (2004)

The Korea Institute for S&T Evaluation and Planning (KISTEP) was established by law to assist the NSTC. Furthermore the NSTC has several subcommittees consulting on policies and programmes of individual ministries and agencies (the Subcommittee for S&T Policy, the Subcommittee for R&D, the Subcommittee for Biotechnology and Bioindustry, and the Subcommittee for Nanotechnology).

An important feature of the Korean R&D system is the existence of the government-funded research institutes (GRI) as the main instrument for implementing national R&D programmes. GRIs used to play an important role in the earlier years of Korea's industrialization process. In the past years there have been strong concerns regarding research effectiveness and operational efficiency of the GRIs. Their role has also been questioned due to the improved and extended research capabilities of both industry and universities. In order to respond to the criticism about the role of GRIs, a law on the creation, operation, and development of GRIs was enacted in January 1999, giving GRIs more management autonomy. Under the new system, there are five research councils (assigned to the Prime Minister's Office) that monitor the operation of the GRIs. These are: the Research Council for Industrial Science and Technology, the Research Council for Public Technology, the Research Council of Fundamental Science and Technology, the Council of Economic and Social Research Institutes, and the Council of Humanities and Social Research Institutes. This new system is expected to improve research productivity, strengthen linkages between institutes, and to increase transfer and commercialization of research results.

Figure 3.5: Organizational Structure of Korea's Public R&D System



Source*: Suh, Joonghae, "Performance Evaluation System and Guidelines for R&D investment in Korea", July 2003.*

Note: PACST: Presidential Advisory Council for S&T, OPM: Office of the Prime Minister, MPB: Ministry of Planning and Budget, MOST: Ministry of Science and Technology, MOCIE: Ministry of Commerce, Industry and Energy, MIC: Ministry of Information and Communication, GRI: Government-supported Research Institutes

- The **Presidential Advisory Council for S&T** (PACST) recommends long-term strategies to the president. The council is composed of eleven members representing prominent industries, academia and research institutes. Members are appointed by the president for a two year term. The council has three mission-oriented sub-committees (A) Policy of S&T, Infrastructure and Future Scientific Technology, (B) Biotechnology and Environment technology, (C) Information technology and Nanotechnology. The council meets on a monthly basis and reports to the president at least once every year.
- The **Ministry of Planning and Budget** (MPB) allocates the annual budget.
- The **National Science and Technology Council** (NSTC) was established in April 1999, to strengthen the overall coordination of national science and technology policy. Its main role is to coordinate major policies and overall plans for promoting science and technology (S&T), expand the science and technology-related investment and set priorities for national R&D programmes. The NSTC consists of 19 members including the President as chairman and major cabinet members involved in science and technology policy. The NSTC has several sub-committees that help coordinate ministries. The KISTEP (Korean Institute of Science & Technology Evaluation) assists the NSTC in priority setting.There are three **Research Councils for S&T** (consisting of one for Fundamental S&T, one for

Industrial S&T and one for Public Technology) monitoring the government-sponsored research institutes and advising the Office of the Prime-Minister.

Table 3.4: Major R&D Programmes and Management Agencies

	Major R&D Programme	Management Agency
Ministry of Science & Technology (MOST)	Specific R&D	Korea Institute of Science & Technology Evaluation & Planning (KISTEP)
	Nuclear Energy	
	Basic Science	Korea Science & Engineering Foundation (KOSEF)
Ministry of Commerce, Industry & Energy (MOCIE)	Industrial Technologies	Korea Institute of Industrial Technology Evaluation & Planning (ITEP)
	Energy Technology	Korea Energy Management Corporation (KEMCO)
	Clean Production Technology	Korea Institute of Industrial Technology (KITECH)
Ministry of Construction & Transportation (MOCT)	City Railroad Vehicle Standardization	Korea Rail Road Institute (KRRI)
	High-speed Railroad Technology	
	Construction & Transportation Technology	Korea Institute of Construction Technology (KICT)
Ministry of Information & Communication (MIC)	Information & Communication Technology	Institute of Information Technology Assessment (IITA)
Ministry of Maritime Affairs & Fisheries (MOMAF)	Maritime Science Technology	Korea Ocean Research & Development Institute (KORDI)
	Fisheries	Korea Maritime Institute (KMI)
Ministry of Agriculture & Forestry (MAF)	Agricultural & Forestry	Agricultural R&D Promotion Center (ARPC)
	Rural Production Base	Korea Agricultural & Rural Infrastructure Corporation (KARICO)
Ministry of Health & Welfare (MOHW)	Health & Medical Technology	Korea Health Industry Development Institute (KHIDI)
	New Drug Development	
Ministry of Environment (MOENV)	Environmental Engineering Technology	National Institute of Environmental Research (NIER)
Ministry of Education (MOE)	University Research Promotion	Korea Research Foundation (KRF)

Source: Suh, Joonghae, "Performance Evaluation System and Guidelines for R&D investment in Korea", July 2003

Furthermore, the government enforced the Guidelines on the Management of the National R&D Programmes, which apply to the management of all government-sponsored R&D programmes, regardless of the sponsoring ministry.

Strong leadership from the government has characterized the Korean innovation system. One reason for this being the influence on the decision making process of the government sponsored research institutes. The researchers are only passively involved in policy making and there is almost no participation by the private sector or NGOs.

The new administration has formulated the main building blocks of a strategy for reforming the Korean NIS. Changes are being planned for the structure of the NIS, resource allocation and regional development. There is a focus on developing the horizontal innovation policy with cooperation and coordination between the government departments and participation by the general public in policy formulation. In the following chapter priority setting in the Korean Science, Technology and Innovation system is presented, the existing priorities are listed and categorized.

3.3.2 STI-Policy Priority Setting

Korea sets thematic, missionary and structural priorities. Missionary priorities are set in Vision 2025, the long term S&T plan for Korea and the shorter term 5-Year Plans. Thematic priorities are generally set in the programmes. Structural priorities are set in the 5-Year Plan for S&T Innovation, in the 5-Year S&T Principal Plan,[14] in government statements and in programmes. See below for an explanation on the relation of the 5-Year Plan for S&T Innovation and the 5-Year S&T Principal Plan.

Thematic Priorities

This section presents the thematic priorities in both (basic) research and technology & innovation policy. In general thematic priorities are not set for basic research, whereas thematic priorities are set at some detail for technology and innovation. In 2003 new priorities were selected for technology and innovation policy: Korea selected ten priority industries together with 80 priority technologies that shall contribute to promoting the priority industries.

Thematic Priorities in (Basic) Research: As in most countries, basic research is generally funded without being limited to certain priority areas. The 21st Century Frontier Programme is an important large-scale R&D program, that focuses on both basic and applied research in core technology areas. The programme was started in 1999, following its predecessor the HAN-programme. Its vision is to develop core technologies with a time horizon of 10 years and to secure leading-edge technologies in promising areas. It is managed by MOST. Like its predecessor, the HAN project, it promotes a combination of basic and applied research. Every project receives approximately US$ 8 million for ten years. The selected core areas are:

- ICT
- Biotechnology
- Life sciences
- Nanotechnology
- Environmental Technology
- New Materials.

Thematic Priorities in Technology and Innovation: In the following section thematic priorities in Korean technology and innovation policy are described chronologically. The current priorities are found at the end of the sub-chapter.

When the national science and technology council (NSTC) was established in 1999, an increase in R&D investment in the highly developed technologies, i.e. biotechnology, environment technology, new materials, information technology and nuclear energies was aimed for. Out of these priority topics biotechnology and nanotechnology received particular policy attention.

In the year 2002 the Korean STI-Ministries set aside a total amount of US$ 1.009 bn for five selected priorities:

- IT: US$ 400 m

[14] Government documents and other reports refer to the documents as S&T Principal (or Basic or Framework) Law, but all three words (principal, basic and framework) are translations of the Korean word, Gi-bon, into English.

- Biotechnology: US$ 307 m
- Environmental technology: US$ 116 m
- Space technology: US$ 102 m
- Nanotechnology: US$ 84 m.

Some of the priorities are explained in more detail below:

- Information Technology: Information Technology has long been a key technology area in Korean STI policy. The MIC is in charge of IT policy in general and is in charge of developing key information and communications technologies. In this sense, the MIC's R&D programmes are highly mission-oriented. MOCIE is also involved in information technology research and development, but its focus is more on the "development" side. MOST is concerned with long-term generic technologies, for example, "Next Generation Memory Technology" in the 21st Century Frontier Programme.
- Biotechnology: In 2001 (declared as the Year of Biotechnology) the third Biotechnology Development Plan (2002-2007) was established. In the same year a National Genetic Information Center, an Advisory Committee on Ethical Issues in Biotechnology were set up and a "Biotechnology and Industry Committee" was established under the NSTC, to coordinate national biotechnological policy. In the MOST programme "Biotech 2000" the priority areas genomics, proteomics and bio-information technology were selected. The Ministry of Health and Welfare is also engaged in biotechnology programmes and these tend to be mission and application-oriented.
- Nanotechnology: In 2001 the government formulated the Comprehensive Plan for the Development of Nanotechnology.
- Space and Aeronautics: The key goal of the National Long-Term Space Development Plan, which was revised in 2000, is to establish indigenous satellite technology capacity including launching capability by the year 2015. In 2000 the construction of a "Space Center," including a "Spaceship Launching Site" was started. It is expected to be completed by 2005. The Space and Aeronautics Programme, initiated in 1990, aims to acquire core and fundamental technologies in key areas of national defence and aeronautics.

In July 2003 the current government selected **ten new-growth industries** that should help Korea speed up the process of reaching a national per capita income of US$ 20,000. The ten new-growth industries should help promote job creation in the next 5-10 years[15] and act as "a cash cow". The selected ten new growth industries are:

- Digital TV/Broadcasting
- Digital Displays
- Intelligent Robots
- Future Automobiles
- Next Generation Semiconductor
- Next Generation Mobile Telecommunication
- Intelligent Home Networking

[15] MOST (2003), "Science and Technology in Korea"

- Digital Contents and Software Solutions
- Next Generations Batteries
- New Bio-Medicine Organs.

The selection of these growth industries was based upon the size of the global market, strategic importance, trends in market and technology, possibility for securing competitiveness, and effects on the economy and industries.[16] Additionally to the ten new growth industries, **80 key technologies** were selected that are responsible for promoting the ten new growth industries. National R&D ressources are focused on the selected target technologies. This will take place under the coordination of the NSTC. MOST will be responsible for the development of core and generic technologies. The MOCIE and the MIC will focus on applied technologies. The technology development plan will be set up and executed jointly by the government and the private sectors in the form of national R&D projects starting in 2004.

Functional Priorities

Functional Priorities in Science: The following aims with respect to functional priorities exist:

- Increasing investment in basic research
- Promotion of studies and training in the natural sciences and technical disciplines
- Improving the opportunities for researchers
- Affirmative action programmes to increase the number of female researchers in scientific and technical disciplines.
- Promoting international cooperation in basic research projects.

Functional Priorities in Technology and Innovation: With regard to technology and innovation the key priorities are as follows:

- Development of core technologies that drive growth (see above for the selected 80 key technologies)
- Innovations with a long development horizon (the „Programme for the 21st Century“ promotes 10 year-projects)
- Technology transfer, diffusion und commercialization of new technologies
  - Activating Technology-Transfer in cooperations between universities and government research institutes (GRI).
  - Promotion of cooperation between GRI-business incubators and new technology start-ups
  - Promotion of R&D commercialization by firms.
- Activation of private R&D organizations. The MOST initiated an “Industrial Cluster Support Program” in 2002. It supports research clusters made up of SMEs and research institutes working to identify common key technologies.
- Diffusion of the S&T culture: A Five Year Promotion Plan for S&T Culture was established in 2001.

[16] MOST (2003), “Science and Technology in Korea”.

- Strengthening the internationalization of R&D activities. In the year 2001 the government issued an “S&T Globalization Strategy”. Measures include researcher exchange programmes and R&D networks with foreign institutions.
- Promotion of Regional S&T

  The Korean government set up a five year Comprehensive Regional Science and Technology Promotion plan, which consists of:
  - Inducing local governments to invest a certain portion of their budgets into S&T
  - Establishing an S&T department in each provincial government
  - Creating major high-tech science complexes, i.e. “National R&D Special Districts”.
  - Promotion of regional innovation, e.g. Regional Research Centers (RRC), industry-science consortia.
  - Supporting local governments in carrying out regional R&D cluster projects integrating research centers with industry, universities and research institutes.

In principle, the time-horizon and the nature of R&D are different between MOST and the other ministries. Formally responsibilities are divided between MOST and other ministries as follows: MOST is responsible for generic, long-term and basic research. The other ministries concentrate on mission-oriented, short-term and applied research.

In reality, the division of labour is not so clear and overlapping or duplication of programmes among ministries takes place. That was the main reason for establishing the NSTC. But despite the existence of the NSTC, the problem of overlapping and duplication has not yet been solved. MOST and MOCE are for example being criticized for the fact that many of their projects are duplications, which creates an inefficient use of the government budget.

Mission Oriented Priorities

In Korea mission oriented priorities such as space and nuclear R&D exist. A ten-year national nuclear R&D programme was launched in June 1992. Nuclear power plants supply 44,6% of Korea’s power consumption. A national emergency division was established in the MOST in 2001 to deal with national rescue in case of radioactive disasters.

The priority “Space and Aeronautics” is not only a thematic priority, but also a mission-oriented priority: Korea wants to reach space-launching capability by the year 2015.

Programmes within the National R&D Programme are often mission-oriented, focusing on issues such as environment, food supply, energy supply and health.

The MOST and the Ministry of Defence (MOD) are important players in funding mission oriented priorities. The MOD funds the development of weaponry and defence-related matters.

Frequency of Priority Setting and Adaptation

A long-term STI-development plan „**Vision 2025**“ was issued in 1999. „Vision 2025“ establishes a fundamental policy direction and strategies for STI-development. Aims are divided into three time-periods within the 25-year time horizon. Each time-period has its own priority areas:

- First step (until 2005): Korea’s S&T competence should reach the level of the leading countries in this area, through resource mobilization, building-up infrastructure, improvement of laws and regulation in this area.

- Second step (until 2015): Korea should stand out as an important R&D nation in the pacific-region, active in scientific research and enabling a prolific R&D environment.
- Third step (until 2025): Korea should reach the S&T competitiveness-level of G7 countries.

Short term targets include, raising R&D investment, increasing basic research investment and increasing the number of researchers in R&D. Long term targets include, reducing the role of the government and shifting the national innovation system toward a private one, harmonizing the NIS with the global system of innovation and attaining world leadership in key areas of science and technology.

Five-Year Plan for S&T Innovation: Since the 1960s eight 5-Year S&T Development Plans have been established. The aim of the Five-Year Plan for S&T innovation (1997-2002) was to promote the national R&D capacity to the level of the G7 countries. The follow-up Five-Year-Plan for S&T innovation was established in 2001: the Five-Year-Plan for S&T Innovation (2002-2006). The regular establishment of S&T plans is required by law.

Five-Year S&T Principal Plan: Under the S&T Framework Law, the Korean government established the first Five-Year-Principal-Plan in 2002, to set the goals of national S&T development. It was revised in February 2003 when the new government came to power (the government period is five years long). The Five-Year S&T-Principal-Plan serves as an action plan for achieving the first stage of "Vision 2025" and acts as a follow-up plan for the Five-Year-Plan for S&T Innovation.

The relationship between the “5-Year Plan for S&T Innovation” and the “5-Year S&T Principal Plan” is explained as follows. The 5-Year Plan for S&T Innovation is based on the S&T Innovation Law. The S&T Innovation Law was formulated as a “temporary law”. Its period of validity has ended and the S&T Framework Law was established as its successor and as a “permanent law”. Both laws demand that a 5-year S&T plan is established by the government. The first 5-Year Plan was created based on the Innovation Law, but as the new S&T Framework Law was permanently established, new five year plans were also established. The main content of the two plans is almost the same however.

In the Five-Year S&T Principal Plan there are several action lines such as the establishment of a basic S&T policy direction, expansion of national S&T investment, implementation of various national R&D projects, increase of public awareness on S&T, nurture creative S&T manpower, technology transfer and commercialization, and globalization of S&T activities.

Five-Year Regional Promotion Plan (2000-2004): The regional promotion plan was established to expand local growth potential and to realize balanced national and local S&T development. The regional promotion plan also states that MOST shall formulate the implementation plan every year.

Plans for Specific Priority Areas: Furthermore strategy plans are also established for specific topics. In the year 2001 the Third **Biotechnology Development Plan** was issued for the years (2002-2007). In 2001 the government formulated the Comprehensive Plan for the **Development of Nanotechnology**. A National Long-Term **Space Development Plan** exists, which was revised in 2000.

Priority Setting Process

Research and Technology development is generally organized decentrally. Ministries plan their own programmes, in which they set their own priorities. In 1999 the national science and technology council (NSTC) was established. The NSTC has the ultimate authority in the R&D investment decision and in the determination of STI-priorities. The MOST acts as a "secretariat office" for the NSTC. The NSTC is officially responsible for priority setting. However in practice, the ministries often carry out priority setting and the NSTC coordinates the resource allocation process. Korea is currently trying to change its STI-policy system, so that the NSTC and MOST receive more autonomy and budget authority. The NSTC meetings are held roughly once every three months. The agenda of the meeting is usually prepared by the MOST in consultation with other ministries. Since the NSTC is the highest authority organization, the meeting usually ends with a final approval, which implies that the ministries should then coordinate and (find compromises) among each other.

Until now, the budgeting process is conducted as follows: ministries individually negotiate with the **MPB (Ministry of Planning and Budget**). The MPB receives an "annual evaluation report on the ministries' R&D programmes" from the NSTC (de-facto prepared by the MOST). The annual report gives some hints/guides on the budgetary decision of the MPB. The negotiations between the ministries and the MPB are generally more effective that the annual report of the NSTC.

In front of this background, the Korean government (the president) recently decided to promote the Minister of S&T to the vice-prime minister position and to give him more power to coordinate with other R&D-performing ministries. Institutional and organizational changes are expected resulting from the President's decision.

The Korean Institute for Science and Technology Evaluation and Planning (KISTEP) is responsible for assisting the NSTC in priority setting. The NSTC has several sub-committees for advising ministries and agencies: the sub-committees for S&T policy, for R&D, for 'biotechnology and bio-industry' and for nanotechnology. The committees contribute to coordinating national S&T policy.

Foresight

There have been a number of technology foresight activities in Korea. They can be categorized into three types. (1) Foresight to support the launching of national R&D programmes and S&T development plans, (2) large-scale foresight carried out on a national level and (3) technology roadmaps (Choi, 2003).

We start off with the first type: When the HAN programme was started in 1992, a large-scale technology survey was conducted. A screening was carried out with 214 candidate technologies (product-oriented technologies and fundamental and generic technologies), out of which 60 were selected.

In the mid-80s foresight activities were carried out involving more than 800 experts for the development of the "Long-term plan for S&T development toward the year 2000". Large-scale foresight activities were also carried out for the launching of the "Vision 2025" with about 200 experts. These foresight exercises were carried out by MOST.

A second type of foresight activity are the technology foresight exercises at the national level. A large-scale Delphi exercise was carried out first in 1993 and a second time in 1999. The main purpose was to assist R&D organizations by providing data exploring the path of technological progress. The first Korean Delphi exercise (1993) used a three-round Delphi as an exploratory method. It dealt with 1174 topics and the forecasting period was 20 years, from 1995 to 2015. After the survey a comparison was carried out with Japan and Germany. The costs of the survey amounted to about 150,000 US dollars (the second Delphi exercise cost approximately the same amount).

Figure 3.6: First Foresight Exercise in Korea (1993): Three Round Delphi

Preliminary Stage (June 1992 – May 1993)

- Brain-storming for forecast-technologies: blank papers sent to 25,000 experts
- 30,000 ideas from about 5,000 experts; then reduced to 9,000 forecast topics

Pre-Foresight

- Constructing the technology foresight committee and 12 subcommittees
- Reviewing 9,000 topics and selecting 1,127 topics
- Reviewing the questionnaire

Main Foresight (Aug. 1993 – Sept. 1994)

- Two-round Delphi by sending the entire set of questionnaires to 5,000 experts (1,600 returned in first rounds, 1,200 in the second round)
- 47 topics added to the second questionnaires: 1,174 topics

Source: Shin, Taeyoung, „Technology Forecasting and S&T Planning: Korean Experience“, STEPI.

In the Second Korean Delphi (1998) the foresight period was extended from 20 years to 25 years, i.e. from the year 2000 to the year 2025. 1155 topics were covered, which were arranged into 15 topics. After the foresight exercise a comparison with Japan and Germany was carried out.

Table 3.5: Technology Foresight Exercise 1998

Field	No. of topics in field	Index of Importance[1]	Level of R&D[2]
1. Information and electronics	93	66.1	50.6
2. Communication	40	65.5	55.5
3. Machinery and production	88	63.8	47.5
4. Transportation	64	59.5	51.1
5. Aerospace and astronomy	61	57.1	31.9
6. Environment	67	64.9	47.0
7. Marine science and earth science	57	60.7	43.1
8. Energy and resource	117	59.7	49.6
9. Urbanization and construction	65	63.5	49.7
10. Materials	104	64.0	49.6
11. Chemistry and processing	86	66.1	50.1
12. Life science	91	71.4	41.0
13. Agriculture, forestry and fisheries	88	71.8	49.2
14. Health and medical care	104	72.7	44.0
15. Ultra-technologies	30	57.1	43.7
Total	1,155		
Average for all fields		65.0	47.1

Source: Lim, K., Jung, K.H., Kim, H.S., & Lee, H.J., The Second Science and Technology Forecast Survey; Korea's Future Technology, STEPI, Seoul, 1999 (in Korean) quoted in Shin, Taeyoung, (2000) "Technology Forecasting and S&T Planning: the Korean Experience".

1. The importance of a topic could be indicated as "high", "medium", "low", or "none". The index of importance is 100 when all the respondents indicate "high" and "0" when all indicate "unnecessary".
2. The level of R&D indicates the R&D capability of Korea compared with that of the world leader on the topic, which is set at 100.

The foresight exercise influenced long term S&T planning. Eight thematic priorities were identified: information and electronics, machinery and equipments, materials and process, life science, energy and resources, large scale and complex technology, social-welfare technology, and basic research. 80 technological areas were selected, which should be pursued strategically (incl. B-ISDN, traffic control system using GPS and logistics system, **ULSI - Ultra Large Scale Integration**, flat panel display, factory automation including H/W and S/W, and generic production technology).

The third type of foresight activity are **Technology Roadmaps (TRM)**. Technology Foresight and national Technology Roadmaps differ in that the technology-foresight process is broader searching for future technologies whereas the roadmap is aimed at specific questions, e.g. trying to determine in which specific technology field Korea should set priorities. The TRM approach originates in technology development activities at the firm level. The Korean government decided to use a **National Technology Roadmap (NTR)** in 2002. It did this to set up national R&D programmes that are more closely linked with market demands. The process was divided into two stages. In the first stage, technologies were identified that are important for competitiveness in 2012. In the second stage road maps were drawn up for the technologies identified in stage one.

The S&T ministry (MOST) carried out the roadmap exercise in the year 2002. Other ministries like MOCIE and MIC work on similar technology roadmaps. The roadmaps are not established on a regular basis. Universities, government research institutes and industry are currently also working on a technology road-map based on their own aims and perspectives. Several channels exist through which the aims of the road map can flow into the national agenda.

In conducting technology foresight and technology road map exercises, the exercises are typically organized and managed by the management agencies (listed in Table 3.4) and sponsored by the ministries concerned. The organizing agencies involve Korean scientists and engineers from the GRI but also from universities and industry. On average, the participation of scientists and engineers from the GRI is highest, but in some exercises, for example, in the MOCIE's technology road map exercise industry is also actively participating. This can be explained by the fact that the final goal of the MOCIE technology road map is to identify industry needs, whereas the technology foresight by MOST tries to identify "national" priorities.

Formalisation/ Implementation

In 1999 the government launched the long-term S&T development plan "**Vision 2025**". To turn the vision into reality by the year 2025, the Korean government launched the "21st Century Frontier Science Programme" and enacted the Science and Technology Framework Law. Based on the current and preceding laws, the Korean government formulated the First Five-Year S&T Plan (1997-2002).

Science and Technology Framework Law: The "Science and Technology Framework Law" established in 2001 defines the basic framework for technology support and R&D institute funding in Korea. It provides the legal basis for the National Science and Technology Council (NSTC), which is responsible for setting priorities for S&T policy and R&D investments of the government. The law also emphasizes the co-ordination of national S&T policies and investments.

The **Government Research Institutes** (**GRI**) are responsible for the implementation of the national R&D programmes. In January 1999 a Law was passed to regulate the creation, management and development of GRIs. There are five research councils (assigned to the Office of the Prime-Minister) that monitor the GRIs.

The National R&D Program, initiated by MOST in 1982 is based on the Technology Development Promotion Law. The management of the public R&D programmes is delegated to management agencies e.g. KISTEP, ITEP, IITA, KOSEF and KRF (see Table 3.4 for details). The government issued guidelines for the management of national R&D programmes. These guidelines apply to all government R&D programmes, independent of the Ministry.

In the case of Regional Science and Technology Policy, a "Regional Science Promotion Division" was newly established in 2000 in the MOST and in 1999 a "Regional S&T Promotion Council" with members of the local and federal government was set up.

Evaluation Procedures and Results

Korea has been evaluating public R&D expenditures and activities since the early 1990s. Korea's current R&D evaluation primarily focuses on evaluating programmes and project management. Performance evaluation of programmes, i.e. the analysis and measurement of the socio-economic contribution of R&D programmes currently receives little attention. Inter-ministerial and comprehensive evaluations have rarely been carried out in the past.

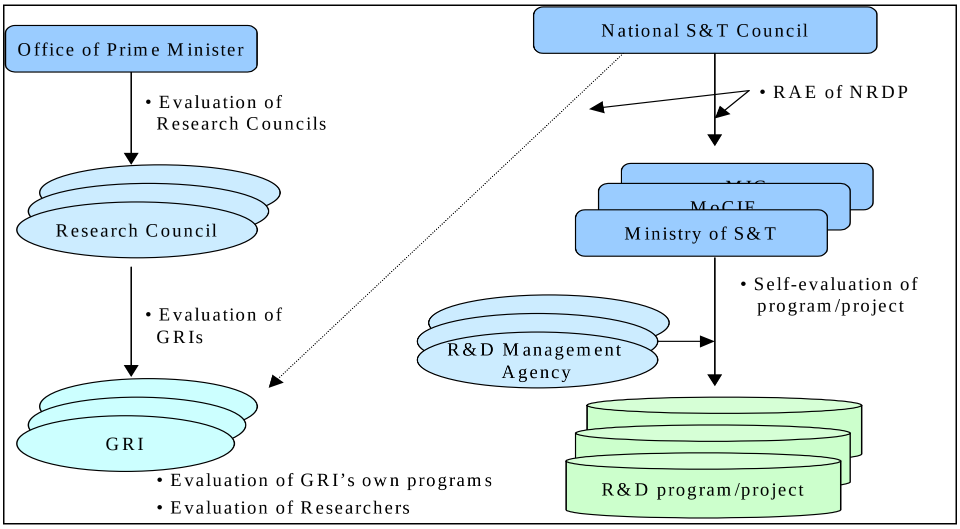
The NSTC is the highest authority in coordinating, monitoring and evaluating the diverse ministerial R&D programmes. The NSTC carries out an annual pre-coordination, review, analysis and evaluation of the large R&D programmes of the ministries. The evaluation serves as a guideline for the budget allocation to the ministries and departments. The NSTC set-up a master plan for the evaluation of national R&D programmes. The ministries carry out evaluations of their own R&D programmes and projects.

The office of the prime minister carries out an annual performance-evaluation of the GRI (institutional evaluation). The prime minister's office uses the evaluation carried out by the research councils as a basis for their own evaluation. However the reliability of the evaluations by the research councils has frequently been questioned.

Until 2001 Korea carried out the Highly Advanced National (HAN) program, a large national R&D programme which was started in 1992 and ended in the year 2002. The government conducted an ex-post performance-assessment from the scientific, economic and business perspective. The new 21st century programme is the successor of the HAN-programme. A project manager is in control of each project and has autonomy in allocating resources. MOST evaluates each project every three years and decides whether the project managers are achieving their goals. An evaluation of the government research institutes (GRI) has also become necessary. The GRI had an important role in the early stages of Korean industrialization, however the growth of research capacity in industry and university made it necessary to redefine the role of the GRI and to evaluate their performance.

Korea is planning to establish a dual R&D performance evaluation system, consisting of self-evaluation by the R&D ministries and a meta-evaluation by external organizations.

Figure 3.7: Korea's R&D Evaluation System



Source: Suh, Joonghae (2003), „Performance Evaluation Systems and Guidelines for R&D Investment in Korea"

3.3.3 Conclusions

Korea is characterized by strongly formalized and government driven STI priority setting processes. The S&T Framework Law (2001) sets the institutional framework and regulates the policy field together with other S&T laws. Long-term and short-term STI policy plans are set up at regular intervals. Currently the long-term plan „Vision 2025“ is in effect, which addresses the years 2000 to 2025. Short-term plans are frequently issued and address five-year time frames.

The main players involved in STI-priority setting are the national science and technology council (NSTC), the Ministry of Science and Technology (MOST) and a few other ministries. The national science and technology council is a political board led by the prime minister and consists of several ministers. In principle the NSTC is the highest authority in S&T priority setting, but the ministries also have significant power. The government supported research institutes (GRI) carry out a major portion of the publicly funded R&D, however their role has weakened in the past years. Industry and research institutions are involved in consultations for priority-selection including foresight exercises and roadmaps, which are regularly used for the identification of thematic priorities.

An important factor influencing S&T priority setting in Korea is that in the past Korea focused strongly on the rapid commercialization and imitation of foreign technologies. In order to become more innovation-oriented, functional priorities such as the promotion of basic-research, the development of core technologies and the promotion of innovations with a ten-year horizon are given high importance. Korea sets thematic priorities on a low level of aggregation when compared to thematic priorities in other countries. In the year 2003 Korea identified ten growth industries and eighty growth technologies.

Evaluation has been used since the early Nineties. Past efforts in evaluation have focused strongly on programmes and project management, but not on performance evaluation. In future dual evaluation systems are to be implemented consisting of self-evaluation by the ministries and meta-evaluations by external organizations.

3.4. Netherlands

Klaus Kubeczko (systems research)

3.4.1 The Dutch Innovation System – some stylized facts

The Netherlands produce more than 1% of the total international publications and the publications are cited above average. The output of Dutch research in terms of share of international publications compared to other leading countries like Sweden and Switzerland of similar size is highest in practically all disciplines and is well above the average of all countries. Relative to the number of R&D personnel of the country, Netherlands is the second West European country in patent activity behind Switzerland with a share of around 2% of the patents in the database of the European Patent Office. The GERD/GDP ratio was 1.97% in 2000, of which the private business sector with 4,87 bn € was the major funding sector while 3,23 bn € were funded by the government.

To give an overview of the functional priorities in Dutch STI policy the following table from the country report in the European Trend Chart on Innovation can be used (see Table 3.6 below). The policy area which receives most attention in present day research policy is “Gearing Research to Innovation”. I.e. policy makers prioritise company research, cooperation between company research and university research and start-up activities (see circled numbers in Table 3.6). “Establishing a framework conducive to innovation” is the second most important priority area. This implies tax incentives, changes in the law and regulatory aspects and to a lesser extent financing of innovation.

Table 3.6: Dutch Innovation Policy Priorities Table[17] for 2000 – 2003

Innovation policy priorities table

Priority areas and sub-areas	July 2000	Sept 2001	Sept 2002	August 2003
I. Fostering an Innovation Culture	12	12	10	9
I.1. Education and initial and further training	3	3	3	3
I.2. Mobility of students, research workers and teachers	1	1	1	1
I.3. Raising public awareness and involving those concerned	2	2	1	1
I.4. Innovation and management of enterprises	2	2	2	2
I.5. Public authorities	0	0	0	0
I.6. Promotion of clustering and co-operation for innovation	4	4	3	2
II. Establishing a Framework conducive to Innovation	10	10	12	12
II.1. Competition	1	1	1	1
II.2. Protection of intellectual and industrial property	2	2	3	2
II.3. Administrative simplification	2	2	3	2
II.4. Legal and regulatory environment	1	1	2	3
II.5. Financing of innovation	2	2	1	1
II.6. Taxation	2	2	2	3
III. Gearing Research to Innovation	*18*	*18*	*18*	*19*
III.1. Strategic vision of R&D	2	2	2	2
III.2. Strengthening research carried out by companies	5	5	4	5
III.3. Start-up of technology-based companies	3	3	4	5
III.4. Intensified co-operation between research, universities and companies	5	5	5	5
III.5. Strengthening the ability of SMEs to absorb technologies and know-how	3	3	3	2
Total points	40	40	40	40

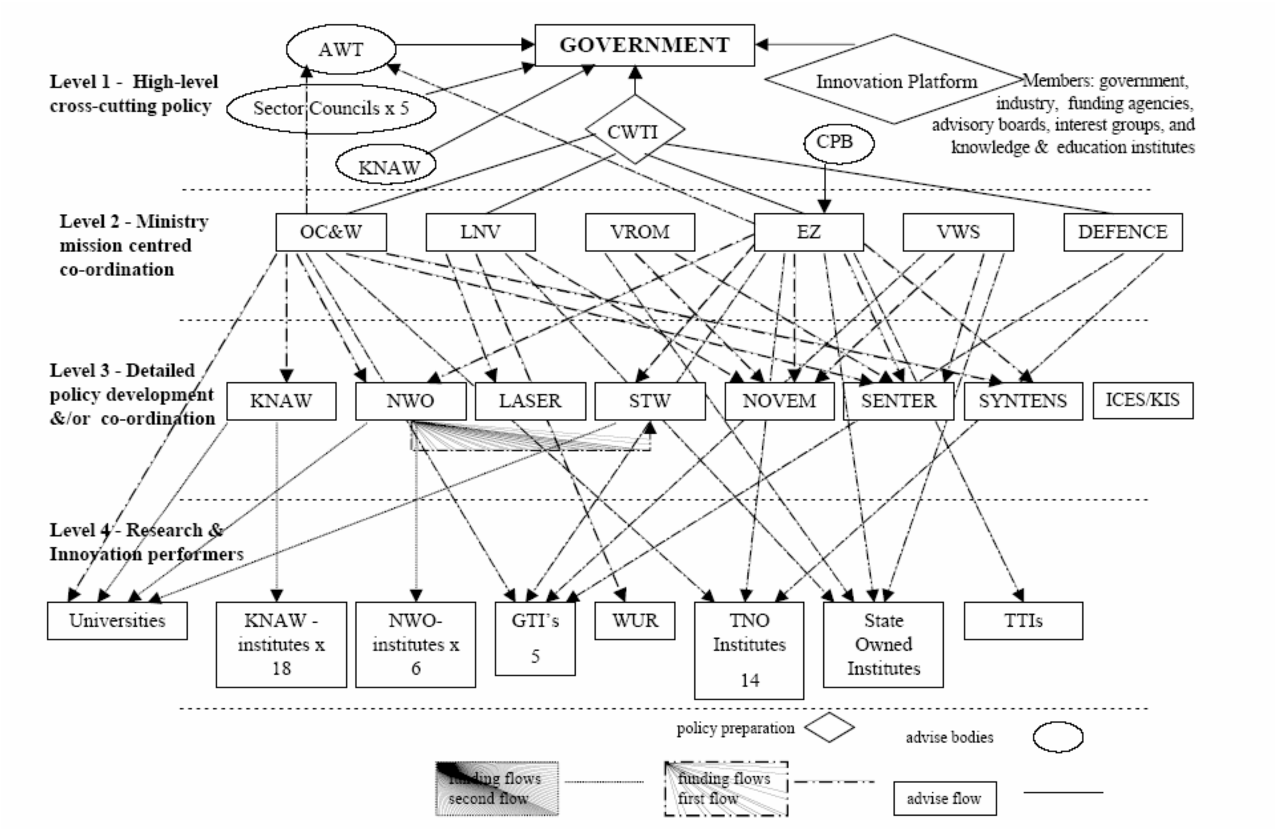
Source: (DG Enterprise 2003)

Particularities of the Dutch Innovation System

The governance of the Dutch innovation system is characterised by a well defined network of actors. The key actors providing advise on the governance of the Dutch RTD system and the funding flows between ministries and the institutions running the programmes can be summarise in four hierarchical levels: advisory bodies for high-level cross cutting policy (Level 1), ministries (Level 2), executing agencies for detailed policy development and/or co-ordination (Level 3) and research innovation performers (Level 4), see Figure 3.8.

[17] Each Action Line is allocated a number of points reflecting its relative importance in terms of national priority objectives. A maximum of forty points is allowed. The table is meant to convey a sense of which Action Lines are viewed as important in terms of national policy formulation, and to reflect the relative amounts of "effort" expended on the promotion of measures dealing with that Action Line (DG Enterprise 2001).

Figure 3.8: Governance of the Dutch RTD system



Source: DG Enterprise 2003

Table 3.7: Abbreviations and explanations of institutions in the Dutch RTD System

Level 1 - Advisory Bodies	
AWT	Advisory council for Research and Technological Policy
CWTI	Interminsterial Committee for Science, technology and Information Technology
CPB	Netherlands Bureau for Economic Policy Analysis
KNAW	Royal Netherlands Academy for Arts and Sciences
Sector Councils (ACR)	5 sector councils (health research, agriculture, nature and environment, development co-operation and spatial planning)
Innovation Platform	A high level advisory organ, aiming at a more integrated policy approach
Level 2 - Ministries	
OC&W	Education, Culture and Science
LNV	Agriculture, Nature Management and Fisheries
EZ	Economic Affairs, especially DG Innovation
VROM	Housing, Spatial Planning and Environment
VWS	Transport, Public Works and Water Management
Defence	Department of Defence
Level 3 - Executive Agencies	
KNAW	Royal Netherlands Academy for Arts and Science
NWO	Dutch Research Council (Netherlands Organisation for Scientific Research)
STW	The Technology Foundation
NOVEM	Netherlands Agency for Energy and Environment
SENTER	Agency of the Ministry of Economic Affairs for business and research institutions
SYNTENS	Agency of the Ministry of Economic Affairs for SMEs
ICES/KIS	Interdepartmental Commission for Economic Structure

Most important for the priority setting process are the AWT, 5 **Sectoral Councils (ACRs**), the Royal **Netherlands Academy for Arts and Sciences (KNAW**) and the newly founded Innovation Platform. At the ministerial level a new body, DG Innovation, was established to coordinate the innovation policy and the priorities in this field. The first three advisory bodies are more related to the field of science policy and the linkage between science and innovation from the point of view of public research & innovation performers. Due to the novelty of the Innovation Platform one can not yet say what the viewpoint of this advisory body will be.

The tasks of the most important organizations in the priority setting process are shortly described below:

Advisory Council for Science and Technology Policy (AWT): The AWT is a council that advises the Dutch government on science and technology policy. Within the government, the Minister of Education, Culture and Science and the Minister of Economic Affairs are responsible for this policy fields and are coordinating the policy. A new task of the AWT is to commission or carry out foresight studies in the field of science and technology (that were previously conducted by the **Foresight Steering Committee OCV**). This foresight studies shall be published publicly for the notice of relevant actors in the field of science and technology.

Innovation Platform: The innovation platform is a new institution initiated by the government. It is described as a high level advisory body, aiming at a more integrated policy approach. The platform is made up of 18 people who have been selected from government, industry, and knowledge & education institutes (universities, etc). The cabinet is represented by the prime minister (chair of the platform), and by the ministers for Economic Affairs, and Science, Education and Culture. The platform shall “draw-up plans and develop a vision that will give an impulse to innovation in The Netherlands” (DG Enterprise 2003). It has to deliver concrete recommendations to form a basis for policy formation and execution.

Sectoral Advisory Councils on Research (ACR) were established by the ministry responsible for sciences (Ministry of Education, Culture and Sciences) in 5 different fields in the 1970s and 1980s: **health research** (**RGO**), **agriculture** (NRLO), **nature and environment (RMNO), development co-operation** (**RAWOO**) and **spatial planning**. They play an important role in the bottom up processes by different kind of actors like users of research results, researchers and representatives of research organizations as well as representatives of government agencies. Their formal task is to give advice on the formulation of programmes for medium and long term research in quadrennial document on the overall policy and research direction of the sector. Their main influence however is given through interim reports and networking with funding agencies and other actors. The various councils conducted foresight processes and evaluations.

Royal Netherlands Academy for Arts and Sciences (KNAW) is an advisory body and a funding agency that advises the government on matters related to scientific research.

DG Innovation: The Directorate-General for Innovation (DG Innovation) within the **Ministry of Economic Affairs (EZ)** is responsible for the innovation policy of the country. It has the mandate to strengthen innovation policy within the Dutch economy in the areas of knowledge, technology, labor and innovative entrepreneurs. The core tasks of the DG Innovation include: vision and knowledge of innovation; improved efficiency of the public knowledge infrastructure; promotion of innovation development in the market; establishment of a strong ICT base.

3.4.2 Existence and kind of priorities in STI

The Dutch STI policy is defined in White Papers and strategic plans. This includes priority setting of different kind in all field of STI policy. Priority setting is taking place at different levels of executive agencies (see Level 3 in Figure 3.8). There exist a relatively clear distinction between priority setting in science policy and technology & innovation policy in The Netherlands. Therefore, in the following the peculiarities of the different policies as well as of the different levels at which executive agencies operate are taken into account.

Science policy

Science policy is presently predominantly functional oriented at Level 1. However, very focussed thematic priority setting is also taking place. At the level of executive agencies thematic priorities are the main way to distribute resources. The lack of thematic priorities on the higher levels might be the reason for the lower levels to reach some concentration of resources. The presently relevant policy is formulated in the **White Paper "Nothing ventured, nothing gained, Science Budget 2000"** by the Ministry for Education, Culture and Science (OC&W). This white paper (OCW 1999) defines the focus of the Dutch research and science policy for a period of four years (2000 – 2005). The priorities made by this white paper are functional in the sense that it concentrates on generic problems of the research system. It does not actively formulate functional priorities in the sense of functions for the Innovation System as a whole, except for cooperation between science and trade and industry.

Focal points are:

- **Room for accountability of the research system**: The most significant aspects of this focal point are the requirements of the research system to become more transparent and the withdrawal of the governance system from priority setting. This implies that government leaves the responsibility for priority setting with the research system.
- **Research as a career opportunity**: The lack of human resources has been identified as a threat for the success of the research system.
- **Investing in knowledge for the future**: The government intended to set up an Innovation Incentive Scheme in cooperation of the leading executive bodies.
- **Social responsibility**: This implies an improvement of the communication of research outcome to the public.
- **New forms of cooperation**: New types of cooperation are addresses to cross the boundaries of present institutions and subjects, multidisciplinary, researchers together with those who apply knowledge.

These functional priorities receive additional financing of 575 million € for 2002 – 2005 through the Science Budget 2000.

Apart from the functional priorities, the Dutch government, in the Science Budget 2000, has set one thematic priority by an extra investments of a total of 189 million € (2002 – 2005) for a special programme for genomics research that crosses the whole innovation process.

Priority setting also takes place **at the level of executive agencies**, especially in the case of Dutch Research Council (NWO). The NWO has been setting thematic priorities in the Strategy

Document, “Themes Plus Talent” (NWO 2001). It has selected nine research themes to subsidize in the period from 2002 to 2005. The chosen themes are:

- Cultural Heritage
- Ethical and Social Aspects of Research and Innovation
- Shifts in Governance
- Cognition and Behaviour
- Fundamental Processes of Life
- System Earth
- Digitalisation and Computerization
- Nanosciences
- Emerging Technologies.

As the title of the strategic plan suggests, the emphasis on theme-based research, new talents in research shall be promoted. This functional priority is combined with the intention to avoid concentrating only on pre-selected priorities. NWO wanted to guarantee the identification of future research themes with a potential of longer term effect on innovation activity. Incentive grants for outstanding academic careers of young researchers will be the way of funding this non-prioritised themes, with 68 million € per year (Stronkhorst 2001).

Technology and Innovation Policy

In technology and innovation policy, functional priority setting is taking place in the sense of the state taking an active position in developing the National Innovation System. The role of the state is therefore seen in

- functioning as a broker for supplying strategic information (benchmarks, cluster studies, technology foresights),
- offering public consultancy (focus groups, platforms, workshops),
- developing innovative subsidy-schemes and
- initiating supportive activities in public relations and exchange of experience.

“Strengthening research carried out by companies”, “Start-up of technology-based enterprises” and “Intensified co-operation between research, universities and companies” are the three subjects of top functional priorities identified by the priority exercise in the National Report to the European Trend Chart on Innovation for 2003 (DG Enterprise 2003 and see Figure 3.8).

On the ministerial level, the newly founded Directorate General for Innovation has, apart from its mandate for innovation policy in general, one thematic priority in ICT in the sense of a specific mandate to promote innovation in this field.

Technology Foresight plays a less important role in present day priority setting in innovation policy, than it used to play in previous years. The outcomes of the foresight process are not seen as research priorities, however they are seen as starting points in a discussion process in the technology fields identified by the process. The following fields of innovation were identified in a Delphi type technology foresight process „Technology Radar“ (EZ 1998):

- Mechatronics
- Bioprocess Technology
- Software Engineering

- Catalysis
- Separation Technologies
- Gene Technology
- Polymers
- Composites
- Surface Treatments
- Production Automation
- Energy Saving
- Data and Knowledge
- Interactive and Multimedia Technologies.

Priority setting in technology and innovation policy is also taking place **at the level of executive agencies** (see Level 3 in Figure 3.8). To give one example, thematic and, to some extent, mission oriented priorities were defined under the direction of the Interdepartmental Commission for Economic Structure (ICES/KIS). A new (3rd) Science & Technology Investment Impulse was formed (EUR 0,8 bn € from 2004 to 2008); eight themes with a high significance for science and innovation policy have been identified (OECD 2002):

- Systems innovation
- ICT
- Competences in Information Society
- Integrated systems for multifunctional and high quality use of scarce space in the Netherlands
- Use of knowledge in SMEs
- Sustainability in economy, technology, ecology & culture
- Breakthroughs in health, food and gene- and biotechnology.

The frequency of adoption and re-formulation of priorities

The formulation of priorities in the ministry responsible for science has been taking place occasionally (van der Meulen and Rip 2001) by means of a partly regular and institutionalised process over the years and sometimes in a controversial manner (Hackmann 2003). Important actors here are the ACRs that provide quadrennial documents on the overall policy and the research directions of the sectors they represent. In the 1990s the ministry institutionalised a foresight process in various panels that led to a final report after 4 years. The report “A Vital Knowledge System” defined 14 priorities for science policy which were accepted by the government as a basis for its next Science Budget. It was intended by the minister of science at that time to use the foresight report as national research agenda for the next ten to fifteen years. This was counteracted by the ministry three years later, with a change in policy and another change with the present government.

The nature of the priority-setting process

Dutch STI policy is in a period of change in the last years. In the late 1990s the policy was focussing on thematic and some mission oriented priority setting by knowledge themes that are defined in a foresight process. Recent development point into another direction. Universities are asked to formulate strategies that are the basis for financial support by intermediary research funding organisations.

Since the publication of the **science budget 2000**, the thematic priority setting process has been reversed from a top down priority setting by means of foresight (see Box 1) to a bottom up process from the side of universities. The policy was to base strategy building of executive agencies on the strategies of the universities. The ministry stated that “the government keeps in the background when it comes to the actual content of research” (OCW 1999). As the foresight report conducted by the AWT in September 2001 also concentrates on functional aspects, no thematic priorities were set top down.

A survey with actors of the Dutch research system shows that priority setting is also based on tacit knowledge on the important issues of the day. This survey reports that national thematic priorities therefore refer to a number of “we all know and agree” type of subjects. Subjects named are topics like functional genomics, bioinformatics, nanotechnology, food security but also ecology, biodiversity and global warming (Hackmann 2003). This priorities receive privileged attention in terms of financial resources and incentives. A number of the topics are institutionalised either in organisations like national commissions or a new NWO programme like the programme on genomics.

At the **level of executive agencies** NWO is one of the agencies **setting priorities**. Over the next few years, NWO intends to increase its efforts to promote innovative research themes. As a main factor, the requirement of a concentration of resources and talent is emphasised. The NWO is aware that, to achieve this, a small country like The Netherlands must make choices. The selection of the themes involved (see list in p. 55) both an interactive process of identification of trends in science and extensive consultation and coordination with other stakeholders, including bodies involved in the conduct of foresight studies, such as the Science and Technology Advisory Council (AWT), the Academy of Arts and Science (KNAW) and the sector councils for research and development.

Box 2: Foresight in the 1990's: (Hackmann 2003)

In the early 1990s a Consultative Committee on Foresight (OCV) was established in the attempt to have overall science policy priorities. The OCV's report 1996 was (acc. to the Minister at that time) intended to outline a national research agenda for the next ten to fifteen years.

The OCV consisted of researchers in key positions in the research system and some representatives of the industry. The focus of the OCV was on foresight studies of specific research fields and societal aspects. It was not intended to perform a comprehensive Delphi type study.

The activities were seen as an initiative to transcend disciplinary boundaries and support an integrated set of foresight activities aimed at producing national priorities with some relevance for society.

The OCV organised, supervised or joined in 31 foresight activities and 20 background reports. By this the OCV has built on ongoing exercises and earlier foresight-related activities in the selected areas. It helped to articulate and systematise bottom-up foresight and strategic priority setting activities already existing.

After approximately 4 years, the OCV published its final report "A Vital Knowledge System" defining 14 priorities for science policy which were partly problem oriented and partly generic to the science system.

Those priorities belong to two different types. Ten priorities, called "knowledge themes", are rather thematic and problem oriented. These are considered as strategic areas that are "vital" to meet the challenges of "the information and communication society", a "sustainable economy", internationalisation and regionalisation" and "quality of life". Four priorities are rather functional and regard the organisation of the knowledge production mainly within science

- Ten thematic priorities (knowledge themes):
- Long-term research on electronic highways
- Learning and human capital in a knowledge-based society
- Agriculture and food - innovation and improvement of quality
- Research for the service sector
- Ecological modernisation – Factor 4 research
- Integral utilisation of Space
- Business activity and innovation
- Process of internationalisation and regionalisation
- Social cohesion
- Health research on quality of life, and efficacy of health services

Four functional priorities "vital to maintain a healthy science base" (van der Meulen and Rip 2001)

- Develop coordinated strategies for the natural and engineering sciences
- Organise multidisciplinary programmes in the social sciences
- Improve coordination of humanities
- Improve coordination of research in medical technology.

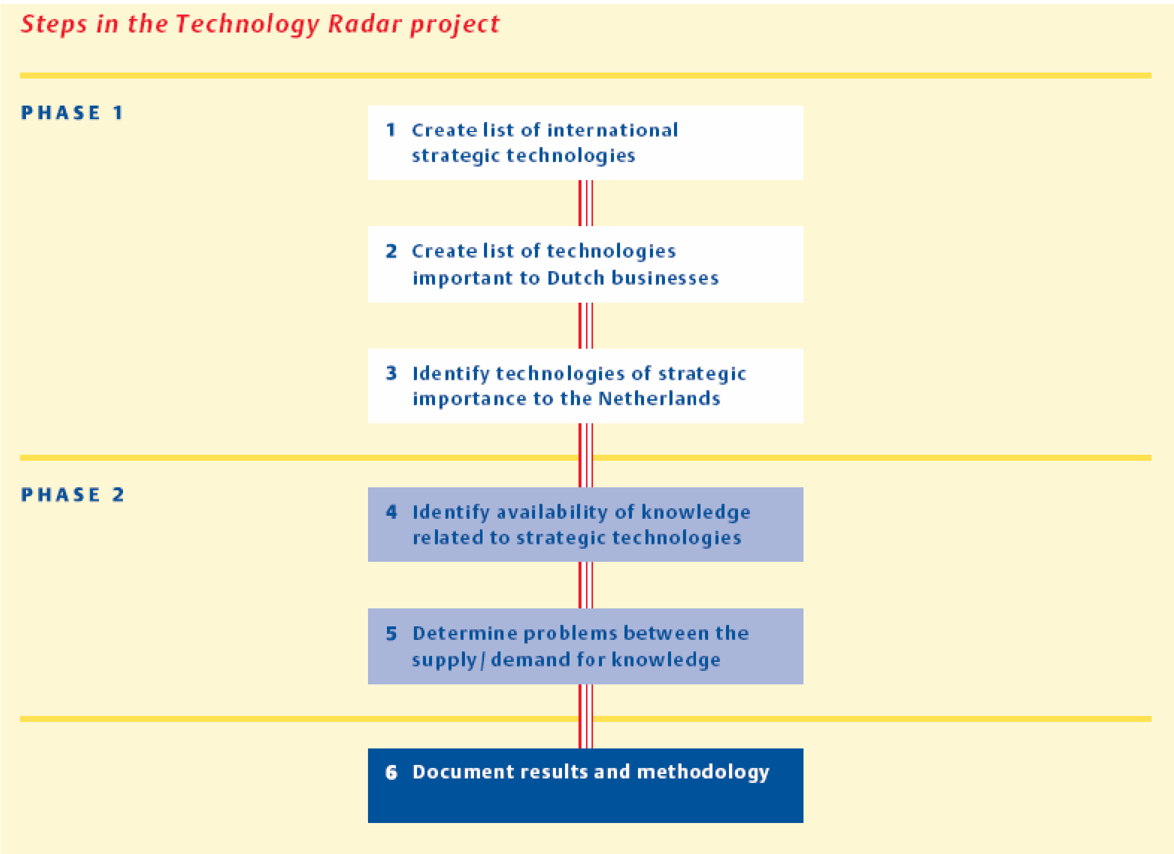
In the realm of **technology and innovation policy priority setting** is linked to the Technology Radar. The **Technology Radar** (EZ 1998) was a Technology Foresight Exercise conducted by RAND Europe and other consultancy companies for the Dutch Ministry of Economic Affairs. This programme was designed to alert SMEs in particular, to possible applications of existing technologies which may yield immediate commercial gains. On the other hand, the Technology Radar primarily focuses on future technological developments.

The two primary objectives were:

1. identifying technology fields that are likely to be of strategic importance to Dutch business and industry within the next ten years.
2. investigating whether sufficient knowledge build-up is taking place in the fields of strategic importance.

The general approach that was used in the project is shown in Figure 3.9. The project was divided into two phases. Phase 1 produced a list of technologies believed to be of strategic importance to the Dutch economy. Phase 1 concluded by identifying the subset of the important technologies that were most critical for the entire Dutch economy. Phase 2 compared the demands and supplies of knowledge supporting these technologies, and made a number of observations regarding their relationships (EZ 1998).

Figure 3.9: Foresight Process of the Technology Radar



Source: EZ 1998

The link between the priority-setting process and the overall strategic S&T-policy discussions

The leitmotif of the latest multi year plan for **science policy** is the self responsibility (*eigen verantwoordelijkheid*) of the Dutch research system (Hackmann 2003). This implies a shift from a priority setting on the level of the government to autonomous priority setting by individual actors in the research system.

The overall strategic **S&T policy** discussion in The Netherlands is strongly based on the concept of National Innovation Systems. The idea is to build a policy portfolio around the bottlenecks and challenges presented in the system. Some key aspects of this concept are: improving the interaction between R&D actors in the system, improving the exploitation of knowledge, and streamlining policy instruments.

The policy instruments that match these concepts can be divided into a number of categories: Generic instruments to stimulate private investment in knowledge (e.g. tax incentives), a category of instruments to improve the exploitation of knowledge (mainly co-operation in R&D), and a number of targeted instruments to support strategic technology areas. In the near future an Action Plan on knowledge workers, and particularly scientists and engineers planned to be published. (DG Enterprise 2003)

From the policy document **"Scope for Industrial Innovation" (June 1999)** can be seen that Dutch S&T policy discussion was dominated by a non-interventionist line of arguments. The policy document states that interventionism is not an effective industrial policy. Therefore there is widely no mission oriented structural policy taking place. Principles of the industrial policy concentrate on

- facilitation (concerning industrial premises, infrastructure, corporate governance etc),
- competition policy securing a high degree of openness and efficiency of markets
- flexible and dynamic policies with regular testing of the effects.

Mission orientation is explicitly neglected by the policy document. However, the promotion of competition is interpreted in the way that a lack of private investment in R&D shall be compensated by public investment.

The concept of Dynamic Innovation Systems (DIS) was used to reformulate the innovation policy in the Netherlands. This implies that the innovation system is seen and understood to be developed as a whole. Supporting co-operation among different partners in the innovation process plays a dominant role in policy making in the Netherlands. The state was seen as a facilitator for clustering and co-operation by setting up optimal framework conditions. Accordingly, not only explicit networking programmes are aiming at this goal. Also programmes supporting project-related co-operations are aiming at improving co-operation structures between the research and the industry sector. The Dutch DG Innovation is presently undergoing efforts to systematically analyse the bottlenecks in innovation system research that can help to design future policies based in an Innovation System approach (see Box 3).

Box 3: New Policy document - Dutch Ministry of Economic Affairs (October 200: In Action for innovation, tackling the Lisbon Ambition (Innovation White paper)

The new Innovation White Paper '*In Action for Innovation, Tackling the Lisbon Ambition*' outlines the steps the current cabinet plans to take to promote the strengthening of innovation capacity in Dutch industry. The Innovation White paper is intended to be a part of a broader strategy towards a sustainable knowledge economy, where both education and research play an important role.

The White Paper, the authors state, should not be seen as a 'set in stone' policy document, but as forward-looking agenda for innovation.

The White Paper is divided into three sections:

Part 1: Presents the new policy strategy with related solution lines

Part 2: Gives an analysis and outlines the foundations of the strategy

Part 3: Gives the line of reasoning behind the actions and the status of the actions

An analysis of the situation of the Dutch position has highlighted the bottlenecks for reaching target levels of innovation. The contours of the policy agenda that are a reaction to these bottlenecks include:

Framework conditions: Tackling of the short supply of knowledge workers and distribution of knowledge.

Industry: Development of the innovation climate and the stimulation of innovation in Dutch industry.

Interaction: The interaction between knowledge infrastructure and industry is seen as one of the critical success factors to really make the future knowledge economy work.

More focus on crucial technology areas: Investment in key technologies is long term investment. They create new innovation opportunities in all areas. The core of this action line is a focus on, and provision for excellence in a portfolio of crucial technologies for The Netherlands.

Working on the government: The foundations for innovation policy have been set. The core of this action line build on this foundation and focuses on the increasing co-operation and transparency in the various instruments, while strengthening the coordination between national, regional and European policy and investment in interactive policy forming.

Features of the New Innovation Strategy

With this in mind the White Paper describes the foundations of the new innovation policy, focusing on strengthening the growth possibilities for the Dutch economy. The proposed actions contribute to the realisation of the ambition of The Netherlands. Three main bottlenecks provide the approach for policy:

1. The innovation climate is not attractive enough
2. Lack of businesses that innovate
3. Not enough focus on critical mass in research.

These bottlenecks translate into the three policy areas. In addition, two threads run through the policy areas – firstly it should contribute towards sustainability, and secondly the international dimension should be kept in focus and increasingly utilised.

Box 4: Preparing for a Functional priority setting of DG Innovation (den Hertog, Oskam et al. 2003)

As an element of its activities, DG Innovation initiated an innovation research programming exercise. The exercise, was presented in a position paper "Innovation research and innovation policy - Usual suspects, hidden treasures, unmet wants and black boxes" (den Hertog, Oskam et al. 2003). The exercise was an interactive process based on the assessment of a mixed research team, lead by an consultancy company (dialogic), expert judgement (including the considered opinions of an expert workshop and a small international expert questionnaire) and a review of some of the most recent literature on innovation.

After making an inventory of the current bottlenecks in the Dutch innovation system and the themes covered in current innovation research, the mismatch between policy and research themes was mapped out. At this point it proved helpful to differentiate between two perspectives on themes for innovation research, namely: a pure research perspective and a policy perspective.

Explicitly the exercise was intended:

- to help in a multi-annual research programming, departing from the bottlenecks in the Dutch innovation system and giving direction to the policy-making activities of DG Innovation in the coming years;
- to come to a more systemic research programming, i.e. a research programming which takes the notion of what has been phrased as Dynamic Innovation System (DIS) as the starting point;
- to improve the use of existing innovation research, by identifying systematically where current empirical innovation research is under-utilised;
- to enhance the contacts between Dutch policy makers in the field of innovation and innovation researchers by creating an operational network.

Aggregation Level - the scale and scope of priorities

The Science Budget 1997 set thematic priorities in **science policy** on the highest level defined by the foresight process. Contrary to this, the science budget 2000 avoided thematic priorities setting.

Due to the necessities in the allocation of resources, thematic priorities are set on the level of executive agencies like in the case of NWO priority setting (see above)

The priority setting process based on foresight resulted in a formulation of priorities in a very general way. To give three examples:

1. "IC technologies and infrastructure" was one of the 10 *knowledge themes* of the consultative foresight. The only form to narrow down that knowledge theme was to focus on long term innovation rather than on medium term implementation research.
2. „Social Cohesion" had a specific focus on the importance of individualisation, new social relations and the role of the government (Hackmann 2003), which is also not too much of a focus.
3. Ecological modernisation was widely understood as reduction of environmental pollution and sustainable development under the umbrella term of "Factor 4", a concept by the German Wuppertal Institute.

Priorities in **technology and innovation policy** on the level of research programmes are relatively focused compared to priorities set for science policy. Dutch innovation oriented research programmes used to be on different levels of aggregation in the 1980s and early 1990s. Today they partly focus on specific topics within a sector (metals, catalysis, industrial proteins, genomics, etc.) or on cross sectoral topics, like human-machine interaction or precision technologies.

Formalisation of prioritisation and subsequent implementation

Science policy strategies or the Foresight priority setting results were implemented on the level of the science budget. The recent developments point into the direction of thematic priorities financed by national funding agencies set by individual universities based on their strategies reported to the agencies. For the formulation of the **Science Budget 1997**, the report by the OCV of 1996 was used. The OCV report indicated that the implementation of the results of the foresight process should be done by establishing a new set of national stimulation programmes (STIs) and by taking up the OCV agenda in the strategic plans of the universities and the intermediary organisations (NWO, KNAW etc.). The Ministry (OC&W) and the government responded by re-labelling and re-interpreting the knowledge themes defined by the OCV. This was done by adding themes and by specifying a particular focus to some themes. The OC&W then set up its plans for research promotion on the revised set of themes. In some cases these plans involved committing additional support for existing research organisations, or simply highlighting the importance of existing funding programmes and other initiatives. In other cases executive agencies and advisory bodies were consulted for further planning. Some of the themes were identified as research projects to be commissioned by specific ministries. The predominant way of implementation was seen in setting up new stimulation programmes to be prepared by the NWO. The NWO did not have to reallocate its resources to the new priorities but received additional money for the new task. Nevertheless, the NWO reallocated some of its own resources to the new programmes or incorporated existing programmes into the new STIs. The priorities defined in the White Paper by the OC&W has resulted in extra investment in the science sector by the **Science Budget 2000**. A new incentive scheme has been initiated to increase career opportunities for creative young researchers. The employment possibilities and difficulties for researchers are investigated and a new scheme to promote women researchers to higher positions is set up. With the science budget 2000 the universities and the executive agencies no longer have to let their strategies being approved by the OC&W. On the contrary, the process has been reversed. Strategy building of executive agencies shall be based on the strategies of the universities.

Technology and innovation policy priority setting by means of the Technology Radar is a rather informal way of setting priorities as the exercise is intended only to serve as a thematic orientation for industry. Another way of thematic priority setting used is to promote research of direct relevance to industry by means of **applied research institutes** (Top Technology Institutes TTIs). In 1997 such TTIs were established for metals, polymers, telematics and food research under joint responsibility of ministry of economic affairs (EZ) and the Ministry of Science (OC&W).

Evaluation Procedures: Which evaluation procedures do exist?

In the policy document “Scope for Industrial Innovation” (June 1999) one of the principles is to perform dynamic policies with regular testing of the effects. Pursuing an “holistic” approach to innovation policy, oriented by the concept of Dynamic Innovation Systems, the Netherlands follow a systemic perspective in assessing the effectiveness of innovation policy. Evaluations are given a central position. They are used as ex-post and as strategic ex-ante instruments (den Hertog, Oskam et al. 2003).

3.5. New Zealand

Helmut Gassler (Joanneum Research)

3.5.1 The Innovation System of New Zealand – some stylized facts

New Zealand belongs to the medium-income countries (GDP/capita) within the OECD. With about 22,800 USD (at current PPP) GDP/capita in 2003 is somewhat below the OECD average (26,000) and the EU average (26,600). Some main stylized facts concerning the national innovations system of New Zealand can be summarized as following:

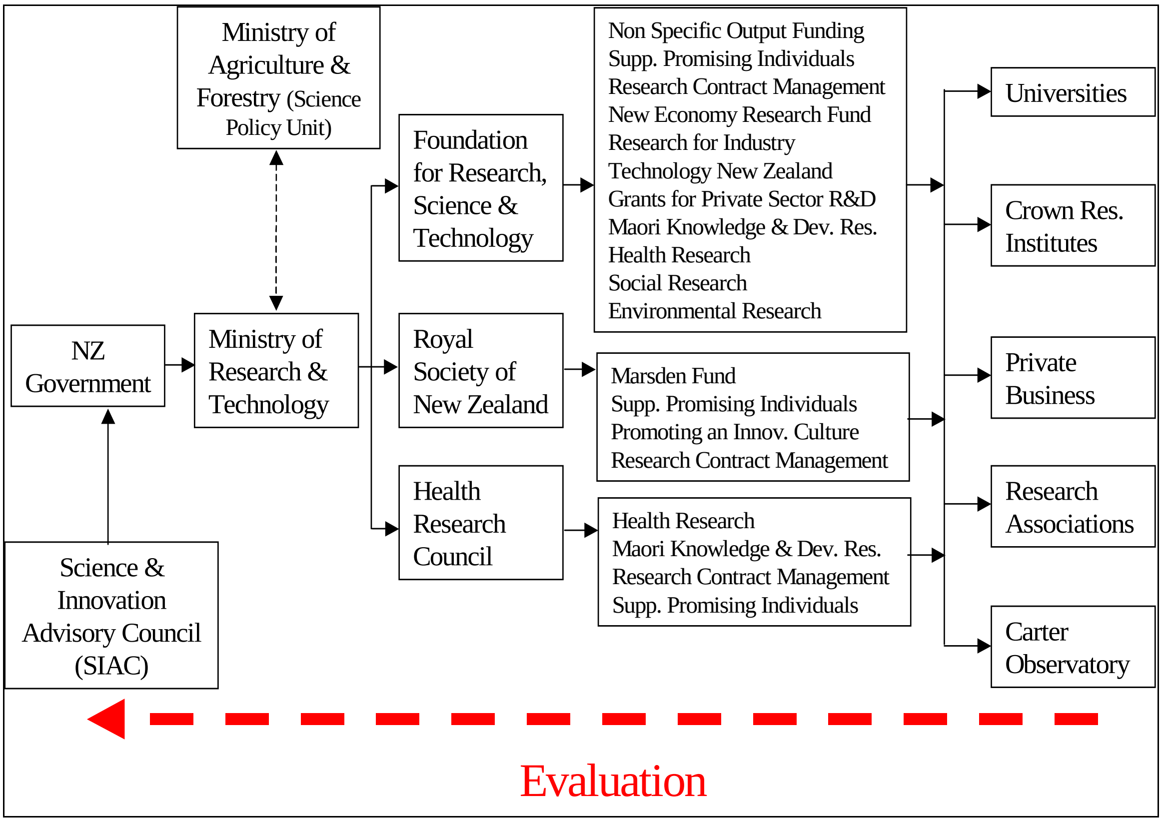
- Relatively **low overall R&D expenditures** (GERD/GDP): Although R&D expenditures have been increasing steadily since 1994, the overall R&D activity (about 1.2% of GDP in 2002) is still relatively low compared with other OECD countries. In 2002 the percentage of R&D activities of GDP in New Zealand was only about half that of the average of the OECD countries.
- In addition, a relatively **low share** of these (already low) R&D expenditures is **financed by the private business sector** (BERD in New Zealand is approximately 0.5% compared to 1.5% in the OECD average). Although the private financed R&D expenditures are growing relatively faster than the public ones (business R&D increased by around 30% between 2000 and 2002) the role of the business sector is much smaller than in other OECD countries. Thus, due to the lagging contribution of the business sector, the major source of financing of R&D in New Zealand is still the public sector (46% compared to OECD average of 29%).
- The overall low R&D intensity of New Zealand is (at least partly) due to the (relatively) significant weight of **resource-based industries** (e.g. agro-business) in the New Zealand economy. The competitiveness of these sectors relies usually more on the efficient (often capital intensive) processing and shipping of (abundant) staples and only to a lesser extent on scientific research and/or technological innovations (often important innovations are only adopted by these sectors but were generated in other economic sectors).
- New Zealand produces only a small share of the world's academic publications (average share 1995-1999 0.46%). However, considering scientific output for the number of people involved in R&D, New Zealand leads the OECD countries. Thus, concerning **publications per R&D personnel New Zealand is the most productive country**. However, measured in terms of publications per total population, New Zealand ranks in a medium position of OECD countries (in the range of Canada and Belgium, but well above Austria). The relative international impact of New Zealand academic publications is particularly high (impact index above world mean) in agriculture/ veterinary/ environmental sciences as well as in chemical and physical sciences. Information technology, mathematics and medical sciences are significant below the average.

The institutional framework of the New Zealand National Innovation System

During 1998-1999 a broad Foresight Project (under the guidance of the Ministry of Research, Science and Technology, MOST) has been undertaken leading to a major organizational change of the institutional framework of the RT&S system in New Zealand (see Figure 3.10 for an overview of the current system). An independent advisory entity, the Science and Innovation Advisory Council (SIAC) was set up in 2000 to provide advice to government on measures it could take to improve the National Innovation System and to act as a channel for discussion between government and stakeholders on NIS issues. The SIAC is fundamentally different in comparison to traditional sources of government advice (such as its policy ministries) in that it provides independent advice directly to the Prime Minister on high-level issues affecting innovation. The broad aims are set out in the „New Zealand Research, Science and Technology Vision 2010 and can be summarized under the heading *„creating a world's best small-country RS&T system"*. Regarding inputs, New Zealand aims to increase government-funded R&D up to 0.8% of GDP in 2010 and to stimulate private business R&D investment to more than three times the current level. Six key aspects have been identified to achieve the principle goal of a best-practice small-country RS & T system (MoRST, 2004):

- *„Increased and more effective investment that optimises opportunities for, and from, RS&T in New Zealand.*
- *A vibrant RS&T environment with the capability to attract and develop exceptional people.*
- *An ‚excellent' RS&T knowledge base that supports the requirements of our national goals.*
- *Effective diffusion of RS&T knowledge base that increases innovative potential and transformation across industry and government.*
- *Greater awareness, understanding and confidence in RS&T within our various stakeholder communities including the general public.*
- *Well-established international RS&T connections that foster increased knowledge sharing and global collaboration."*

Figure 3.10: Institutions and Actors in the New Zealand Innovation System



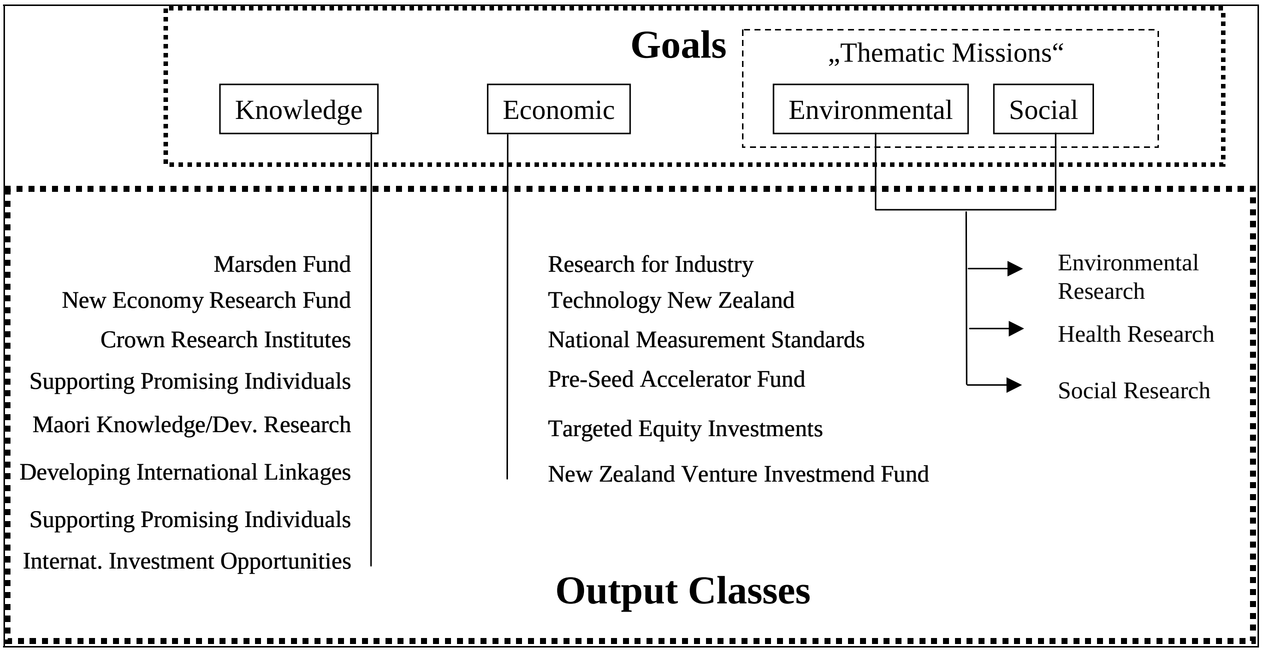
Source: MoRST

3.5.2 Priority setting in S&T policy in New Zealand

The re-organisation of the institutional framework of science and technology policy led to a reformulation of the broad governmental goals for RTD and in particular of the links between specific programmes and institutions/agents to these goals. Four different strategic goals were established which build a common-sense framework for guiding the public investments in RTD. These **four goals** are as follows (Figure 3.11):

- **Innovation/Knowledge goal**: Investments which help the overall innovation system to run as effectively as possible. It includes the costs of developing and running the system, ensuring a flow of new ideals through basic research and initiatives to apply and promote the results of research and innovation.
- **Economic goal**: Investments which assist New Zealand enterprises to be competitive in international markets through innovation. This includes strategic research to identify new products and services, as well as support and apply these.
- **Environmental goal**: Investments which help New Zealanders to understand, maintain and enhance a healthy environment. This maintains a high living standard & quality and thus is be seen as a strategic advantage in a somewhat deteriorating global environment.
- **Social goal**: Investments which generate knowledge that can improve social well-being in New Zealand. This includes especially investments in social sciences, humanities, Maori and health areas.

Figure 3.11: The four goals for RS&T in New Zealand and associated funding schemes



Source: MoRST

Four major funding & investment agencies are responsible for funding:

- Royal Society of New Zealand (RSNZ)
- Health Research Council (HRC)
- Foundation for Research, Science and Technology (FRST)
- New Zealand Venture Investment Fund Ltd (NZVIF).

In 2004/2005 total amount of NZD[18] 621.1 million will be available. To each goals so called output classes (funds/investment schemes) are associated and these funds are administrated by one of the aforementioned four funding & investment agencies (see Figure 3.12). The distribution of financial funds over the four goals are as follows:

Innovation/Knowledge goal (150.5 m NZD 2003/2004; 165.96 m NZD for 2005/06)

- Marsden Fund (“basic science fund”)[19]: supports investigator-driven research that encourages excellence in the advancement of knowledge, expands the knowledge base and supports people with knowledge, skills and ideas. 32.79 million NZD for 2003/04. Agent: RSNZ.
- New Economy Research Fund: funds researcher-led innovation aimed at developing capability and knowledge in new areas or applications where industries are emerging or yet to emerge. 63.88 million NZD for 2003/04. Agent: FRST
- Non-Specific Output Funding: for CRIs (Crown Research Institutes) to undertake public-good research in order to maintain viability and capacity. Crown Research Institutes are government-owned research organisations with a focus to on servicing the

[18] 1 € = about 1.8 New Zealand Dollar (NZD)
[19] It is named after Sir Ernest Marsden (1889-1970), a renowned researcher and research policy maker, who founded the Department of Scienctific and Industrial Research in 1926.

technology/research and innovation needs of important sectors of the New Zealand economy. Today there are nine Crown Research Institutes in place (see Annex 2), covering a broad range of research and technology sectors: research in land-based industries; environmental and resource management research; technology development in the industrial sector; environmental health. 28.58 million NZD for 2003/04. Agent: FRST.

- Supporting Promising Individuals: supports human resources, science and technology and contributes to the development of people with required skills. 14.55 million NZD for 2003/04. Agents: FRST, HRC, RSNZ, MoRST.
- Maori Knowledge and Development Research: develops Maori research capability and evolves Maori knowledge. 5.48 million NZD for 2003/04. Agent: FRST, HRC.
- Promoting an Innovation Culture: develops networks that strengthen and encourage a culture of innovation in New Zealand. 2.69 million NZD for 2003/04. Agent: MoRST, RSNZ.
- Developing International Linkages: promotes and supports New Zealand research, science and technology internationally. 2.08 million NZD for 2003/04. Agent: MoRST, RSNZ.
- International Investment Opportunities Fund: supports research providers to participate in research collaboration that attract international co-funding, to recruit highly experienced researchers from overseas and to support participation in international research programmes. Agent: FRST, HRC.

Economic goal (230.96 million NZD 2003/2004; 255.94 million NZD for 2005/06)

- Research for Industry: aims to increase the competitiveness of New Zealand industries and sectors through strategic research. 185.04 million NZD for 2003/04. Agent: FRST
- Technology New Zealand: increases the ability of firms to adopt new technology and apply technological learning and innovation. 36.04 million NZD for 2003/04. Agent: FRST.
- National Measurement Standards: provides a set of internationally accepted standards for New Zealand products, processes and services. 5.08 million NZD for 2003/04. Agent: IRL (Industrial Research Ltd).
- Pre-Seed Accelerator Fund: aims to increase the rate of commercialization of innovations from publicly funded research. 4.80 million NZD for 2003/04. Agent: FRST.
- Targeted Equity Investments: provides investments into CRIs (Crown Research Institutes) that have the capability to develop commercial prospects but are unable to find suitable commercial partner or to borrow the necessary funds. Agent: FRST.
- New Zealand Venture Investment Fund: co-invests with private sector investors in early stage ventures that show potential to create high added value goods and services. Agent: NZVIF Ltd.

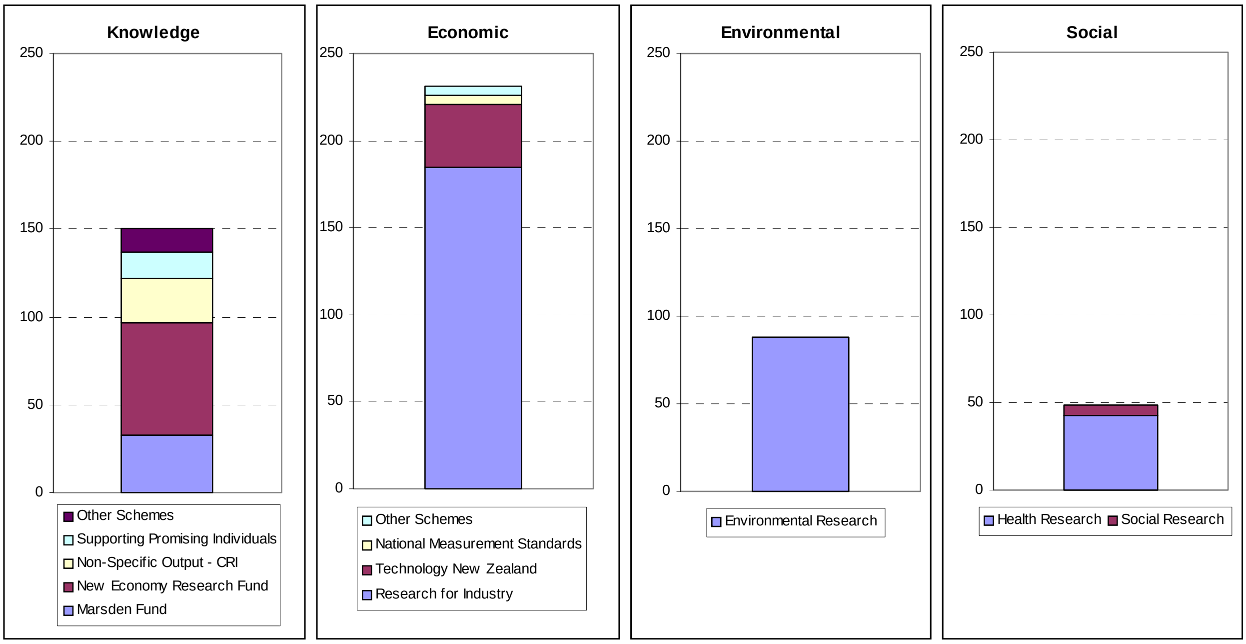
Environmental goal (88.17 million NZD in 2003/2004; 94.1 million NZD in 2005/06)

- Environmental Research: supports public-good research, science and technology that enhance the understanding and management of our environment. Agent: FRST

Social goal (48.82 million NZD in 2003/2004; 54.33 million NZD in 2005/06)

- Health Research: supports public-good research, science and technology that improves the health status of New Zealanders. 42.23 million NZD for 2003/04. Agent: HRC.
- Social Research: supports public-good research, science and technology that improves societal well-being. 6.59 million NZD for 2003/04. Agent: FRST.

Figure 3.12: Funding Schemes within the four goals of the New Zealand RS&T system



Source: MoRST, own calculations

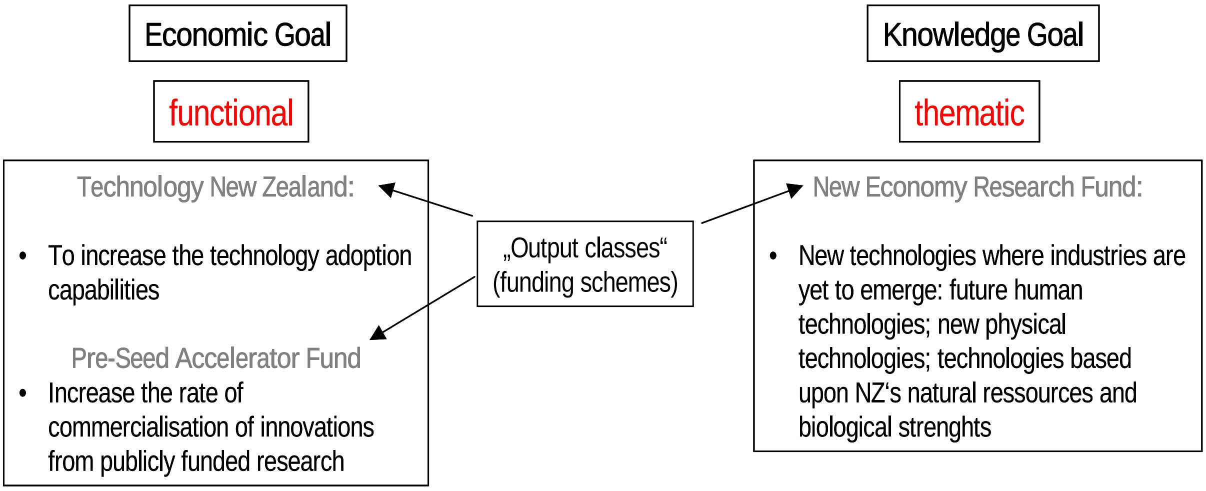
Thematic and functional priority-setting takes place mainly at the level of the individual investment/funding schemes. However, the broader goals for the RS&T system define the principle aim and scope under which the specific funding schemes have to operate. In general, the priority setting process may be characterized as organized around a set of different hierarchical layers. The top-level layer is constituted by the four mentioned strategic goals which are highly general and encompass both, thematic as well as functional elements.

However, two of the four general goals (i.e. "environmental goal" and "social goal") do have a scope which may be characterised as a "mission". Thematic priorities are inherent in both of these missions. Within the environmental goal a broad range of environmental research is covered, particularly in areas which directly affect the status quo and the sustainability of New Zealand's environment, like biodiversity, climatic change, biosecurity and oceanography. Within the social goal, health research (as a cross-disciplinary thematic priority) accounts for the major share of available funds whereas the second thematic priority within this goal, social research, attracts only a smaller fraction of available funding.

The ministry of research, science and technology (MoRST) plays the crucial role in the priority-setting process. Indeed, MoRST defines itself as the "leader" within the RS&T system and wants to promote system-wide thinking and take an *"active stewardship role in the RS&T system"*. The direction setting process is based upon inputs of different sources, from the "high-policy arena" (government, minister, parliament) down to consultation with actors and organizations directly involved in the RS&T system (through stakeholder surveys, directions workshops, and regular stakeholder meetings.

The next layer constitutes the level of funding schemes (so called output classes). This may be characterized as the operative level (see Figure 3.13 for an illustrative example). However, the degree of generalization is still quite high (varying between the different funding schemes) and both aspects of priority setting (functional and thematic) can be found. Within these various funding schemes the actual priority setting takes place and again both elements, functional as well as thematic ones can be found within these schemes. Hence, beside the hierarchical structure, the priority setting may be characterized as matrix-orientated with the two dimensions of functional elements on the one hand, and thematic orientation on the other hand.

Figure 3.13: Layered Priority-Setting: some examples for functional/thematic priorities



Given the rather significant number of individual investment/funding schemes currently in place in New Zealand, it is quite difficult to summarize the patterns in the scale and scope of the priority-setting process for all individual schemes. Thus, in the following, on of these investment/funding schemes, the so called NERF, will be described in more detail with respect to priority setting. The New Economy Research Fund (NERF) is a relatively new investment scheme that was established in 1999/2000 to support basic research aimed at stimulating new knowledge-intensive enterprises and sectors in New Zealand. The principle approach within the NERF can be characterized as rather orientated to the "science push"-model and there is not much direction in top-down strategy by FRST. The outcomes to be expected from NERF are as following:

- Generating new knowledge with value to New Zealand by NZ researchers at or near forefront of their field.
- Creating wealth for New Zealand by developing high value opportunities.
- Helping diversify NZ's economy by developing new and emerging enterprises and industries.

Following *functional elements* characterise NERF funding activities:

- Complex technology/science/knowledge;
- Higher risk for potentially high reward;
- A greater emphasis on science excellence including assessment by peer review.

Beside these functional element, three *thematic priorities* have been chosen (see Annex 1 for a detailed description of these three thematic priorities):

1. Leveraging New Zealand's Natural Resources and Biological Strengths through Technology.
2. Creating Opportunities Through New Physical Technologies.
3. Future Human Technologies.

These thematic priorities recognise that New Zealand has to invest both in areas that are NZ strengths as well as in globally important technologies that allow NZ to 'play in the global game'. Within each thematic priority, three distinct types of research activities should be stimulated:

1. Supporting world leading research teams to get to and/or remain at the forefront of their area;
2. Fostering highly novel research (that may not be undertaken by world leading teams):
3. Building new research capabilities for NZ's future.

Evaluation

New Zealand hast a long evaluation tradition in respect to public interventions. Thus, instruments/measurements of science and technology policy are evaluated routinely using a various set of evaluation methods and approaches in various stages of the implementation of policy instruments (ex-ante, mid-term, ex-post). As one example of evaluation, again the (New Economy Research Fund) (NERF) is chosen. This evaluation was designed, in part, to gather early feedback on the performance of the scheme. The relative newness of NERF meant that the evaluation approach was not directly aimed at measuring outcomes or even impacts. Instead, the evaluation focused on the researchers' perceptions and priorities for achieving success from research of this kind. Their views on how 'success' should best be measured were also sought. Specifically, the evaluation objectives were to:

- Gather evidence of any successful research and commercial outcomes, if any, recognising that many programmes might well be quite new;
- Identify pathways for achieving these outcomes;
- Elicit researchers' views on a future evaluation framework for NERF.

3.5.3 Conclusions

- The science, research and technology system is regarded as a key element for a sustained economic development of New Zealand. Given the still well below average resource allocation to R&D activities in New Zealand, it is a stated aim of RS&T policy to increase the amount of resources allocated to R&D, both publicly funded as well as privately funded.
- The science and technology policy system of New Zealand is organized around four general long-term goal areas (knowledge, economic, environmental, social), which are defined at the top-level of government. Two of those long-term goals (environmental and

social goal) may be characterised as "mission orientated". Both of these goals are supported by explicitly thematic orientated funding schemes (e.g. for environmental research, social and health research) with a given attached amount of monetary funds to each of those schemes. Explicit priorities, both thematic and functional do exist at various levels of aggregation. However, in general, functional aspects seem to attract more attention. Thematic priorities exist in areas, which are supposed to be the prominent generic growth technologies in the near future as well as in areas in which New Zealand does have comparative advantages and strength (e.g. agro-business).

- The nature of the priority setting process was a broad one: a series of evaluations in the 1990ies led to a policy strategy discussion channeled into a broad Foresight project in 1998-99 involving some 140 different sector groups. There exists a well established communication and advising process between the various stake-holders and acteurs of the innovation system.
- The priorities are multi-layered: on the top there are four distinct policy goals guiding different „output classes" leading to specific (thematic or functional) measurements/funding schemes which define the priorities at the operative level.
- The priorities are formal in the sense, that they are defined by specific instruments/funding schemes to which a given amount of monetary resources is allocated.
- New Zealand has a well developed evaluation culture. A broad mix of different methodologies are used at different stages of implementation of policy measures (ex-ante, mid-term, ex-post).

Annex 1: New Economy Research Fund portfolios

1. Leveraging New Zealand's Natural Resources and Biological Strengths through Technology

Purpose: Investments in *Technologies to Leverage New Zealand's Strengths* will lead to the generation of knowledge and capture of IP, with the potential to establish new enterprises or generate market value in novel technologies, and the associated human capital skills that can leverage New Zealand's comparative and competitive advantages in its existing biological resources and capabilities and our unique environment and geological characteristics.

Scope of portfolio: Investigator-led basic research and associated development targeted at novel technologies and the convergence of enabling technologies such as genomics, proteomics, metabolomics, environmental technologies, information technologies, artificial intelligence and advanced material technologies that have the potential to create new enterprises in areas ranging from, but not limited to, animal, microbial, food and plant biotechnologies and technologies relevant to New Zealand's unique environmental, geological and other resources, opportunities and issues.

2. Creating Opportunities Through New Physical Technologies

Purpose: Investments in *New Physical Technologies* will lead to the generation of knowledge and capture of IP, with the potential to establish new enterprises or generate market value in novel physical technologies and the associated human capital skills that can create future comparative or competitive advantage for New Zealand

Scope of portfolio: Investigator-led basic research and associated development targeted at novel science and technologies that have the potential to create new enterprises in areas ranging from, but not limited to, nanotechnologies, medical devices and electronics, biomaterials, superconductivity, artificial intelligence, energy technologies, robotics and the convergence of enabling technologies such as information and communications technologies.

3. Future Human Technologies

Purpose: Investments in *Future Human Technologies* will lead to the generation of knowledge and capture of IP, with the potential to establish new enterprises or generate market value based on technologies that interact directly with individual humans to improve their quality of life, performance and well-being, and the associated human capital skills that can create future value for New Zealand.

Scope of portfolio: Investigator-led basic research and associated development with a focus on the human condition that is targeted at global opportunities derived from but not limited to emerging technologies in human health, cognitive sciences, information and communication technologies and their interface with individuals and that have the potential to create new enterprises in areas ranging from, but not limited to, pharmaceuticals to creative industries and information services.

Annex 2: Crown Research Institutes

Name of CRI		**Revenue (m NZD) 2001**	**Staff 2001**
AgResearch	*AgResearch Limited*	*122,2*	*920*
Crop & Food Research	NZ Institute for Crop & Food Research	31,1	300
ESR	Institute of Environmental Science and Research Ltd	27,3	270
Forest Research	NZ Forest Research Institute	39,9	370
GNS	Institute of Geological and Nuclear Sciences	31,3	260
HortResearch	Horticulture and Food Research Institute	55,0	500
Industrial Research	Industrial Research Limited	56,2	400
Landcare Research	Landcare Research New Zealand Ltd	42,7	370
NIWA	National Institute of Water a. Atmospheric Research	76,3	580
Sum		*482,0*	*3970*

Source: Association of Crown Research Institutes

3.6. United Kingdom

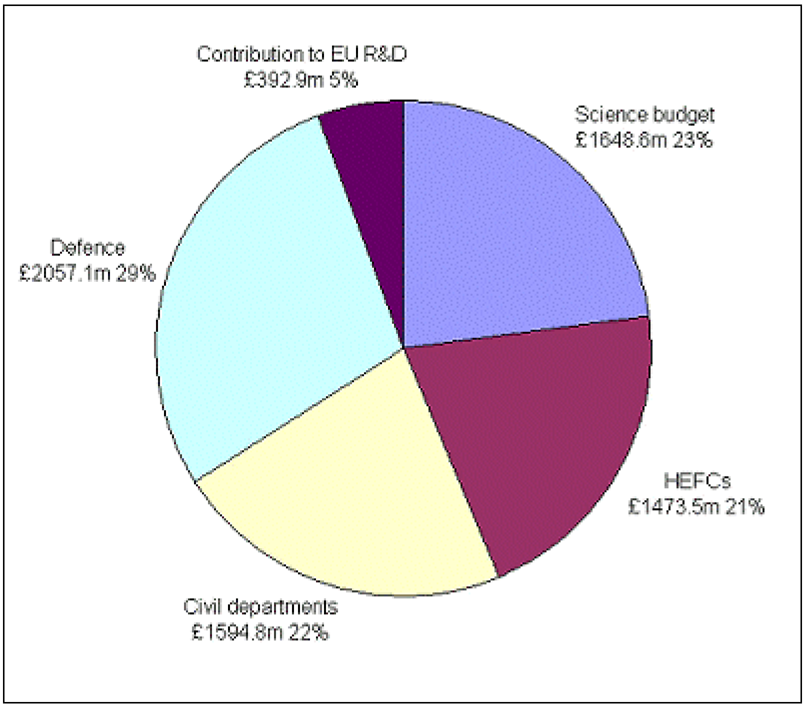
Michael Keenan (PREST) and Klaus Kubeczko (systems research)

3.6.1 The U.K. Innovation System – some stylized facts

The Government's four spending reviews (in 1998, 2000, 2002, and 2004) have all made substantial increases to the science budget, which will have increased at a rate of 10% year-on-year in real terms by 2004/05, and by 2005/06 will have more than doubled its value of 1997/98. The net total of all Government expenditure on science, engineering and technology (SET) in 2001-02 (including the UK contribution of £393 million to the EU R&D budget) was £7,407 million. The Science and Engineering Base (Research Councils and Higher Education Institutions) accounted for 44% of total SET expenditure, with 22% by civil departments, 29% by defence and 5% by the UK's contribution to EU R&D (Figure 3.14).

The European Trend Chart on Innovation provides an overview of functional priorities associated with UK innovation policy. As Table 3.8 shows, there is much policy focus on gearing research to innovation – for example, in the form of supporting start-up technology based companies, supporting SMEs in their ability to apply new knowledge, and supporting cooperation between research and industry. Another focus is on fostering an innovation culture by means of education and the promotion of clustering and cooperation. Framework conditions would appear to be less central according to the Trend Chart report; however tax incentives are used as instruments to support SMEs.

Figure 3.14: Breakdown of UK Government expenditure on SET



Source: SET Statistics, OST, 2002

Table 3.8: Functional Priority areas and sub-areas[20]

	July 2000	Sept 2001	Sept 2002	Sept 2003
I. Fostering an Innovation Culture				
I.1. Education and initial and further training	2	2	3	4
I.2. Mobility of students, research workers and teachers	3	3	3	3
I.3. Raising public awareness and involving those concerned	1	1	2	1
I.4. Innovation and management of enterprises	3	2	2	3
I.5. Public authorities	1	0	1	2
I.6. Promotion of clustering and co-operation for innovation	4	4	4	4
II. Establishing a Framework conducive to Innovation				
II.1. Competition	1	2	1	1
II.2. Protection of intellectual and industrial property	1	3	3	2
II.3. Administrative simplification	1	1	1	1
II.4. Legal and regulatory environment	3	2	1	1
II.5. Financing of innovation	3	2	1	1
II.6. Taxation	2	2	3	2
III. Gearing Research to Innovation				
III.1. Strategic vision of research and development	1	3	2	2
III.2. Strengthening research carried out by companies	2	2	2	1
III.3. Start-up of technology-based companies	4	4	4	4
III.4. Intensified co-operation between research, universities and companies	4	4	4	4
III.5. Strengthening the ability of SMEs to absorb technologies and know-how	4	3	3	4
Total points	40	40	40	40

Source: European Trend Chart on Innovation, Country Report UK 2003 (DG Enterprise 2003)

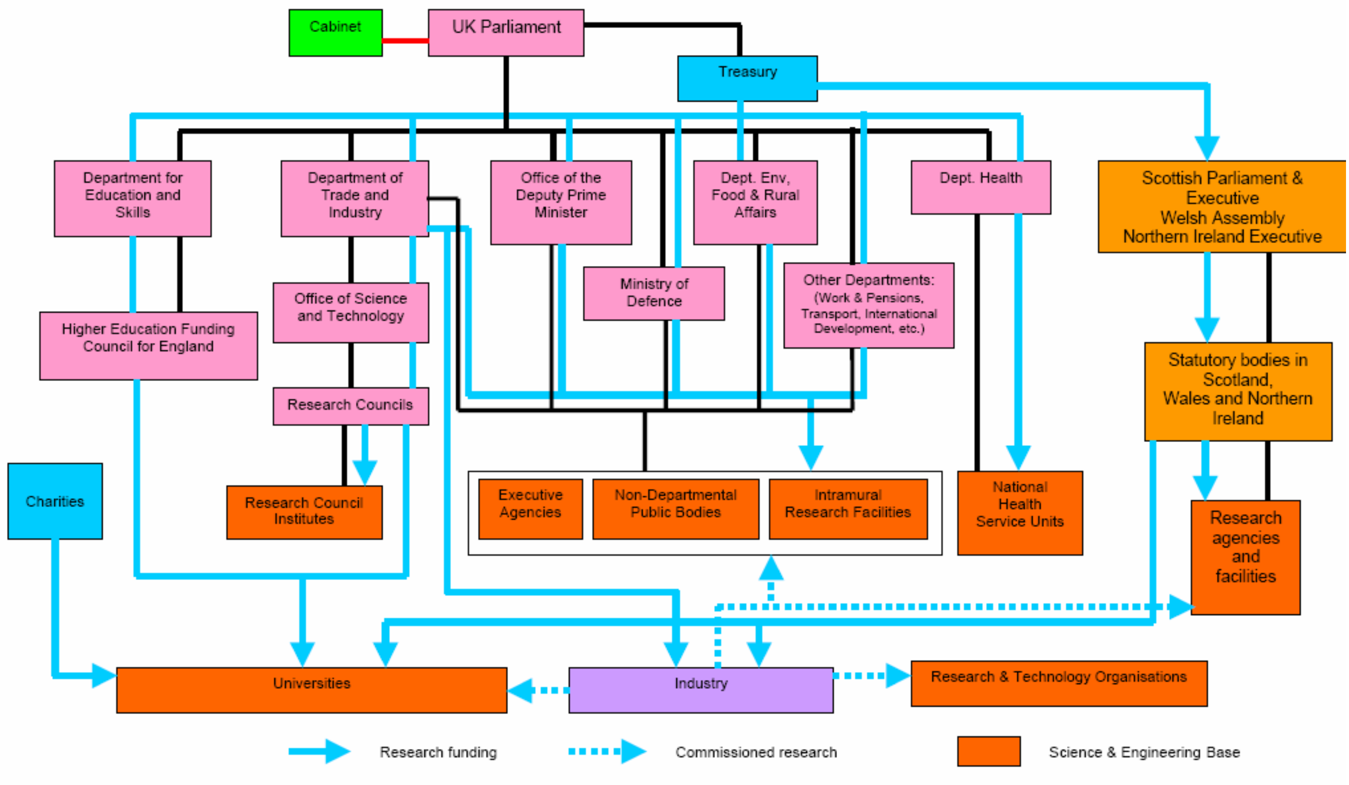
Particularities of the UK Innovation System

The UK Innovation System can be divided into 3 groups of actors:

1. Government and Ministries, who formulate strategies and fund research through various organisations (see Figure 3.15);
2. Various, widely disciplinary defined, Research Councils, which are responsible for more detailed strategies to direct research funds; and
3. Universities, Research & Technology Organisations, Research Council Institutes and last but not least industry, who are research and innovation performers.

[20] Each Action Line is allocated a number of points reflecting its relative importance in terms of national priority objectives. A maximum of forty points is allowed. The table is meant to convey a sense of which Action Lines are viewed as important in terms of national policy formulation, and to reflect the relative amounts of "effort" expended on the promotion of measures dealing with that Action Line.

Figure 3.15: Overview of UK system of governance of science and technology



Source: Guide to the Organisation of British Science and Technology, GOST,(British Council 2003).

Funding for public R&D in the UK is organised through what is known as the dual-support system. On the one leg of the dual-support system is the Department for Education and Skills (DfES), which funds (through the Higher Education Funding Councils) research and teaching infrastructure in universities. Funding is distributed to universities on the basis of the quality of the research they carry out, as indicated by a *retrospective* review of academic publications through the Research Assessment Exercise (RAE). The other leg of the dual-support system consists of the seven Research Councils, which support research activities, generally in universities, through the provision of funds for centres, research programmes or individual grants (on the basis of *prospective* research proposals). The Research Councils are non-departmental public bodies, whose budgets come from the office of the Director-General of the Research Councils in the Office of Science and Technology (OST). The seven Councils are as follows:

- Biotechnology and Biological Sciences Research Council (BBSRC)
- Council for the Central Laboratory of the Research Councils (CCLRC)
- Engineering and Physical Sciences Research Council (EPSRC)
- Economic and Social Research Council (ESRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Particle Physics and Astronomy Research Council (PPARC).

Whilst the OST forms part of the much larger Department of Trade and Industry (DTI), its budget is ring-fenced and it acts rather autonomously, as do the individual Research Councils. Overall coordination of Research Council policy is carried out by Research Councils UK (RCUK), which was set up in 2002. One of RCUK's initial tasks is to develop an investment strategy for the Research Councils aimed at enhancing the quality of research investment prioritisation.

Besides support for basic science, the OST also plays a role in supporting innovation. For example, it takes the lead on a number of innovation programmes, most notably the UK Foresight Programme, and the LINK scheme (which is the UK government's chief funding instrument to support industry-academic research collaboration). Outside of the OST, the DTI also plays a major role in supporting innovation. It has established innovation growth teams (IGTs) that cover several industrial sectors, and also supports innovation and technology development through its new Technology Strategy. The DTI is also involved in providing "third stream" funding for universities, i.e. funding that is in addition to the traditional funding lines of the dual-support system. The best known form of third stream funding is the Higher Education Innovation Fund (HEIF), which funds universities to work with industry and regional actors. Given the regional focus, the Regional Development Agencies (RDAs) and Devolved Administrations (DAs) are now heavily involved in administering the HEIF.

Several other government departments (OGDs) also play major roles in supporting science and technology (and in some instances, innovation). For example, the Ministry of Defence, the Department of Health, and the Department of Environment, Food and Rural Affairs (DEFRA) each spend hundreds of millions of pounds on R&D each year. Research is carried out to support policy aims and technological development. Finally, in recent years, the Treasury has played an increasingly important role in STI policy, to coincide with the large increases in spending in support of STI. Several policy reviews have been conducted, and in 2004, the Treasury took the lead in establishing a ten-year framework for science spending. More will be said about this below.

Strength and Weaknesses of the IS

With 1% of the world's population, Britain carries out 4,5% of global science and produces 8% of the world's scientific papers. But the UK has also recognised that the record of knowledge transfer and exploitation by business has generally been weak. According to various official papers, the UK recognises that it has been less successful in using scientific and technological knowledge to be capitalised in added value by successful innovations. This has seen much emphasis placed upon linking research to innovation.

3.6.2 Existence and kind of priorities in STI

Priorities of all three varieties – thematic, functional and mission-oriented – exist in UK STI policy making. Moreover, they are articulated at many different organisational levels.

Functional priorities

At the 'top' are the functional priorities of STI funding institutions, such as the DTI and the Research Councils (spelt out in the form of White Papers and other strategic documents). The Treasury has recently become active in formulating these priorities in conjunction with the DTI and the DfES, i.e. with both legs of the dual-support system. The latest document to emerge in a long line of strategic reports is the *Science & Innovation Investment Framework (2004 – 2014)*[21], published in July 2004 in support of the Government's Spending Review (2005-08). Its priorities are shown in Box 5 and are typical of those found in policy documents across the STI system. The Investment Framework was preceded by the 2000 Science and Innovation White Paper "*Excellence and Opportunity"* (see Box 6, the 2001 Enterprise, Skills and Innovation White Paper "*Opportunities for all in a world of change*"; and the 2002 science strategy "*Investing in Innovation - a government strategy for science, engineering and technology*".[22] The latter was largely influenced by the Roberts' Review on the supply of scientists and engineers in the UK -- *"SET for Success*", and by the Chief Scientific Adviser's *Cross-Cutting Review of Science and Technology,* and its initiatives were underpinned by the additional funding that science received from the 2002 Spending Review. The 2003 Higher Education White Paper also introduces some important concepts for university research funding in the future. Other key science policy documents of the OST include the biennial *Forward Look* document.

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[21] Science & Innovation Investment Framework (2004 – 2014) by HM Treasury, DTI and Department of Education and Skills, July 2004 (http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm)

[22] Investing in innovation: A strategy for science, engineering and technology, July 2002. (www.hm-treasury.gov.uk/Spending_Review/spend_sr02/spend_sr02_science.cfm)

Box 5: Ambitions for UK Science and innovation

World class research at the UK's strongest centres of excellence:

- Maintain overall ranking as second to the USA on research excellence, and current lead against the rest of the OECD; close gap with leading two nations where current UK performance is third or lower; and maintain UK lead in productivity
- Retain and build sufficient world class centres of research excellence, departments as well as broadly based leading universities, to support growth in its share of internationally mobile R&D investment and highly skilled people

Greater responsiveness of the publicly-funded research base to the needs of the economy and public services:

- Research Councils' programmes to be more strongly influenced by and delivered in partnership with end users of research
- Continue to improve UK performance in knowledge transfer and commercialisation from universities and public labs towards world leading benchmarks

Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:

- Increase business; investment in R&D as a share of GDP from 1¼ per cent towards goal of 1.7 per cent over the decade
- Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the UK

A strong supply of scientists, engineers and technologists by achieving a step change in:

- The quality of science teachers and lecturers in every school, college and university, ensuring national targets for teacher training are met
- The results for students studying science at GCSE level
- The numbers choosing SET subjects in post-16education and in higher education
- The proportion of better qualified students pursuing R&D careers
- The proportion of minority ethic and women participants in higher education

Sustainable and financially robust universities and public laboratories across the UK:

- Ensure sustainability in research funding accompanied by demonstration by universities and public laboratories of robust financial management to achieve sustainable levels of research activity and investment

Confidence and increased awareness across UK society in scientific research and its innovative applications:

- Demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and acknowledgement and responsiveness to public concerns by policy-makers and scientists

Source: Science & Innovation Investment Framework (2004 – 2014), HM Treasury, DTI, DfES (2004)

Box 6: Excellence and Opportunity" Science and Innovation White Paper (2000)

This strategy set a framework for the role of the government in the governance system in three different ways.

- Investment: Science is seen as the mayor field for financial intervention. The government understands itself as key investor in the science base.
- Facilitation: Cooperation between research organisations and the firm level is seen as a mayor function in the innovation process to be dealt with. The government understands itself as facilitator for collaboration between universities and business.
- Regulation: The institutional setting for the Innovation system is also being considered of high importance. The government sees its role in regulating for innovation, including the promotion of public confidence in science

Apart from the focus on the three roles of government, human capital (skills) is the fourth mayor role defined by the government in the February 2001 White Paper on "Enterprise, Skills and Innovation".

Thematic priorities

As an advanced large European country, the UK is active in most areas of science and technology development. Accordingly, thematic areas such as biotechnology, nanotechnology, ICTs, etc. are comprehensively covered across the whole spectrum of Frascati research 'types' (by Research Councils and Government Departments). No explicit prioritisation occurs between these thematic areas, but more emphasis may be placed on chosen themes at certain times. For example, over the last 10-15 years, biological sciences have increasingly accounted for a larger proportion of research spending in the UK. This reflects an international trend, whereby the biological sciences have enjoyed large increases in spending whilst increases in the engineering and physical sciences have been more modest (for example, this can be seen in the EC's Framework Programme). Cuts are rare – rather, new spending increases are assigned to those areas that show the most visible promise. How such promise is constructed and received is well beyond the scope of this short paper; suffice to say that no formal processes are used to determine which thematic priorities should be supported more than others. Instead, such decisions are based upon the claims of scientists, media reports and public opinion, international precedent, politics, etc.

Mission-oriented priorities

Research priorities in government departments almost always tend to be mission-oriented in that they are set to meet some particular policy goal, e.g. tackling crime, reducing deaths from cancer, eliminating industrial hazards, etc. Indeed, this was enshrined in the 1971 Rothschild Report reforms, which saw the introduction of an explicit customer-contractor relationship for research funded by policy departments. Big R&D spenders include the **Ministry of Defense, the DEFRA, and the Department of Health**. Each of these has its own (functional, thematic, and mission-oriented) priorities and funding arrangements, with little or no coordination between Departments. This is because the research commissioned by such departments is intended largely to meet their specific delivery targets.

By contrast, the research traditionally funded by the Research Councils has been more basic, with scientists largely left to decide on the topics of their research. However, this is not to say that priorities are absent. On the contrary, of the £ 2.4 bn (a little under € 4 bn) spent on research each year by the Research Councils, about half goes through 'programmes' (the other half is non-directed responsive mode funding, whereby scientists apply for funding outside of the programmes). Programmes are targeted activities with their own objectives and strategies. These are formulated by Programme Managers after consultation with colleagues in academia, industry, government, learned societies, professional organisations and Strategic Advisory Teams. Increasingly, there is a growing tendency to focus resources in large, partly mission oriented, collaborative, interdisciplinary programmes such as genomics, stem cells, e-science, sustainable energy, and rural economy and land use. For example, in each of the aforementioned areas, the Research Councils have come together to formulate multimillion-pound research programmes under the auspices of Research Councils UK (RCUK). The Research Councils have come to realise the importance of relating the research they fund to socio-economic problems and thereby securing large increases in resources from the Treasury.

Technology and innovation priorities are driven largely by **DTI** through schemes such as Faraday Partnerships, the SMART initiative (the Small Firms Merit Award for Research and Technology), and new R&D tax incentives. The most important programme has been the LINK scheme with around £42 million of public financing per year. This programme is designed to support pre-competitive development in cooperation of research organisations and industry in thematic fields that were defined by a foresight process. In addition, the DTI also supports sector-specific programmes in sustainable technologies, energy (both nuclear and non-nuclear), space, civil aeronautics, IT and biotechnology. However, the DTI has recently announced a revision of its support programmes for technology development, which number around 100. The aim is to reduce the number to around 10, thereby allowing a greater strategic overview to be applied to the R&D budget. In 2004-05, some £50 million will be assigned to these programmes, but this is set to rise to £175 million by 2008. Finally, new measures to work with regional development agencies (RDAs) in the promotion of knowledge-intensive business clusters are also being investigated.

Frequency of adoption, re-formulation of priorities

Functional priorities have stayed largely the same in nature over the last decade (since the publication of the watershed 1993 White Paper, *Realising Our Potential*). The main change has been their wider adoption, so that, for example, Research Councils now have responsibilities for helping SMEs to innovate, and regional development agencies (RDAs) are developing functional priorities to support science in their regions. Ironically, although the nature of functional priorities has remained largely similar over the last 10-15 years, they have been re-stated on a regular basis over the last five years in a series of White Papers and strategy documents. This can be seen as an indicator for the growing importance of STI policy to socio-economic development.

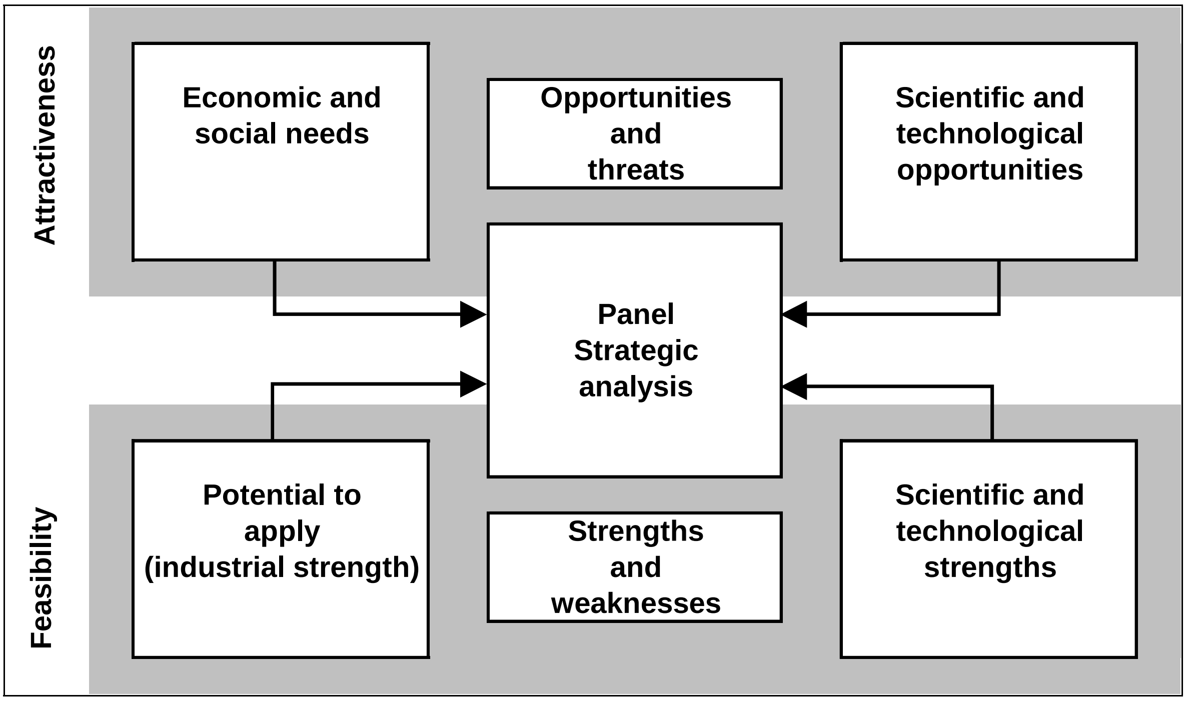
Thematic and mission-oriented priorities change more frequently, yet still rather slowly. For example, many organisations, such as the Research Councils and some of the ministries, have annual planning cycles whereby priorities are reviewed. Commonly, new areas of importance will be identified, but the vast majority of spending will stay along similar lines as in previous years.

Nature of the priority-setting process

At the highest level, things are rather political and subject to currents in the media and wider politics, as well as the activities of lobbyists. Consultation, through documents and workshops, has become increasingly significant in recent years. Rarely, if at all, are sophisticated prioritisation and/or decision-aid tools used. Increasingly, **foresight methods** are being applied, not so much to set priorities as in the past, but more to look over the horizon so as to anticipate any emerging trends. A national exercise was started in 1993 and is now in its third round. Perhaps more significantly, several ministries and agencies, as well as the RDAs and DAs, are conducting their own science and technology foresight exercises.

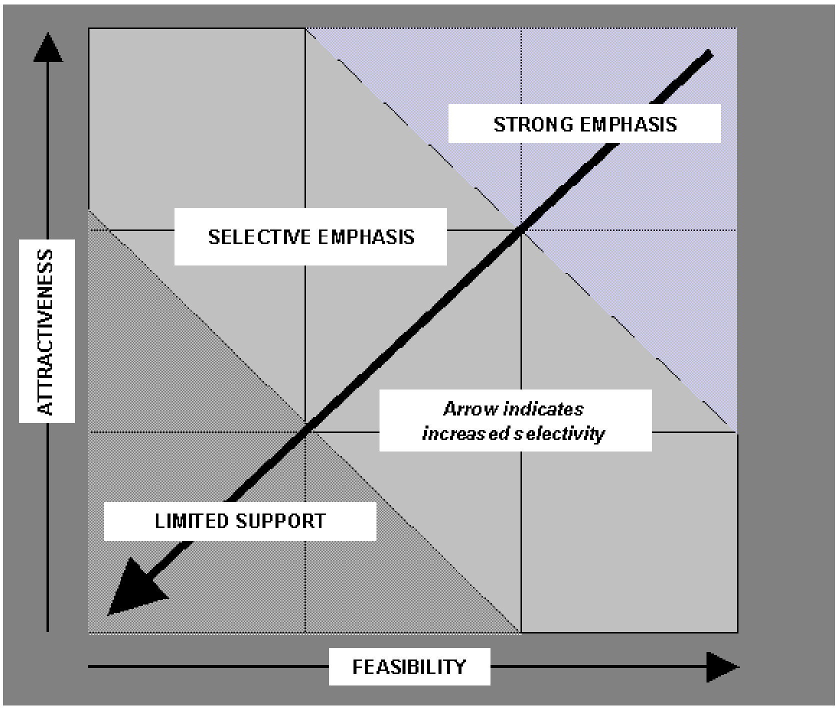
In the first national exercise (1993-99), attempts were made to set priorities at sectoral level, as well as across the whole science base. The criteria used are shown in Figure 3.16. Areas of science and technology were identified through consultation and brainstorming processes, with panel members then voting on each against the criteria. The results were then plotted onto an "attractiveness-feasibility" matrix, and the most favourable areas identified as national priorities (Figure 3.17).

Figure 3.16: Prioritisation criteria used in the first UK Technology Foresight Programme



Source (Keenan, 2003)

Figure 3.17: Attractiveness-feasibility matrix used in the first UK Foresight Programme



Source: Keenan, 2003

The current programme, launched in April 2002, has evolved into a continuous rolling programme that looks at three or four areas at any one time. The starting point for a project area is either a key issue where science holds the promise of solutions, or an area of cutting edge science where the potential applications and technologies have yet to be considered and articulated. Importantly, the foresight project must have an internal government "customer" before it can be initiated.

Most priority setting in the UK is done through combinations of committees and consultation with stakeholders. For example, in the Research Councils, priorities are set and reviewed on an annual basis through these means. Tools, such as bibliometrics, are rarely, if ever, used. As already mentioned, the Research Councils spend half of their budget through 'programmes' (the other half is non-directed responsive mode funding, whereby scientists apply for funding outside of the programmes). The programmes 'emerge' through the planning arrangements in the Councils, which often involve consultation with users and performers of research, as well as desk research. When it is decided that a particular area will be targeted with a research programme, then it is normal for some sort of expert/user panel to be established in order to set directions (priorities) for the programme and to monitor its conduct. Consultation with the wider community is also common at this stage.

The DTI has recently established a Technology Strategy that will prioritise areas for support. A Technology Strategy Board will begin to meet in 2004 and has been given a set of criteria against which to set spending priorities:

- The degree to which technologies will have an impact on sectors that are a major UK strength (e.g. pharmaceuticals and aerospace) or have high growth potential;
- The degree to which a particular technology will have an impact on a number of sectors;
- Strength of the UK SET base relative to other countries;

- Potential economic, social, quality of life and environmental benefits and scope for cross-government collaboration (e.g. healthcare, energy);
- Potential for spill over benefits and whether there is an underpinning market failure; and
- The degree to which there is scope for effective action by Government or others.

At the time of writing, the nature of the priority-setting process has yet to be decided.

Aggregation Level - the scale and scope of priorities

As can be seen from the discussion above, White Papers only give relatively roughly defined priorities which are mainly of a functional nature and are a starting point for institutionalisation of further priority setting processes. The **Research Councils** have R&D programmes that seek to implement the guiding vision articulated at a higher level. These programmes in turn contain sets of priorities that will be implemented through a range of research projects and other support actions at the level of executing agencies. But it should be noted that the Research Councils are autonomous bodies, their autonomy guaranteed by Royal Charter. So to some extent the Research Councils' priority setting is independent from higher-level priority setting and is defined by the members of the Council which come, apart from the scientific community, from various field of society (notably industry). At the same time, the Research Councils take care to ensure that priorities are not too finely specified – for example, it is down to the research community to define the approaches to be taken in addressing particular socio-economic, scientific, or technological problems. By contrast, government departments' priorities may be more specific, and it is not untypical for a hierarchy of priorities to exist.

Returning to the UK foresight exercise, as already mentioned, only the first exercise in the mid-1990s enacted a formal prioritisation process. The resulting priorities, numbering several hundred, were drafted at various levels of aggregation, often in the same report. This aggregation variety was to bedevil attempts by the Government to arrive at overall national priorities – the priorities identified by panels were often non-comparable in scale (granularity). Consequently, the Government chose instead to identify some very broad generic areas as priorities from the programme. However, these were so broad as to be useless as guideposts for funding. Instead, the original priorities identified by the sector panels, which were more specific and actionable, were considered more suitable for making funding decisions (see Keenan, 2003).

Formalisation of prioritisation and subsequent implementation

Prioritisation is formalised insofar as it forms a part of periodic planning cycles in many departments and agencies. However, different approaches may be used from one planning cycle to the next and it is rare for the same procedures to remain in place for longer than 5-7 years, due to things like institutional innovation. But it would seem that prioritisation is inevitable and some sorts of arrangements, however ad hoc, are nearly always in place.

Implementation of all sorts of priorities and at all organisational levels tends to be informal, although there is an increasing tendency for strategy documents to state anticipated progress by years 1, 3, 5, and 10. Moreover, it is now not uncommon for implementation strategies to be appended to government White Papers and strategy documents, and for at least one review of that strategy to be carried out 1-2 years later.

Priorities are normally backed up with money. Civil servants may be given the job of pushing priorities, although it is now common for actors in the wider system to also adopt this role. In other words, implementation efforts tend to be distributed within and beyond government, taking account of the ‘reality’ of the absence of a decree and command culture.

Evaluation Procedures

Priority evaluation might take place in the context of an evaluation of an organisation, such as a Research Council (these are subject to five-yearly reviews). It may also take place as part of a wider review, for example, the Roberts Review and Lambert Review, which were funded by the Treasury and focused upon functional priorities (human resources for S&T and industry-academic relations, respectively). The House of Commons and House of Lords both have S&T committees, and these often examine Government’s strategy and effectiveness in key areas. Other than these ‘political’ evaluations, Government Departments and Research Councils might hire consultants (or some, like the DTI, have their own evaluation unit) to evaluate research programmes and strategies (i.e. more technocratic evaluation), which will include reference to priorities. However, of increasing significance is the use of “indicators” in strategy documents against which the achievement of priorities is assessed. Typically, assessments are made after two years and theoretically stretch out 5-10 years. In reality though, these later evaluations are rarely carried out, since the policy document or strategy has typically been superseded by a “new” strategy with “new” priorities, although their novelty is often rather questionable.

4 Synthesis and Conclusions

Although the selected six countries covered in this study represent a very diverse sample, they share a number of general patterns and common challenges (see also Rammer et al., 2004). The concepts and principles guiding policies for dealing with technological change and innovation and their role for economic growth have become more similar in resent years. In particular the "innovation systems" approach and the recognition of the complex nature of the innovation process (as opposed to the so called linear model of innovation) constitutes a common theoretical ground for most countries covered in this study. This observation goes beyond the six countries covered in this report. In fact, international and supra-national organisations (OECD, EU) have been the major forces behind a diffusion of concepts and approaches in S&T throughout these member countries of technology policy.

This high degree of similarity is also to be found with regard to the general aims of technology policy as well as with regard to the concentration on key generic or functional aspects of the innovations system. In most OECD and EU countries the role of technology transfer mechanisms, academia-business links, innovation-oriented regulation, the changing role of public research institutions, international collaboration, efficient incentives for innovation etc. have been high on the political agendas.

However, besides this general trend towards similar goals and similar underlying concepts, a great diversity concerning specific policy instruments and measures can be observed. The combination of common challenges, converging theoretical concepts and a great variety of particular policy measures offers the potential for policy learning and adaptation of new measures. Indeed, each country is currently scanning the available pool of internationally successful policy measures and trying to adopt some of them to its specific circumstances.

Priority setting in STI policy in historical context

Before discussing the current patterns of priorities and the processes to define them, a brief historical discussion of the changing nature of the meaning and the role of priorities within technology policy may help put the current use of priority setting approaches in historic context.

In the post-war period, priority setting was perceived very differently in science and technology development: in the then prevailing 'science-push' paradigm based on the linear model of innovation, which was most clearly expressed in the influential report by Vannevar Bush, "Science, the endless frontier" (1945), there was no need for priority setting in the realm of scientific research. Unguided, curiosity driven, mostly basic research would lead to results which then would (occasionally) been taken up by society and industry. The only (though for some countries big) exception was the research carried out to pursue some kind of 'public mission', defence, space and nuclear research being the most prominent examples. It was in this realm that priority setting happened – very much in a top-down manner and early on with significant success regarding goal attainment (see Hughes', 2002 description of the 'Manhattan project' as the role model for subsequent targeted research efforts).

This model of priority setting then was transferred in the 1960ies and 1970ies to include commercial and market-oriented R&D in single large-scale projects – mostly with very concrete and dedicated targets for the development of specific technologies (transport and energy technologies like the 'Concord' and the S&T super-sonic plane and the fast-breeder reactor being paradigmatic examples, see Cohen and Noll 1991).

In the late 1970s and early 1980s, some countries even went a step further and ambitiously tried to identify very detailed lists of priorities for the whole of public S&T policies. Often the processes to derive lists of 'critical' or 'strategic technologies' were very much modelled after priority setting in industrial and defence policies: as top down either to protect specific (even new and emerging) sectors against competition (like computer and electronics) and/or to help industries which were seen as being of 'strategic importance' (see e.g. the US support programmes for R&D in ailing industries or industries under competitive strain in the 1970ies and 1980ies, Branscomb 1994).

In general, the results of this approach to priority setting were not as successful or as effective as hoped. It turned out that governments were not well-suited to second-guess potential developments in markets and many projects failed. While the top-down approach worked reasonably well in areas which remained within the public domain, these efforts proved to be too much prone to influences from vested interests ('pork barrel policies') or could not cope with the much greater complexity of market developments when addressing commercial targets . This does not necessarily imply that government policies had (or can have) no influence on the speed and direction of technological change or the development of new markets. But this influence is less straightforward than intended. While the majority of very dedicated technological development projects failed to meet their targets (some even in technical terms, let alone in commercial ones), various government actions ranging from targeted basic research, applied research in government research institutions, regulation, procurement etc. did have a very important influence on the development of certain technologies, e.g. the internet. In the development of internet and telecommunication technologies, this influence materialized not primarily as a result of coherent priority setting and of strategic policy orientation, but rather as the sum of a series of – sometimes only loosely interconnected - public and private actions, the result of which was neither planned from the outset nor fully anticipated. While the process was much more self-organised and in a certain sense 'chaotic', targeted (and conscious) government action nevertheless was shown to be crucial at important stages in the development of internet technologies.

The lessons drawn from past developments by and by accumulated to a kind of new approach to priority setting in S&T policy, which will be described below.

Main elements of current approaches to priority setting

As the history of S&T policy has shown, **priority setting is inherently context dependent, changes over time in rationale and goals and this is necessarily different between National Innovation Systems**. While a full convergence is not to be expected even in the presence of such factors as increasing internationalisation of knowledge production and diffusion, increasing cooperation in research and increasing diffusion of policy practices and approaches, some general and common trends can be observed. These trends – summarized in this chapter – are to be seen in the countries we have selected for closer analysis, but can also be found in other countries (see for a coverage of France, Finland, Germany, Japan, United Kingdom and the United States of America Rammer et al. 2004 and OECD 2004 for a coverage of most recent developments in its member countries).

While the notion of ‚priorities in S&T’ in the past has often been used synonymously with identifying and targeting specific science and technology areas/fields, the concept has been re-defined recently in a pragmatic way to include *„any activity that receives special attention and thus special treatment as regards funds and/or other incentives“ (OECD, 1994, 22)* As a result, in the 1990s, *„alongside the institutional diversification of the priority setting process [...] **the very concept of priorities has become broader**“* (OECD, 1994, 21, our italics): ***‚functional’ priorities were added to the ‚thematic (technology-specific or mission-oriented)’ priorities*** (for a detailed discussion of the concepts of ‘functional’ and ‘thematic’ priorities see Dachs et al. 2003).

Also, in most OECD countries the **process of priority setting has become** – in contrast to the immediate post-war period, when this was the remit of policy and a few institutions like science/research councils – **much more decentralised** as the number of actors in S&T policy and the complexity of the innovation process has grown considerably. In recognition of that fact, explicit or implicit priority setting increasingly takes place through the actions of the research actors and other intermediaries – e.g. by the setting up of new institutes at universities, establishing new branches of public research institutions, and funding agencies selecting specific target groups for support. At the same time, strategic planning has been becoming more and more widespread since the 1990ies and often goes hand in hand with periodical setting and re-definition of priorities.

The degree of (de)centralisation with respect to priority-setting varies from country to country. A good mix / division of tasks between the actors at different levels must be sought, which takes into account historically grown competencies as well as the respective political cultures. However, in general terms, the empirical evidence indicates that policy level is best left with

(a) establishing the overall degree of priority given to science and technology in the context of public policies, also reflected in the budget allocations to S&T,
(b) the determination of ‚system-wide’ framework conditions for S&T (regulations, promoting business start-up, fiscal incentives for S&T, etc.), as well as with
(c) the identification of <u>general</u> priority areas (both functional and thematic), in which there is need and scope for policy action.

In practice, these key policy tasks require addressing a market/systems failure hampering the development of the innovation system or setting societal needs as S&T policy missions (e.g. environmental and health research) while leaving it to the level of intermediaries (funding agencies, technology transfer institutions an the like) and the research performers (universities, research centres, enterprises) to translate these general policy orientation into concrete actions/priority setting.

Past and present priorities are very often reflected in the institutional framework (e.g. space and nuclear energy agencies, or environmental technology agencies). As soon as established, institutions become entitled to a certain amount of resources and institutions with certain missions don’t change overnight. Thus, **there is a path-dependency in policy formulation which limits the degrees of freedom for choices between priorities** at a given point in time. This problem is most severe, when institutions are very much sector/technology specific (e.g. dedicated research centres, specific research councils etc.). The mere existence of such specialised institutions ensures a certain budgetary allocation to a specific topic. Recently, governments have tried to increase the degree of flexibility (and the degrees of freedom for priority setting by putting greater emphasis on programme funding instead of institutional (‚block grant') funding. This is a tendency to be seen in almost all countries, although to a varying degree.

A great number of concepts have been employed in the past decades to define science areas and technologies that should somehow be at the forefront of political attention: inter alia, the notions of ‚strategic', ‚critical', ‚key', ‚emerging', ‚path breaking', ‚infrastructure', ‚general purpose' and ‚generic' have been used. However, **most of these "lists" of technologies** – especially when drafted at the national level **- remain at a level of abstraction that makes them only a poor guidance for policy** (see e.g. Branscomb, 1994, 42 and 48 for such lists. Practically all countries which have chosen to identify thematic S&T priority areas, have addressed ICT, new Biotechnologies, Nanotechnologies and new materials, environmental technologies, health technologies as priority areas. Only a few technology areas are specific in the respective country portfolios, e.g. wood in Finland (see for a list covering UK, US, JAP, FRA, FIN - Rammer et al., 2004, 31 and 59). As these technologies cover most of R&D spending by enterprises, **these lists are almost non-discriminatory**, which puts into question the very notion of ‚priorities'.

The renewed interest in priority setting

While in the 1990s, after some disillusion about priority setting following the experiences of the 1970s and 1980s, the main thrust of S&T policy was more towards "functional" priority setting and general improvement of the "systemic" performance of innovation systems, **in recent years thematic priorities have received renewed interest**. This interest is driven by increasing pressures on public budgets and by the Europeanisation and internationalisation of research, which both require concentrating research efforts on a limited set of thematic areas. On the other hand, the adoption of the systems of innovation approach as theoretic fundament for technology policy has led to a sustained recognition of the very importance of ‚structural' priorities. Hence, these **different approaches to priority setting (thematic versus structural/functional) co-exist today**. Thematic priority setting which has never been completely abandoned, seems to make a come-back in most countries. Today, also scientific research (including basic research) is increasingly organised in programmes or targeted areas (e.g. in thematically defined ‚centres of excellence'). Increasingly, also structural priorities are ‚inscribed' into thematic ones, e.g. by targeting collaboration or SME support in a specific technology area. Also, in a number of countries (e.g. the UK, Finland, and even in Korea with its strong ‚technology-orientation' of programmes) **priority setting with respect to societal goals has seen a revival** (in comparison with the 1980s and 1990s, where the emphasis was very much on economic goals). This is reflected in a number of programmes addressing topics like environmental and health research. These types of priorities are often to be found at a high level of aggregation (with respect to thematic specification) and therefore often labelled as "new missions" - in contrast to the "old mission-orientated" programmes targeted towards thematic topics like aero-space, nuclear energy and the like (see Dachs et al. 2003).

The ways in which priority setting is carried out differs vastly from country to country, depending on the structure of the economy (e.g. with strong energy, nuclear sector, space), with political role of the country (defence/military/security R&D[23]) with the conceptual framework in which S&T policy operates (science push, demand pull, mission orientation, diffusion orientation etc) and

[23] Interestingly, this renewed trend towards thematic priority funding is funnelled significantly due to the increased interest (and funding) in the life sciences, with bio-technology highlighted as a strategic or a key technology of the near future.

with the institutional setting of the STI policy system (centralised/decentralised, central/regional, strong/weak role of intermediaries). Very often, the concrete topics (especially of programmes) are set at the operational level of the "policy delivery system". At this level, a number of mechanisms have been established to identify concrete topics – either by consultation with respective communities or based on technology foresight exercises of one kind or the other. Following common trends are to observe:

- As already mentioned, functional priorities (even within thematic orientated schemes) have become very important.
- Increasingly systematic approaches to strategy formulation are used, which often goes along with priority setting.
- The role of programmes is increasing (both for science and technology policy), but in general there is a mixture of bottom-up and top-down funding of R&D even in the countries most geared towards programmes.
- There is an increasing number of actors with competence/capacity for priority formulation (even at the intermediary/operational level), in search for an appropriate division of tasks. Usually, at the policy level one can observe strategic orientation like budget allocation and broad orientation whereas at the operational level concrete priority setting takes place.

All mechanisms for priority setting described above, co-exist, indicating not only the path-dependency of policy formulation and the historical ‚stickiness' of institutions, but also the different – and increasingly differentiated – rationales behind the various forms of intervention/action. What is changing over time is the composition/mix of mechanisms. But again, the trend is far from being unidirectional, as can be seen from the re-surge of specific thematic priority setting in recent years.

But this move (back) towards thematically oriented programmes has been accompanied by a marked change in the character of the technology programmes: the new forms of thematic priority setting (as well as the new forms of mission oriented programmes – see Soete, Arundel 1995) are – in most cases – not simply taking up where the old-style thematic programmes with their very narrow industry/discipline focus started from, but incorporate functional dimensions of the innovation system as well (e.g. by fostering collaboration, notably between industry and science). These dimensions include (see Rammer et al, 2004, 65-67):

- Support for Industry science-cooperation,
- Integration of different technologies and research areas,
- (Regional) Cluster programmes,
- Special emphasis on and support for SMEs, NTBFs and start-ups,
- Formulation of R&D programmes with an eye on innovation and diffusion.

Especially cluster-oriented programmes, which have specific thematic orientations, address at times a great variety of structural dimensions (infrastructure, awareness, SMEs, networking, education) as well. As such, they are ‚innovation system oriented policy in a nutshell' (den Hertog 2002). Also, e.g. the Dutch special programme on genomics research is an example in case of a thematic priority spanning across narrowly confined R&D support to include the whole innovation chain and thus, integration of thematic priority setting with the more functional innovation systems approach. Also, the coupling of educational / training / mobility aspects with thematic orientations can be found in e.g. in the thematic priorities of the Dutch NWO.

Against the background of the increased number of actors, the distinction between **priority-setting in the various fields** itself creates a **coordination problem**. E.g. the multiple strategy formulation processes at the various levels in the Netherlands and in Ireland are examples in case. In the Netherlands, the priority setting for science and technology respectively has engaged different foresight processes, leading to different lists of areas and fields. More recently, the processes have changed in the science realm: now priority setting is increasingly delegated to the individual actors, i.e. the universities, which have to come up with specific strategy statements and the research councils respectively, which are formulating their four years strategy orientations.

The Netherlands are an example both for a recent change in policy orientation (S&T policy much more structural/functional than in the previous period, which was much more oriented along the thematic priorities paradigm). The adoption of the NIS approach apparently did play a role in that shift of emphasis.

The Dutch case is also an example of the co-existence of the two approaches to priority setting: many thematically dedicated/specialised institutions serve as a ‚built-in' stabilizer of thematic priority setting. And once institutionalised as such, they constitute strong ‚lock-in' effects. **It might rather be preferable to have broad institutions, which can internally re-arrange topical areas much more flexibly** – but even then it is sometimes difficult, as the attempts of re-orientation of several public research organisations away from out-dated missions in the past decades have shown.

Expectations that priority-setting could be supported by forecasting and planning techniques, which have been very prominent in the 1960s and 1970s, have largely vanished. Though still present in some corners, they **have given way in many countries to much more modest efforts in ‚technology foresight' or technological "road-mapping"**, which is more about a dialogue-based formation of common visions and the anticipation of different future scenarios rather than about actually forecasting scientific and technological development. (‚the demise of the planning hybris'). A number of countries have nowadays **coupled** their **strategy processes with systematic, organised forms of ‚strategic policy intelligence'**. These forms include technology foresight exercises, technology roadmaps, technology monitoring and evaluation of programmes, institutions and sometimes policies. The use of such tools is not confined to the level of policy making at the national level. Rather, these practices have spread and are often linked to strategy formulation processes on the level of individual organisations (research councils, funding agencies, research institutes). The links between these forms of strategic policy intelligence and actual policy making vary considerably between countries and types of actors. E.g. in general, the coupling between the results of such exercises and policy making on the national level seems to be more loose than at the level of individual institutions (research councils, funding agencies, dedicated/specialised research institutions).

Triggered by the introduction of New Public Management approaches in the 1990s, there seems to be **a tendency** in many countries **to make strategy formulation compulsory for all public institutions**. Thus, the numbers of individual strategy documents is proliferating in these countries (examples being UK, Ireland, Korea and New Zealand). In the UK, even separate White Papers co-exist (for Science and Innovation, Enterprise, Skills and Innovation, and Higher Education, see case study on UK). Normally, these strategy documents also involve some kind of priority setting.

The **problem**, however, **remains to ensure coherence between the various strategic levels and actors**. Sometimes even the time-scales of the different strategy processes do not fit together, often, the respective actor formulates its strategy without strong reference or clear linkage to the overarching policy strategy documents. Some countries therefore have established institutions that aim at achieving greater coherence in the strategy and priority setting process – these can come in various forms:

- As specific councils or advisory bodies for STI policy (like the SIAC in NZL, the OST in the UK, the NSTC in Korea, the CSTP in Japan),
- As inter-ministerial coordination groups (e.g. NL),
- As chief scientific adviser / officer (as established in the UK and planned in Ireland),
- As umbrella/coordinating body like the CRUK in the UK,
- Or as combinations of the above listed.

Councils are either set up as expert councils (like the Austrian Council or the SIAC in NZL) or political councils (like the Korean one) or a mixture of both (like the Dutch Innovation Platform). The most far-reaching effort is probably to be seen in the Netherlands, where the ‚Innovation platform' not only seeks to coordinate S&T, but also innovation policy matters. On the other end of the spectrum are the more ‚modest' approaches restricted to the coordination of a specific corner of S&T policy. An example in case would be ‚Research Councils UK' (RCUK), an umbrella institution aiming at the coordination of the seven individual research councils strategies and priority settings.

Remaining differences between approaches to priority setting

Besides these general trends, which show some tendency towards similarities between the countries, the degree of variety concerning different approaches towards priority setting has still to be acknowledged.

On the **one extreme** is probably Korea (which can be seen as epitomizing an ‚Asian approach' to STI policy setting, as a lot of the elements characteristic for Korean STI policy can also be found in Japan). Here, the emphasis is very much on a somewhat **centralized top-down process**, very often accompanied by extensive and quite regular foresight/forecasting/planning exercises and put down into a ‚basic law on R&D'. **In this model, the emphasis is still very much on thematic priority setting**, which at various levels includes the more general topics which can be found practically in all countries, but goes down to very detailed and much more narrow priority setting at the lower levels (see e.g. the 60 technologies selected in the Korean HAN programme, or the 80 technology areas coming out from the most recent Korean foresight exercise). Though the whole process strives for top-down definition of priorities, coherent policy formulation is not necessarily secured. The reasons being first that the individual ministries have rather large R&D portfolios, for which they claim responsibility and second the existence of sector-oriented government research institutes (GRIs), which constitute a kind of institutional inertia not to be discounted in the priority setting process.

On the other extreme, there are countries which **deliberately refrain from setting thematic priorities at the policy level**, but focusing very much on functional/structural priorities (UK being the prime example for this policy stance, NL recently moving in this direction). Also Ireland and New Zealand with its mix of mainly functional priorities with a few very broadly defined thematic priorities might lean towards this category). However, in particular the British case shows that functional/structural rhetoric can still be accompanied by targeted thematic initiatives. These systems are nevertheless characterised by **intense strategy formulation processes** involving also priority setting and are often accompanied by foresight exercises, though these seem to be only loosely linked to the policy formulation process. Here, the **process is much more decentralised**, with all relevant agencies formulating such strategies. Apart from the more structural stance of policy, thematic orientation is institutionalised in the form of a larger number of research councils for the specific scientific disciplines or in the existence of research institutes dedicated to specific technology areas (e.g. the Crown Research Institutes in NZL) or to be found on lower layers of technology policy (i.e. on the level of thematic orientated specific funding schemes co-existing with a broad range of non-specific funding schemes). **The problem in this institutional setting is the coordination between the various strategies** formulated at the level of policy implementation or performance of research.

Alongside the increased emphasis on strategy formulation in many countries, it seems that **priority setting has become more frequent and more institutionalised** – though the degree of institutionalisation differs considerably between the form of a ‚basic law' (Korea, Japan), a number of consecutive white papers (UK) or the more informal procedures of priority setting that exist on the operational levels (e.g. the national technology programmes in TEKES, or the research councils in the UK). Timing varies according to task and level: White Papers are normally formulated in the time interval of some 4-7 years (some have been one-off efforts), but not necessarily in a strict frequency. Annual budgeting procedures are a very important timeframe for priority setting in all countries. In these procedures, the general priorities set in the overarching policy documents are broken down into budgetary allocations. On the level of the operational institutions (the ‚policy delivery system' of funding agencies, research councils, government research institution and the like), these are formulated in concrete programmes. It is very often here that the prioritisation process proper takes place. (This step often precedes the annual budgetary decisions which are often based on that prioritisation than the other way round).

With respect to the thematic priorities a general pattern of some common "future" technologies (i.e. biotechnology, ICT, nanotechnology and all their derivatives) can be found. These common future technologies are at least in some countries accompanied by additional priorities which are based upon perceived country-specific strength or special endowments (i.e. wood cluster in Finland, agri-business complex in NZ). However, in most countries (with the notable exception of Korea), the level of aggregation of these thematic priorities is relatively high and hence their degree of discrimination should be not overstressed. In addition, it is important to mention, those thematic priorities are often appendices to broad non-discriminatory funds (both with respect to basic science as well as to more applied research). The latter still outweigh the former in terms of allocated resources considerably in most countries. Hence, when comparing the countries examined for this study the common denominator may be best characterised as being the concurrence of functional, systems-orientated approaches (inherently non-discriminatory with respect to thematic orientation) and specific, thematic targeted (and sometimes even narrow) themes. The all-embracing common ground is to foster innovation and to smoothen relations within the innovation system, thus accepting the fact that the inherent complexity does not allow for simple-minded fixes.

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