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Reorganisation of the Chilean Public Technological Institues

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REORGANISATION OF THE CHILEAN PUBLIC TECHNOLOGICAL INSTITUTES

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Content

EXECUTIVE SUMMARY

Over the last two decades Chile has recorded an impressive economic performance. It has succeeded to achieve a remarkable “growth acceleration” with GDP per capita growing at 5-6 % per year in the 1990s, more than twice the long-term trend of 2.4 % of the preceding 40 years.Chile’s strong economic performance of the past two decades has been underpinned by the country’s effort in economic reform and building modern and stable institutions following best international practices regarding macro-economic management and the development of market mechanisms.

The Chilean innovation system faces many challenges. Chile has a strong need to take a determined course of transition to a more R&D and innovation-based growth. In this context, an important role of the government is to correct market and system failures that keep the country from reaching its full innovation potential.

From the point of view of market failures, government is needed to compensate, complement, support and take care of harmful externalities of the market economy. Briefly, government has to take main responsibility for long-term basic research and R&D infrastructures, it is needed to share the risks and other uncertainties entailed in R&D and innovation within companies and capital markets, and it is the task of the government to try to avoid harmful sideeffects of technologies to people and nature. Climate change has increased the importance of the last mentioned aspect.

Chile has a range of Public Technological Institutes (PTIs) dedicated to applied research and technological development, technology transfer, the supply of technological services and the generation of information on natural resources. They provide the State with relevant information to comply with its regulatory functions in the area of natural resources and the environment, supply public infrastructure, especially in the area of standards and metrology, foster innovation through the generation of spin offs, transfer and development of technologies for firms, and the dissemination of technologies for SMEs, among others.

Regardless of certain reforms and positive developments in recent years, there are several needs for further development in individual institutes as well as in the institute system as a a whole. The actual R&D intensity of most of the institutes is low as only few PTIs are actually

active in R&D. Many of the institutes are mainly dedicated to the supply of “technological services” and the generation of information. Their performance remains quite uneven, and a number of them are generally seen as inefficient, and detached from the sectors they are meant to serve.

The growing needs of the Chilean economy and society as well as development of public policy require active redesigning of the entire Chilean PTI system. It is necessary to understand and accept the new competitive environment and to define a coherent strategic vision for the whole system, and to redefine the missions of the institutes in this new context. This should go hand in hand with building up of a new governance system for the institutes and strengthening of the capabilities and competencies of the institutes.

From the point of view of organisation and governance of the institutes, the current situation is more a result of sporadic historical development than based on analytical consideration of the roles of the institutes in the Chilean innovation system, either individually or as a whole. The institutes are very much out of the steering mechanisms of the Chilean innovation system and innovation policy.

The main lesson to be learnt from international experiences is that there is not an ideal model or the best practice for reorganising PRIs. Rather, there are several options which are even combined in different ways. As we can see, even countries like Denmark, Finland and Sweden which are considered to be homogeneous in many respects, have adopted distinctive mechanisms to organise their PRIs. This means, that in every country, reforms must be built, whether you like it or not, on existing organisations, structures, resources, cultures etc., and particularly on unique national social and economic needs as well as societal and political objectives.

The conclusion which is to be made on the basis of international analysis is that pooling of resources and integration of the institutes under a common umbrella organisation is a good foundation in Chile. It is a solution which best meets the needs which Chile has to make better use of the institutes and create conditions for their further development. Experiences of many OECD countries give strong support to this kind of arrangement.

The point of departure for balanced financing of all PTIs is that they have a sufficient amount of basic financing (block funding) for self-initiated development and maintenance of basic

knowledge and skills as well as for research characterised by risk and uncertainties. In a modern world even the maintenance of a desirable level of knowledge requires determined actions and solid financing not to mention ambitious upgrading of the knowledge base. From international analysis we can conclude that a common proportion of basic financing of total financing of an institute is 30-40. In certain cases, if it is considered necessary for specific national reasons or for unavailability of other financial sources, the proportion of basic financing can be even higher. Another important aspect is stability in the growth of financing. Continuous fluctuations and uncertainty about future development of resources are most destructive for R&D institutes.

There are several other actions which are needed to make sure that the aims of the reforms are achieved. Organisational reform can be a necessary but not sufficient condition for this. Other important areas of development are management practices of the PTIs, monitoring and evaluation of performance, improving connectivity with other actors, commercialisation of results, and internationalisation of the institutes.

PREFACE

The role of science, technology and innovation, as well as their results and social impacts are intensively discussed and studied in all developed and developing countries. The emergence of a globalised knowledge economy, and the innovation capacity that this trend enables and informs, provides a new context in which assistance to research and development needs to be considered.

Different national economies exposed to the same transformation pressure have different capabilities and arrangements to innovate and to cope with change and they have established different principles and institutions for the promotion of innovation and knowledge-based development. Although innovation happens very much in firms, in key respects it is a collective process, but there are many dimensions of public policy that affect rate and directions of innovation.

The focus of this study, commissioned by the Council of Innovation for Competitiveness has been on Chilean Public Technological Institutes with the aim to make recommendations for the further development of these institutes. More specifically, the aim has been to evaluate the state of the art of the institutes, to characterize the arguments which justify their existence, to benchmark Chilean institutes with international counterparts, and to make a proposal for reorganization of the institutes.

The study turned out to be just as demanding, challenging and intellectually stimulating as we expected. The task would have been impossible to carry out without cooperation of several people too numerous for all of them to be individually mentioned here. We however want to specifically thank Ms. Marcia Varela, , Mr. Pedro Rosas, Mr. Leonardo Mena, and Mr. Eduardo Giesen Amtmann. We also want express our warmest thanks to the members of the Public Research Institutes for their time and views in the workshops and interviews. In addition, we owe thanks to the many colleagues or ours who generously used their time to provide documents and other information, and to discuss matters related to the study. Naturally, we solely are responsible for the contents of the study.

Helsinki and Santiago de Chile October 8, 2008

Tarmo Lemola Christian Peña-Ratinen

1 Background and objectives of the study

1.1 Background

As the OECD Review of Chiles Innovation Policy points out (OECD 2007), over the last two decades Chile has recorded an impressive economic performance. It has succeeded to achieve a remarkable “growth acceleration” with GDP per capita growing at 5-6 % per year in the 1990s, more than twice the long-term trend of 2.4 % of the preceding 40 years. After a short-lived stagnation at the end of the 1990s, growth performance picked up again sharply in 2004 and 2005, partly due to favourable conditions in it main export markets.

Chile’s strong economic performance of the past two decades has been underpinned by the country’s effort in economic reform and building modern and stable institutions following best international practices regarding macro-economic management and the development of market mechanisms. One example of this was the shift of R&D funding from direct state funding to competitive allocation since mid 90s. Openness to international trade and foreign direct investment has featured prominently among the factors explaining Chile’s success in deriving increasing income from its comparative advantages.

The emergence of dynamic export-oriented activities have tested the capability of the Chilean innovation support system, revealing that it is largely unable to deliver relevant services and knowledge. Partly as a response to new, more sophisticated demand from some firms, but also in response to other needs of the society and economy, Chile has started to build a more comprehensive innovation system. This is a demanding task which requires consistency, patience and above all strong commitment of major actors and other stakeholders to the long-term development of the national innovation system as a whole.

Scientific research, technological development and the ability to convert research results into economic and social benefits play an increasingly important role in determining economic development and international competitiveness of countries. Globalization and rapid distribution and transfer of knowledge by information and telecommunication technologies have also made investments in knowledge increasingly pertinent. This includes the generation and adoption of new knowledge created by scientific research and technological development, investments in education and research, adoption of best practices, and openness to social, economic, and cultural innovations.

The Chilean innovation system faces many challenges. The level of R&D intensity of the Chilean economy (0.67 % of GDP in 2003) is less than a third of the OECD average of 2.25 % (2003). Compared to OECD emerging economies, Chile compares favourably with Turkey and Poland, but not with others, like Hungary and the Czech Republic. Chile has a strong need to take a determined course of transition to a more R&D and innovation-based growth. In this context, an important role of the government is to correct market and system failures that keep the country from reaching its full innovation potential.

The OECD review remarks that regardless of certain reforms in recent years, the Chilean innovation system is still very much characterised by lack of efficiency. This along with low investments in R&D exhibits strong unbalances and bottlenecks which lead to disappointing performance and low returns on investment in R&D which slows down capacity building. The review pays particular attention to the following five aspects of the current Chilean innovation system:

- A lack of innovation culture in the society and shortages of specialised human capital
- Higher and quicker returns on alternative investments
- Lack of maturity of the capital market
- Low level of inter-firm learning from national and international best practices
- An unbalanced innovation policy mix

R&D is not an end in itself, but because it plays an important role in the innovation processes which are increasingly vital to current and future profits for Chilean companies and through them to the social and economic benefits of the whole Chilean society. R&D results in the technology that brings new products and services to the market place. R&D and Innovation result in high quality jobs, successful businesses, better goods and services and more efficient processes. International research has consistently demonstrated the positive correlation between R&D investment intensity and company performance measures such as sales growth and share price. Businesses are in a better position to achieve and maintain competitive advantage in the increasingly global market place with sustained R&D and other related intangible investments at the right internationally competitive levels.

Chile has a range of Public Technological Institutes (PTIs) dedicated to applied research and technological development, technology transfer, the supply of technological services and the generation of information on natural resources. They have a key role within the National Innovation System (NIS). They provide the State with relevant information to comply with its regulatory functions in the area of natural resources and the environment, supply public infrastructure, especially in the area of standards and metrology, foster innovation through the generation of spin offs, transfer and development of technologies for firms, and the dissemination of technologies for SMEs, among others.

The National Innovation Council for Competitiveness made some recommendations on PTIs in its Report of March 2006 **(**Hacia una Estrategia Nacional de Innovación volumen I**)** especially in the sphere of technological transfer and diffusion. The recommendations included strengthening the PTIs, distinguishing the functions of each depending on its mission, which should be reviewed beforehand and redefined in accordance with a global or systemic viewpoint within the NIS. This also implies identifying the inadequacies from its original mandate resulting from the historical outcomes of each one.

The Council has emphasised that the pertinence of products and services needs to be reviewed in light of the relevant market failures in the supply and demand of these goods and services. Likewise, the Council has identified in its proposal a range of public goods required to develop the innovation activity in the country, based on the

relevant market failure criteria in the supply and demand markets, which should be contrasted with the supply from institutes in the current system.

1.2 Objectives of the study

The objective of the study is to make a proposal of public policy recommendations for incorporating public technological institutes in terms of pertinence, efficiency, efficacy, additionality, and substitution/complementarity with the private sector, in order to maximize their contribution in the production of relevant public goods for the National Innovation System. Accordingly, following specific objectives have been set for the study:

- To evaluate the current visions and missions of the institutes, types of products and services that they provide, present and potential demand, human resources, capabilities and competences, the present financial system, and links with the international system, among other aspects.

- To characterize the market failures that justify the existence of each of these institutes and find the most efficient solutions based on that analysis.

- To carry out an international benchmarking analysis on the trends and good practices observed in world-class technological institutes as regards the public goods produced, as well as the other products and services versus those provided by the private sector, and definition of the target areas for research.

- To make an institutional redesign proposal for the PTIs aimed at eliminating the market failures. Likewise, to propose a financing and governability structure for them that minimizes the failures of the State, particularly eventual problems of dynamic in consistency, capture and agency.

2 Diagnosis of the current situation of the public technological institutes

2.1 Diagnosis of current situation of the PTI's

The Chilean PTI's are a heterogeneous group of institutes that are difficult to categorize by common denominators. Size, financial structures, strategic objectives, visions, etc. differ greatly from each other. Importantly, the PTI's have been established for distinct reasons and different actors. Diversity of the institutes has significant implications when the fifteen PTI's are diagnosed as one single group. At the same time, for policy purposes, it is useful to find some commonalities between sub-groups of institutions. Any effective policy approach requires general outlines which include several institutions, if not all.

The diagnosed institutions in this chapter are:

Institution	Legal status	Corresponding Government Department
CCHEN	Autonomous State Institution	Ministry of Mining
CIMM	Private Corporation	Ministry of Mining
CIREN	Private Corporation	Ministry of Agriculture
IFOP	Private Corporation	Undersecretariat of Fishing
IGM	Army Unit	Ministry of Defense
INACH	Autonomous body of the State	Ministry of Foreign Affairs
INFOR	Private Corporation	Ministry of Agriculture
INH	Autonomous Public Corporation	Ministry of Public Works
INIA	Private Corporation	Ministry of Agriculture
INN	Private Foundation	Ministry of Economy (CORFO)
FCHILE	Private Foundation	
SAF	Unit of the Air Forces	Ministry of Defense
SERNAGEOMIN	Decentralized Public Service	Ministry of Mining
SHOA	Navy Unit	Ministry of Defense

Table 1 *The diagnosed institutions in chapter 2.1.*

In this chapter the PTI's are diagnosed broadly, with greater consideration of the factors that are important for a policy redesign. The focus of the diagnose therefore are the critical factors of the institutions such as *staff, funding*, and *activities*. Other considered aspects are current *service and product offering*, and *mission and vision*.

2.2 General description of the PTI's

Agricultural Research Institution – INIA

The mission of INIA, established in 1964, is to contribute to strategic, applied and adaptive research that create new knowledge and technologies that can be transferred to diverse actors of the agricultural sector in Chile. The objective of the research is to produce results that enhance competitiveness, productivity, and sustainability of the sector. The long-term strategic aim of INIA is to secure and improve the global position of Chile as an important producer of agriculture and food goods.

INIA depends on the Ministry of Agriculture, but has multiple clients, with whom the interaction is direct through national and international networks.

The clients of INIA include:

- Farmers and agricultural producers
- Private companies
- The State
- Academic sector
- R&D centers

Public sector clients constitute for over two thirds of the use of the services, but the private sectors, companies in particular, are becoming increasingly more important. This change is relatively recent, and particularly the orientation of the past few years. This requires some balancing between producing public goods, and servicing the private sector.

In the past few years INIA started to patent some of the research results, indicating both the quality of research and the orientation of institutional role. In 2002 INIA had no patents, by 2007 the institution held 22.

INIA diffuses its knowledge to students and researchers through universities and other knowledge-intensive institutions. The technology transfer to private companies is done through joint projects, which are mostly privately financed, and carried out with correspondent personnel of the private enterprises. Practical training of small producers and others similar actors is channelled through various means, including publications and courses.

The products of INIA include:

- Scientific knowledge
- New technology and processes
- Information (and its diffusion)

The network of partners, such as universities, Fundación Chile and international partners, play an important role in creating and disseminating knowledge and information.

The total number of employees of INIA (in ten regional centers) is 1046 of which there are 55 researchers, and total of 272 persons working in research related activities. Over two thirds of staff is specialized in agricultural engineering. Currently the long-term outlook of availability of high quality researchers scientific area is discouraging. Current development indicates that in less than ten years there will be less PhD graduates available in Chile than there are currently. However, the large grant funds made available for overseas studies are expected to produce changes favourable for INIA. INIA has only limited resources to finance training and education abroad. Furthermore, INIA cannot compete with the private sector, and in fact is affected with “brain drain” with young professionals that reach sufficient experience to have demand in the

private market. INIA is not able to compete with the salary levels of the private sector.

The structure of INIA funding depends on 45% public basic funding (Ministry of Agriculture), 45% on competitive funding from several sources, and 10% from the sales of services. Current budget of INIA is approx US $17 million.

The increase of private funding has a negative impact on public funding, as there exists the tendency of the latter to reduce the latter. This dilemma is descriptive of the balance that a PTI has to manage when there is an increasing private market demand, and a strong public role.

Forestry Institute – INFOR

Founded in 1965, the goals of INFOR are to create and transfer high quality scientific and technological knowledge for the sustainable use of Chilean forest resources. The objective is to provide information, products and services satisfying the informational need and demand of the sustainable development of forestry sector at economic, social, and environmental levels.

INFOR has prioritized six strategic research areas:

- Sustainable forest management of native forests
- Integration of family farms and rural SME development forest
- Monitoring of forest ecosystems
- Forest biomass as an energy source
- The environmental services provided by forest ecosystems
- Innovation and management for competitiveness

The clients of INFOR are from both private and public sectors at various levels, but with a focus towards small and medium size actors such as family farms and forestry SME's. Significant public actors, benefiting from the information

generated by INFOR, include the Ministry of Agriculture, CONAMA and CONAF. The largest pool potential clients of INFOR are the estimated 160 000 owners of Chilean forest.

INFOR has a wide national network with five regional offices. Within this network INIA has subgroups that carry out R&D and application of the results. Related services and products include:

- Genetic improvement of trees (biotechnology)
- Evaluation of wood products and production processes
- Market studies and statistical analysis
- Training and technical assistance
- Sales of seeds

Natural Resource Information – CIREN

The beginnings of CIREN originate in the 1960's earthquake, and necessity to map affected territories. Since 1964 CIREN has been a CORFO subsidiary institution focusing national natural resource (water, soil, agriculture, forestry, and others) information generation.

Products include:

- Cartography natural resources
- Satelite imaging and photography
- Cadastral surveys

CIREN has also a vast document centre.

Clients of the CIREN are both public and private. Important private clients of customized services are agricultural companies, investors and consultants. Sales of services generate about 16% of the budget.

Key public user of the services is the Ministry of Agriculture (and its institutions), public programs, universities, and other PTI's. The financial contribution of the Ministry of Agriculture is approx 22%. In this role the Ministry also guides CIREN in its focus areas, namely emphasizing of the responsibilities towards in small agricultural producers. Nonetheless, CIREN relies heavily on project-based funding, approx 62% (primarily CORFO), directing the activities of the institute towards those areas where there are funding opportunities.

As other institutes, CIREN has significant challenges in competing for human resources. Simultaneously, there are only limited financial resources to train staff, as there is pressure to concentrate on productive activities.

Fisheries Development Institute – IFOP

Established by CORFO in 1964, The main activity of IFOP is to research and subsequently produce scientific information for the purpose of regulation and sustainability of fishing and aquaculture in Chile. In this role IFOP, evaluate and monitors quantitative conditions of fishing stock, and recommends accordingly national yearly fishing quotas to the sectoral regulator, the Undersecretary of Fishing (SubPesca).

In 1964 statue IFOP was established with the following objectives:

1. Performs research in:

- National fishing stock
- Methods of improving fishing
- The economy of utilizing and commercializing fish and related products
- Improving sectoral education
- Developing statistical methods

2. Promotion of sectoral development

3. Provide assistance to companies and public actors

The main objective of IFOP in the 1960s was to develop national fishing industry. Since, Chile has become an important exporter of fish and fish products. The role of IFOP today is to provide solid scientific information for policy-makers. However, with collaboration with universities and private researchers, the influence of IFOP reaches much further. With a network of fifteen offices, the institute has a wide national coverage and ability dissemination knowledge locally.

Essentially the main product generated by IFOP is fish stock information, which is primarily used by SubPesca. It is also SubPesca that decides on the public release of research results. Following, other likely users of the information are large and medium size fishing company, fishing communities, and leisure fishers. IFOP intends to increase research and generation of information, speeding the process, and making the information available on online databanks.

Funding sources of IFOP are primarily public and project based (over 70%). Second most important source is SubPesca, which provides about 20% of all income as a basic funding. Income generated from private sources is less than 10%.

Chilean Nuclear Energy Commission – CCHEN

Established in 1964, as the sole Chilean entity responsible of all matters related to nuclear energy. In the establishing law, the responsibilities and functions of CCHEN include:

- Advice the Government on all legal regime matters related to nuclear energy, including international treaties
- Plan and propose national strategy, and execute them if necessary
- Research nuclear material and derivatives
- Train and diffusion of knowledge
- Collaborate with National Health Care in security, contamination, etc.
- Carry out production, acquisition, transport, and management of nuclear material

Since the law has been modified, and redefine the role of CCHEN as a regulatory authority. As regulator CCHEN oversees nuclear safety issues, inspects, authorizes and monitors norms related to the facilities, use and transfers of nuclear material. Beyond regulation, CCHEN has an important educational role, and manages the programs training nuclear scientists abroad.

CCHEN generate a quarter of its income through sales of services and products, to which the institution in many cases hold a monopoly. The clients, over 800 in total, are mining companies, hospitals, universities and some industrial sectors. From public sector main users and clients are the Ministry of Mining and the Ministry of Health.

Due to the nature of the activities, CCHEN holds and manages privately owned infrastructure of high value. At current strategic national interest the infrastructure is sufficient.

National Geological and Mining Service – SERNAGEOMIN

Founded in 1980 to function as a technical advisor to the Ministry of Mining, SERNAGEOMIN generates information related to mining and geology in Chile. SERNAGEOMIN provides services and products, such as sectoral publications, studies, accreditations, and monitoring, to public institutions and private companies. The main objectives of the core functions are to:

- Monitor and control security measures and environmental management of the mining companies
- Provide technical assistance for the purpose of mining and geothermal concessions
- Monitor the active volcanoes, informing and providing emergency assistance to civil protection organizations
- Produce and publish documents and maps of the natural mining resources, geology, and geological hazards
- Train employees of the mining sector in risk prevention, and environmental issues

The main funding source and client of SERNAGEOMIN is the Ministry of Mining, which provides approx 90% of the income. The remaining income is primarily from training services that SERNAGEOMIN provides. Service sales has incrementally increased. SERNAGEOMIN has also won CORFO in the last two years.

Human resource scarce and competed for in the mining sector and SERNAGEOMIN is often in no position to compete with private sector; geophysicists in particularly are in demand.

Hydrographic and Oceanographic Service of the Chilean Navy – SHOA

The background of SHOA, with roots in year 1874, describes importance of hydrography and oceanography in Chilean history. The objective of SHOA is to secure navigation by providing hydrographic and oceanographic information, maps, and technical assistance of Chilean territorial waters, and beyond. SHOA functions as the central actor in coordinating all oceanographic research, mapping, warnings (e.g. Tsunamis) and related activities, including aerial photography. SHOA also represent Chile in international organizations of its field, and trains professionals within the fields of its expertise.

The primary client of SHOA is the Armed Forces, others being the scientific community, fishing companies, and others. Due to the nature of the activities, the functions and funding of SHOA are approach strategically. Funding, which is approved by Ministry of Finance, is planned and carried out on long-term basis (3-4 years) despite the yearly approval.

Military Geographical Institute – IGM

IGM is one the three Armed Forces PTI's, and functions as the official State authority in all matters related to geography, cartography, and land surveying. The institution founded in 1881, considers itself as a complementary provider of territorial information together with other national actors (e.g. SHOA and SAF) and contributes to national development (e.g. education, infrastructure) and strategic military interests of Chile. However, the military role does not restrict the civilian uses of the information generated. All IGM activities are public.

There are some clear contradictions between the role of IGM, which by activities is mostly civilian, and the restriction of applying to any other available competitive public funds other than those designated to military institutes. IGM cannot compete for same civilian funds as the other PTI's (paradoxically IGM competed for a public tender in Spain). Limited basic funding and opportunities to access other type of funding has guided IGM to non-core profitable activities. The service and product sales generates IGM approx 70% of the total budget.

The products and services of IGM include:

- Maps (both civilian and military specifics)
- Atlases and other publications
- Training
- Topography, and related tailored services

The clients base consists of variety of public and private actors, including educational sector.

As other PTI's, IGM undergoes constant struggle to hold onto existing human resources. Approximately after an experience of three year in the institution, employees move into private sector.

Arial Photogrammetric Service of the Chilean Air Force – SAF

SAF, established in 1963, is the official provider of aerophotography to the State, with the responsibility to develop techniques, and carry out projects on request of public officials. In practical terms, SAF produces aeronautic cartography, and manages updates records of international standards for the purposes of national security and national development.

SAF receives approx 29% of direct funding from the Chilean Air Forces, approx 29% from the Ministry of Finance, 35% (two thirds private clients) from product sales (primarily printed and digital aerial photographs and maps). As a military institute, SAF cannot compete or competitive public funds.

Chilean Antarctic Institute – INACH

Compared to the other Chilean PTI's, INACH has a very distinctive activities and roles. Contrasting other PTI's, INACH depends on the Ministry of Foreign Affairs.
INACH is perhaps best described as an institute with an *intermediary* or a *coordinator* role in Antarctic research. INACH itself does not perform research, but rather coordinates and finances it at *ad hoc* basis when funds are available. The objectives and responsibilities of INACH can de described as following:

- Improve the quality of Chilean scientific research in the Antarctic

- Advance international research and logistical cooperation with those countries accessing the Antarctic through Chilean territory, and promote the
- Promote Chilean city Punta Arena as a centre Antarctic services
- Promote and raise awareness of Chilean Antarctic in the country
- Advice the Ministry of Foreign Affairs and other public authorities in matter related to the Antarctic

INACH devises and coordinates scientific programs and projects, tendering the research labour. From the Government viewpoint, INACH is an assessment organization of scientific matters related to the Antarctic.

Outside the coordination of scientific research, INACH produces publication, organizes seminars and symposiums, and maintains a museum and a comprehensive library.

The main clients of INACH are:

- Chilean universities
- Chilean and foreign research centres, researchers, and students
- (Research intensive) companies
- The Ministry of Foreign Affairs
- The Armed Forces

INACH receive direct State basic funding, and project funding from a number of national funds (e.g. COFRO-INNOVA, FONDECYT). In 2007 INACH was awarded an INNOVA project on biotechnology worth US $500 000.

National Normalization and Standard Institute – INN

Founded in 1973 by CORFO, and member of International Organization for Standardization (ISO), INN is the prominent autonomous standardization, accreditation, and metrology organization in Chile. In addition to the three areas INN provides training within its field of expertise. Typically each of the three main division would be spread in individual institutions, because of apparent conflict of interest. However, in the case of INN, the institution has gradually and naturally expanded to the current dimension, which is not protected by any legal regime. Own accreditations can receive from other certified institutions.

In the modified statute of 2004, it is stated that INN:

- Studies the technical norms required for different sectors in the country
- Study and arrange mechanisms that allow implementation of the technical norms it (INN) approves.
- Implement the activities that are required to develop the technical norms, metrology, and evaluation of conformity.

The strategic objectives of INN include:

- Promote and facilitate the use of international technical standards within the Chilean productive system, and provide incentives for the users to develop them.
- Promote and administrate a national accreditation system,
- Coordinate and supervise a Chilean network of metrology, diffusing precise measurement mechanism to the national productive system.

INN is practically fully self-funded, receiving State funding only at approx 10%. Human resources, as with the other PTI's, are scarce particularly in some sectoral expertise areas. Funding limitations restrict training of staff correspondently.

National Hydraulics Institute – INH

The National Hydraulics Institute carries out studies, projects, academic support tasks, and research in the field of hydraulics engineering. Founded in 1964, as an institute depending on the Ministry of Public Works, INH has numerous and unique roles that are also established in the institutional objectives. These include:

- Perform studies and physical and mathematical modelling to secure the safety of hydraulics works, assure environmental protection, and efficiency
- Advice the Ministry of Public Works and other public authorities undertaking works with significant hydraulics component to secure and optimize investments
- Calibrate and certify machinery used in hydraulics works
- Collaborate with university teaching and research, and maximizing the use of existing capacities and facilities, and those abroad
- Disseminate the study and research results, and transfer technology

The State finances approx 50% of INH activities. The other half INH generates from sales of services to clients, of which over 80% are public sector actors. The self-generated funds are generally invested, whereas the State funds cover for the overheads. INH has not accessed other public funds in several years.

INH has a large laboratory of in Peñaflor, with up to 5750 m2 of storehouse space for hydraulic studies, and 1250 m2 for calibration of centrifugal pumps. Current infrastructure corresponds the requirements of clients.

Mining and Metallurgical Research Centre – CIMM

CIMM was established in 1970 to assure that the production of the mining sector would correspond to the international standards and practices. In addition to its initial mission, today CIMM supports the development the human resources, scientific research, technological improvement, and the regulation of the mining sector. In addition to the traditional role of supporting the

competitiveness of the copper industry, CIMM also produces critical scientific information and solutions that contribute to sustainability of the industry. A third role of CIMM, is to coordinate and support the scientific efforts through projects and international linkages.

CIMM categorizes its activities as:

- Sustainability of the industry
- Investigation of copper and metals
- Copper and environment
- Environmental metallurgy
- Coordination of the efforts for innovation

The supporting infrastructure of CIMM include six laboratories (including ecotoxicology, soil and plant chemistry, environmental metallurgy) and a library.

Environmental protection is crucially important in Chilean copper production. The high environmentlal impact of the copper production directly affect other important productive industries, namely agriculture, emphasizes the public role that CIMM has. In addition, CIMM has a important role in supporting the creation of public policies and regulation processes, including those policies that aim at protecting competitiveness of the Chilean mining industry. Typically such challenges are increasing global regulations and standards on copper products and their productions. Public clients of this type of work include the Ministry of Mining, regional governments, CORFO, Comisión Nacional de Medio Ambiente (CONAMA), CONICYT, COCHILCO, among others.

Through its service selling subsidiary (CIMM S&T), CIMM provides services to private and public mining companies. CIMM receives approx 35% of revenues from the profits of its subsidiaries. The remaining two-thirds is generated from competitive projects and programs.

Fundación Chile

Fundación Chile (FC), founded by the Chilean Government and ITT Corporation (U.S.) in 1976, has an exceptional record of new business developing and added value creation in Chilean. In 2005 BHP Billiton became a co-founding partner. FC has three offices in Santiago, Concepción and Puerto Montt, and in addition has ongoing projects in the Regions IV, IX, X, and XI.

FC has created over 70 companies in 30 years in Chile, and has had the most notable success in the salmon industry. With regards to innovation, the business model of FC is to be involved and follow through many of the crucial steps that establishing a new companies requires. FC has an 'innovation platform' working process in supporting and carrying out innovation:

- Identification of opportunity to add value through innovation
- Obtaining technology (i.e. transfer and adapt, or in-house R&D, or develop it using networked R&D institutions)
- Scale-up of technology and its dissemination

The model has successfully included various national actors; research institutes, universities, funding agencies, private investors, ministries, and companies. A large number of foreign entities have also collaborated with FC.

FC has a number of sectors in which it is concentrating. Considering the institutional size, the challenge to address them all is high. The focus sectors are:

- Agribusiness
- Marine Resources
- Forestry
- Environment and Chemical Metrology
- Human Capital

- Information and Communication Technologies (ICTs)

Funding sources of FC are more diverse compared to the other PTI's, however over two thirds (over 66%) of the funding are from public sources. Approx 30% are from competitive funds (e.g. INNOVA, FONDEF, FIA) 22% from service sales to public sector, and 14,3% is basic funding. In 2007 the capital income of FC was few per cent. In addition, FC has received large endowments from the Government and private companies (e.g. BHP Billington in 2005).

Infrastructure of almost 5000 m2 satisfy current needs.

PTI	Total funding million pesos	External funding of % total	Number of staff	Number of researches	PhD's
INIA	17 646	55	1 046	55	74
INFOR	2 636	49	74	44	6
CIREN	-	16	-	-	-
IFOP	7 052	40.5	440	89	-
CCHEN	6 115	24	300	120	-
SERNAGEOMIN	5 831	<10	313	51	13
SHOA	2 870	>10	273	-	-
IGM	3 612	70	316	-	-
SAF	1 145	26	257		
INACH	2 161	-	28?	-	
INN	-	90	73	-	
INH	750	50	61	14	1
CIMM	1 500	70	50	45	45
Fundación Chile	12 241	100	300	-	14

Table 2 *Staff and Funding of the PTI's (2007)*

As seen above, most of the Chilean PTI's have distinguishably different characteristics. The PTI's are also difficult to group according to their size and funding source, as Table 2 shows. Despite the general differences of the institutes, there are some similarities. some of the PTI's have similar fields of expertise and core activities. These common denominators derive from the resources, geography, and national security. However, all of the institutes have their distinctive purpose of existence, and, importantly, historic development. However, these similar fields of expertise and core activities provide opportunities to pool resources and create a more efficient national system. For this purpose it is constructive to analyze the institutions as part of a single system.

2.3 Taxonomy of the Chilean PTI's

2.3.1 Taxonomy by Funding Structure

Funding is the most important policy implementation tool, and one that eventually can reshape the existing PTI network. Therefore it is natural and important to develop a funding taxonomy and establish some criteria when a PTI should be publicly funded. Ultimately these criteria are established by the policy-makers according to national need. However, within the current system, there are some criteria that are inherent. This is not because of the current design, but rather historical development of the system.

As international examples show, funding structures of technological institutes vary significantly, and they are constantly changed. There are no single correct models that fully satisfy the needs of the national system, nor individual institute.

The funding structures of the Chilean PTI's are equally diverse and vary greatly between the institutions. The heterogeneous funding structures are mostly

historic by nature, and have developed and diversified in time. Traditionally public funding of the institutes comes from either a ministry or CORFO. Exceptions to this are the three PTI's part of the Armed Forces (Fuerzas Armadas de Chile); and private technological institution Fundación Chile.

Increasing competitive public funding has been a more profound transformation. Competing for competitive funding, mainly for CORFO projects, has become progressively more important funding source. However, core knowledge and capabilities do not always correspond the content of CORFO projects and programs.

Regardless of this, PTI's have made internal arrangements in order to compete for project and programs, shifting and committing resources to other than own competence areas. With regards to research and development, it is clear that human resources are not most effectively allocated in these scenarios.

Across the PTI's, funding is considered sufficient for the very basic functions and responsibilities. However, funding is very thinly spread and restrains the institutions to concentrate only in the most productive activities, namely externally funded projects and responsibilities that PTI's have towards main financiers, namely ministries.

This lean funding base is often viewed as a constraint from the most creative activities, and long-term planning. Essentially, the institutions often have to focus on securing the existing staff size and activities. To achieve this, the main attention of an institution might be primarily on generation of funds, and not on the actual goals and objectives.

There are a number of financially independent PTI's that also concentrate producing and selling their services. Legally public institution, namely all but Fundación Chile, have nonetheless some disincentives to develop their sales, as 'over-performance' in generation of income will contribute towards the State

budget, not the institution. This legal-structural restriction curbs and in many cases discourage endogenous development and growth of the PTI's. From development approach, it is valuable to assess other mechanisms.

Diversification of funding sources has meant some significant changes to the traditional roles of the institutes. Increasingly, like in other countries, the Chilean institutes are generating additional funds from external sources often to adjust to declining real or relative public funding. New external funding has been generated primarily from two sources, *a) service sales, and b) competitive public funding.*

Sales of services has been a natural development to those institutes producing information that is readily made commercial. Commercialization of knowledge is more complicated, but has been made into products such as technology transfers and "technological services", and accreditation. In many cases this external funding has become the most important source; to the extent that an institute is virtually independent from public funding. Funding generated from sales has subsequently encouraged a decrease of direct public funding, which in turn, has encourage institutions to further service sales.

When redesigning or re-evaluating government role as a financier of the PTI's, independent institutions should be considered as distinctive. They primarily produce *commercial goods and products*. Government intervention therefore is either not necessarily, or its rationale significantly weakened.

Only if the activities, responsibilities, or quality of independent institutions are to be increased or diversified, funding policy probably will require a redesign. If there are no other motivations than financial ones to consider, a *status quo* policy with these institutions is sensible. In the case of these institutions, it is important to evaluate whether it is useful to incorporate an independent institution into a national funding framework. A 'laissez-fair' policy may in fact reinforces the independent status of an institution by exposing it to market

conditions and competition. However, current national strategy in Chile **(**Hacia una Estrategia Nacional de Innovación volumen II**)** is to include all the institutions within the same mechanism. If in fact the role of the independent PTI's are changed, it is clear that also funding should correspond the changes.

Therefore funding structures can be evaluated simply as:

a) Dependent, or

b) Independent.

An accurate and complete classification of the institutes would require consideration of affiliations with main financier, clients, and other interrelations that are basis of the funding decisions. However, the aim of this taxonomy is to allow some distinction between the types of institutions at this early stage of redesign.

This twofold division is a classification that is readily observable and applicable. In reality the issue of financial dependence and independence is significantly more complex when considering public funding. A significant dilemma is the fact that in many cases a PTI might sell its services almost exclusively to other public entities or public authority, and be awarded only public project and programs.

Eventually, organizational identity, strategy, and legal framework of the PTI's have a crucial role in determining how an institution is located in the national system. For instance, under current legal structures the PTI's of the Armed Forces cannot explore their capabilities beyond the areas described in institution-related laws and decrees. In is crucial to take into consideration whether the institutes project, and credibly establish, a future of other kind (e.g. R&D intensiveness or financial independence).

2.3.2 Taxonomy by Activity

Identifying the *activities* of the PTI's is useful for policy purposes. In the case of the Chilean PTI's this is particularly important due to the heavy emphasis of generation of information by the institutes. Often generating information is expensive because of the basic equipment and infrastructure that is required (e.g. airplanes, laboratories). At the same time the information is increasingly readily available, and for continuously reduced cost; often information is virtually free. Consequently, generation of *basic* information is becoming harder to justify, especially if the cost of it is high.

The prominent role of the Chilean PTI's is providing the Government and public sector in general, vital information for regulatory and policy reasons. This public role that the institutes have is significant, and in some of the most important industrial sectors, the PTI's provide crucial information that without the Government could not regulate effectively.

The activities also reveal the type of wider societal role the institution has. From systemic point of view is valuable to identify which public goods and products they are producing, and how they correspond to national demand. For instance, training of researchers can be considered a by-product of the core activities of a PTI, but a crucial product from systemic point of view. It is useful to identify these goods, whether they are primarily result of the activities, or simply a by-product.

	R&D	Knowledge creation	Information Services	Tech. Transfer	Regulation/ Certification	Technical assistance/	Cluster activities	New business creation
INIA	x	x	x	x		x	x	x
INFOR	x	x	x	x	x	x	x	
CIREN		x	x			x	x	
IFOP	x	x	x	x	x	x	x	
CCHEN	x	x	x		x	x	x	
SERNAGEOMIN		x	x	x	x	x	x	
SHOA			x		x			
IGM			x		x			
SAF			x		x			
IACH		x	x			x	x	
INN			x		x			
INH	x	x	x	x	x		x	
CIMM	x	x	x	x	x	x	x	
Fundación Chile	x	x	x	x		x	x	x

Table 3 *NIS elements toward which the technological institutes can contribute with the good they produce. Eight such goods identified.*

There are several crucial NIS elements toward which the technological institutes can contribute with the good they produce. In Table 3 eight such goods are identified. Most of the Chilean PTI's are involved in majority of the fields, with the exception of new business creation. However, only through high quality R&D can the institutes contribute to critical *new knowledge creation*.

Technical training assistance, which is primarily requested by the public authorities, is a significantly contributing activity to most of the institutes. The clients of this training are typically small and medium size private actors, such as companies, farmers, fishermen, and others. Another significant training role, despite being indirect and adverse, is giving new academically trained employees practical working experience. Private companies in Chile have not generally hire graduates, and train them.

All the PTI's lose every year staff to the private sectors after the employee has obtained sufficient experience and training within the institute. In many cases this human resource drain weakens the institutes considerably, and reduces its trajectory. Simultaneously, however, these employees are considerable asset to the Chilean private sector that otherwise would either remain without scientifically trained employees, or has to acquire such resources from abroad.

The activities of the Chilean institutions are constantly changing and being rearranged, often according to the current needs of the main clients or availability of funding. Development of the activities within the institutions can be closely aligned to with national strategy (See 2.3.4 for cluster policy). This way the institutions can strategically develop their activities to support the National Innovation System as a whole. *How* the institutions can develop their activities, becomes a greater question than how they are performing at current level.

As the Chilean Government is heavily investing on human resourse development and the clusters, also the institutions are in strategic position to develop their activities. Availability of funds will play a crucial role in this rearrangement. This does not necessarilly mean increase in basic funding as such, but instead aligning financially significant '*platform'* or *'structural'* grants with cluster policy whenever possible. Institutions could either competitively or non-competitively present their programs or projects that would run for several years, and include considerable investments in human resources and infrastructure. Emphasis should be in creating and increasing R&D capacities, although the institutions should also be allowed to develop their roles in regulation, technology transfer, and so forth, as long as the roles are well justified within the National Innovation System. Importantly, institutions should be able to apply for the grant together with other PTI's and other actors[1].

[1] Note: Most of the PTI's are restricted by law to very specific roles and functions.

2.3.3 Taxonomy by Core Competence and National Role

Beside the activities, the PTI's can be group according to their core expertise fields. A number of the institutes have similar areas of expertise and perform similar activities, to the extent of overlaps. Certainly the characteristics of the institutes are different, but expertise areas are not. There are no direct duplications of work, but there are arguably synergy areas that are not currently exploited. Synergy between two or more institutions contributes towards critical mass of *human resources, funding, and infrastructure.*

There are two areas of expertise that are identifiable in more than one institution. These two expertise areas are:

1) Geographical information
2) Natural resource information.

Many of the institutes appear to be unique, and they serve seemingly different purposes, but the underlying strategic national objectives are very similar. Therefore, human resources in particular, but also infrastructure, of institutions from similar expertise field should be mapped and looked at carefully. A rigorous evaluation of the overlaps and synergies between the institutions can reveal excellent opportunities of pooling critical capacities.

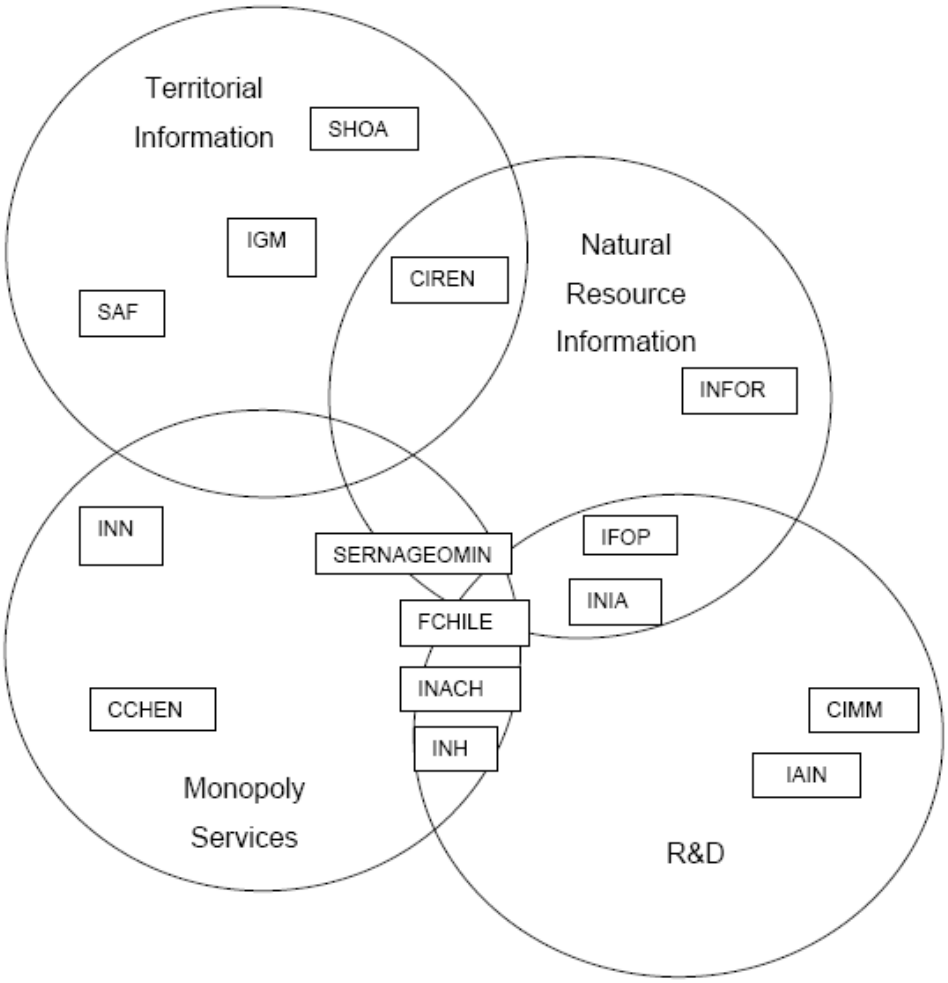

Table 4[2] *The core competence of indicates the national role of the institutes*

This process can also reveal opportunities for new kind of capacities. Innovative cross-scientific approach to old and new national challenges is just one of the alternative methodologies. The challenges Chile face today cross scientific fields, industrial sectors, social issues, and so forth. National strategic objectives, such as *sustainability*, is arguably one of these cross-scientific

[2] *Consejo de Innovacion para la Competitividad (2007)*[2]

challenges that require the inclusion of number of expertise fields and activities; R&D, regulation and technology transfer to mention few.

The core competence of indicates the *national role* of the institutes. Some of this roles are legally protected (e.g. CCHEN), or they are natural monopolies (e.g. INN), but primarily the institutes hold a strong role for their principal competence (see Table 4 for the model of Consejo de Innovacion para la Competitividad).

The roles that the institutes have in Chile can be classified in three specific groups:

1. Information and Service Institutes

Chilean PTI's are heavily concentrated in generating information, and diffusing it to public and private actors. Also training, primarily by the request of public authorities, is an important related activity for almost all the institutes. Some of the institutes generate income from sales of information products or tailored services. Other institutes generate information and related products as free public goods. In many cases the main clients (e.g. small forest owners, small fishing communities) of these institutions (e.g. INFOR and IFOP) are not capable of paying for the services. Therefore all most of the information and knowledge generated is not commercially viable. Simultaneously the knowledge transfer of these institutes significantly increase productivity of small producers. The type of clients PTI's have, often determine the financial independence of the Chilean institutions.

2. R&D Institutes

In Chile most of the R&D is performed by universities and companies. Often the PTI's do not have the required resources to perform R&D, and are less competitive than universities in competing for public and private projects. In

essence, the cost structure of the institutes are different than that of universities. However, some Chilean PTI's are committed to continuous performance of R&D, and have been able to improve the competitiveness of Chilean industries, and have created new ones. There are two noticeable examples of these, INIA and Fundación Chile. Other R&D intensive institutes, such as INFOR, CIMM and INH have significant sectoral roles in creating new knowledge and new technologies.

These organizations have had, and continue having critical roles in developing new technologies that improve products and productivity of some of the most important industries in Chile. The institutes have very different functions and business models, but essentially they are committed to valuable R&D activities. Financial structures of each institutes are different, and they have different levels of dependencies.

3. *National Interest Institutes*

Within the fifteen Chilean PTI's there are institutions that do not comfortably sit with previous two categories. This is not to say that they do not generate information and services, or perform R&D, but instead they exist for specific national purposes or has developed from this. The three institutions of the Armed Forces are the most noticeable examples of this. Currently all three have unmistakable civilian functions, as well as military ones. The information and services the three institutions provide to civilian actors is in no conflict with national security. Despite the military roles, their activities do not differ from the other PTI's. However, their governance and dependencies are very distinct from the other institutions, as their "raison d'être" can be justified outside the arguments of Chilean innovation system.

There are similar arguments to be made about other civilian PTI's. The extraordinary conditions for alternative rationalization for a technology institute, can derive from other than military security issues, or international

commitments. The rationale for funding CCHEN, despite being a primarily accreditation organization, can be national security interest. INACH and IAIN are an important scientific intermediary organizations and international representatives from a scientific fields of great national interest.

The Chilean PTI's are a heterogeneous group of institutes that are difficult to categorize by a common nominator. Some of the institutes also have very distinct features that differ significantly from the others, making them unique. The PTI's therefore cannot be considered as one single natural group of institutes. Also, many of the fifteen Chilean PTI's consider their history and national role to be unique and different from the others, and rightfully so.

Table 5 *Taxonomy by Funding Structure and National Roles*

	Information and Services	**R&D**	**National Interest**
Dependent	Produces public goods and services	Performs R&D for public good	Generates public goods and services, which are of national interest
Independent	Produces and commercializes goods and services	Performs R&D and commercializes results	Generates and commercializes goods and services, which are of national interest

However, identifying some generic common nominators between the institutes are useful for systemic policy redesign purposes. Table 5 combines the two criteria, national role and funding structure. These categories are not conclusive, nor do they exhaustively map the complex roles that PTI's have in the National Innovation System. Nevertheless, this type of grouping of the PTI's support the initial approaches in redesigning the system of the fifteen heterogeneous Chilean institutions.

2.3.4 Flexible Taxonomy Model

For short- and medium-term policy purposes a flexible and an organic taxonomy model is important. The difficulties of structural changes and related conflicts require dynamic policy measures that allow critical adjustments without negative outcomes. Permitting the groups (i.e. funding structures, national roles) of PTI's to have different kinds of policy models that serve the interests of the institutes, their stakeholders and sponsors. Abrupt changes have immediate impact on the functions of the PTI's at the funding level, and importantly at mission and strategic level. Ministries and the Armed Forces provide not only funding for the institutions, but also purpose and national direction. The ministries and the Armed Forces are important clients of the institutes and through this stake and relationship they also provide significant purpose for the institute. In essence, the policy process should be inclusive of as many stakeholders as possible.

The *SNItec* model (National Innovation Strategy Vol. II), provides a clear and centralized mechanism of financing the PTI's. However, where funding of the institution is not necessary (independent institutions), or the institutions have a national security role (national interest institutions), alternatives or diversification of the SNItec should be considered.

***Table 6**: Illustration of one of the possible models how the PTI's dependencies could be viewed*

INSTITUTIONAL FUNCTION	1. R&D INSTITUTIONS	2. NATIONAL INTEREST/ DEPENDENT INSTITUTIONS	3. INDEPENDENT INSTITUTIONS
FUNDING	**ALL NEW AND EXISTING FUNDS** •High and progressive financial incetives •Long-term, strategic focus •All annual "innovation" and R&D taxes •Development of a large endowement capital (e.g. "Innovation Injection")	**STATUS QUO OR REDUCED FUNDING** •Creating pressure to move toward financial autonomy or R&D activities	**STATUS QUO or REDUCED FINANCING** •Incentives to become financially independent •Incentives to improve services
POLICY	**STRONG NATIONAL AND STRATEGIC POLICY** •National R&D areas •Funding •Human resources	**MINISTRIES and ARMED FORCES** •A political and strategic process led by the patron	**LAISSEZ-FAIRE** •Competitive survival mechanism
ACTIVITY	**HIGH QUALITY SCIENTIFIC R&D** •Scientific and commercial results •Close collaboration with universities and private enterprises	**CONTINUATION OF CURRENT ACTIVITIES** •Laissez-faire and strategy of the stakeholders	**HIGH QUALITY SERVICES** •Competitive and profitable services
INSTITUTIONS by example	INIA, CIMM, INH, INACH, INFOR (universities, private research companies)	SAF, IGM, SHOA, CCHEN Sernageomin, IFOP, CIREN	INN, FUNDACION CHILE*
	SNITec	PTI's	AUTONOMOUS INSTITUTIONS

*Fundacion Chile is a autonomous institution which with significant R&D capacities, and competes for research funds.

Table 6 illustrates one of the possible models how the PTI's dependencies could be viewed. In this model R&D institutions are considered as the primary candidates to participate in the SNItec model. R&D institutions can have an important role in improving one of the main weaknesses of the Chilean National Innovation System (OECD 2007), the low level of R&D investment in the country.

The national interest institutions have an important responsibility in providing critical information to their main sponsors, whether a ministry or the Armed Forces. These institutions also support the sponsors in such activities as

information dissemination (e.g. to small producers), and regulation. Reversely, the institutions often depend on the sponsor not only financially, but administratively and even in strategic directions. These institutions that have this type of focused and crucial function, could be considered as a separate group of institutions.

The third group of this model include those independent institutions that have currently an autonomous position. If they satisfy the stakeholders and clients, and if these institutions are financially independent, government intervention might be unnecessary.

A flexible taxonomy model allows institutional development and transformations (which in many cases is difficult due to legal regimes). Institutions which have important competences, but no research activities, should be encourage to develop their activities to include nationally important R&D. Adding value to the activities usually could be considered to correspond the national needs in Chile. This is not necessarily always the case, and thus the institutions should be allowed to move to the other end of spectrum if necessary.

Essentially, development of R&D capacities of the PTI's should correspond to *national strategies*, and public funding for the institutions should support the implementation of these policies. Institutions intensifying their R&D activities, should do so to reenforce national efforts in the areas established by the Government. In Chile the eleven most potential *clusters* recognized by the Innovation Council for Competitiveness is one of such national efforts that provide a natural course for increased public funding. In this regard, the eleven clusters:

- Offshoring
- Tourism
- Porcine and poultry industry
- Fruit industry

- Copper mining
- Processed food
- Financial services
- Logistics and transport
- Communication,
- Construction

These identified clusters provide an important strategic roadmap also for the institutions. Cluster policies can serve as a strategic guideline for the institution, particularly in *new capacity* building, whether that means moving towards more value-added R&D activities, or inlcuding new scientific fields.

Clusters and their requirements can also be used in assessing collaboration between institutions, merging them, or combining parts of them. In essence, the institutions should take aim at corresponding and providing solutions and support for the eleven clusters as effectively as possible when such is reasonably within the scope of the PTI's. This is particularly important when if there are significant *new* capacity building. The PTI's already support the most important clusters, and have an opportunity to deepen and diversify the support.

2.3.5 Recommendations At Institute Level

There are no easily identifiable recommendations that would be inclusive of all the institutes. A beneficial polciy for the PTI's should nonetheless include some critical elements that improve the framework and environment in which the PTI's functions (these restructuring recommendations are found in Chapter 5). At individual institution level there are however some changes that would be beneficial to include in restructuring the overall PTI's system. These changes do not necessarily require any strict reconstruction within the institutions, but instead some new strategic alignment. The focus on the cluster policy is one of such alignment.

In Table 6 the institutes are grouped in three, under three different policy recommendation. This grouping is suggestive, and should not be considered rigid, but instead a framework that is flexible and reflect development of the *capabilities and competences, missions, and potentials* of each institutes. This flexibility is particularly important in coming years as the overseas study programs generates new human capital in Chile.

This performance-driven approach allows the institutes to develop their existing capacities, and seek for suitable measures and paths to improve current relevance to clients, stakeholders, and NIS in general.

Group 1 in the Table 6 include those institutes that would be govern under the SNITec mechanism. Recommendations for this group are:

- Funds for developing human resources should be increased
- Funds for infrastructural upgrades should be increased
- The activities of the institutions should closely follow the cluster policies
- The institutions should deepen collaboration with existing clients and stakeholders, and international partners

Group 2 include institutions that are national interest/dependent institutions. Recommendations for this group are:

- The activities of the institutions should closely follow the sponsors' needs and strategic decisions
- IGM, SAF, and SHOA should explore the feasibility of joint functions and a common development remaining separate or as a single institute
- All the synergies between the institute should be explored and evaluated carefully

Group 3 include institutions that are independent institutions. Recommendations for this group are:

- Complete independence of INN should be considered, allowing the institute to explore new business models and revenues
- Fundacion Chile should continue to enjoy current level of support and independence

2.4 Chilean PTIs and Finnish government institutes in comparison

There are differences between the countries in terms of size, financial structure, functions, R&D intensity etc. of the public research institutes. However, international comparisons show that basic institutional structures in various countries resemble surprisingly much each other. The differences are mainly due to differences in economic structures and the stage of development of the countries. Existence of similarities can be seen from a rough comparison of Chilean PTIs and Finnish Public Research Institutes (Table 3)**.**

Chilean PTI	**Finnish counterpart**
Agricultural Research Institution	Agrifood Research Finland
Forestry Institute	Finnish Forest Research Institute
Natural Resource Information	Finnish Environment Institute
Fisheries Development Institute	Finnish Game and Fisheries Research Institute
Chilean Nuclear Energy Commission	Radiation and Nuclear Safety Authority
National Geological and Mining Service	Geological Survey of Finland
Isaac Newton Astronomical Institute	Finnish Meteorological Institute
Hydrographic and Oceanographic Service of the Chilean Navy	Finnish Institute of Marine Research
Military Geographical Institute	Finnish Geodetic Institute
Arial Photogrammetric Service of the Chilean Air Force	Finnish Meteorological Institute
Chilean Antarctic Institute	
National Normalization and Standard Institute	Centre for Metrology and Accrediation
National Hydraulics Institute	Centre for Metrology and Accrediation
Mining and Metallurgical Research Centre	Geological Survey of Finland

Fundación Chile	Finnish Funding Agency for Technology and Innovation
	Finnish Institute for International Affairs
	National Research Institute of Legal Policy
	Government Institute of Economic Research
	Research Institute for the Languages of Finland
	National Board of Antiquities
	Finnish Food Safety Authority
	National Consumer Research Centre
	VTT Technical Research Centre of Finland
	National Research and Development Centre for Welfare and Health
	Finnish Institute of Occupational Health
	National Public Health Institute

***Table 3**: Chilean PTIs and Finnish government research institutes in comparison.*

Practically every single Chilean PTI has a counterpart in Finland. Both of the countries have research institutes for exploration and exploitation of basic natural resources or for basic industries (agriculture, forestry, fishery and mining). In both countries these research institutes have a long history and a well-established position in their national innovation systems and among the users of their services. The institutes are facing similar significant future challenges coming from globalising economy (a need to improve quality of products and to increase value added of production) and new scientific and technological opportunities (e.g. exploitation of biotechnology in agriculture and forestry).

The other common group of research institutes in Chile and Finland makes up of institutes working for civil infrastructure and national security. These include institutes for meteorology, conservation of the environment, nuclear safety, metrology, standardisation, and marine research. These institutes are providing information and other services for public agencies, private organisations, and also to private citizens. In addition to Chile and Finland, all other countries have

come to the conclusion that a major part of these activities and services must be provided by publicly owned and mainly publicly funded organisations.

The most striking difference is lack of an institute like The Technical Research Centre of Finland (VTT) in Chile. In Finland, VTT has formed a backbone of the whole system of public research institutes in Finland, and has been playing an important role as a creator and developer of technological know-how for a wide range of industries. VTT has not only been involved in R&D but also in testing and inspection. The functions carried out by VTT in Finland, have been divided in Chile by a larger number of actors, including companies, private service providers, universities, and some PTIs. Weaknesses of the Chilean divided model are unsatisfactory coordination and collaboration between different fields of technology and industry, difficulties to reach a sufficient amount of resources, and a risk that certain fields (e.g. new emerging fields of science and technology) or user groups (e.g. small and medium sized companies) do not receive the attention and accumulation of knowledge and know-how which they would deserve.

Another difference between Chile and Finland is that Finland has a government research institute for such governmental functions as international, economic, legal, as well social and health policies. Some of these institutes are fairly small in size, but all of them are considered to be important sources of information and analysis for policy making. In Chile, it is mainly the task of universities to produce well educated experts and new knowledge for the needs of public administration. This is one the basic functions of Finnish universities, but in Finland this mechanism has been complemented by more specialized research institutes with closer links to ministries and public authorities.

3 RATIONALES FOR PUBLIC INNOVATION POLICIES

3.1 Theoretical background for innovation policy

The theoretical background for innovation policy is diverse; it includes literature starting from traditional microeconomic theory, extending all the way to modern systemic theory of innovation. In this chapter we briefly review the relevant literatures and theories. Against this background, we seek to draw some general conclusions about the appropriateness of the institutes we are analysing, and their overall missions.

The diversity of approaches derives partly from different conceptual bases, and partly from different areas of empirical study. Diversity, from one perspective, is a problem since it does not lead to any clear and unambiguous set of conclusions. However it is important to note that all of the approaches have in common a recognition of the centrality of R&D and innovation in economic performance and that there is a rationale for public provision of or support for R&D and innovation performance.

The basic weakness of many of the theories is that they rest on a relatively simple view of the relations between R&D, innovation and growth. The impacts of R&D on output and innovation are seen as rather direct and unproblematic, as a linear chain from basic research to industrial and other innovations with profitable returns. It is necessary to recognize a much greater complexity, stressing a potential need for public support across a much wider range of activities – in basic R&D, standards setting, finance, IPR structures and so on.

At best theories provide a penetrating tool with which to examine the validity of policy interventions and at worst they can close-off obviously beneficial ways forward. The links between policy concerns and theoretical rationales are further complicated by the fact that our understandings of the innovation

process itself have often been driven by policy dilemmas, and these understandings have in turn shaped new approaches to policy.

An interesting question without a clear answer is how much and how theoretical approaches have been used e.g. in above mentioned countries in the construction of R&D systems and mechanims. Technology policy making as making of any other policy is a very pragmatic activity. Decision-making is based to a large extent on the personal knowledge and views of key persons. The views can be based on economic theory, but there are several other sources of inspiration. However, there is a lot of empirical evidence in various countries that the approaches which are briefly described below, market failure theory and system failure theory, have had strong influence on innovation policy making in several countries.

3.2 Traditional microeconomic theory and the concept market failure

The best known and most frequently applied of the few theoretical attempts to explain a need for government intervention in the form of R&D and innovation policy is the market-failure theory based on neo-classical economics (Arrow 1962). A market failure is said to occur if markets fail to achieve the most efficient allocation of resources. The theory assumes that a freely operating market mechanism in general guarantees that companies allocate sufficient resources for R&D and innovation, either in the hope of obtaining additional profit or to respond to a threat posed by other companies. In fact, the problem may be more one of excess investment in the form of overlapping research and development. From the viewpoint of society as a whole this does not necessarily represent the optimal allocation of scarce resources.

Nevertheless, this approach has regarded the tendency of the market mechanism to allocate insufficient resources to research and development a more serious problem than overinvestment. Research and development to which companies have sole rights and which is likely to be economically profitable is in the interests of companies, whereas projects involving risk and requiring persistence and projects whose results will be difficult to protect are readily passed over.

According to the market-failure theory, government intervention is required to ensure socially optimal allocation of resources. The basic function of government is to supplement, and to some extent replace, R&D and innovation conducted by companies with their own resources and in their own units. Moreover, it has also been felt that public R&D, whose findings are normally public and can therefore be freely applied, is more economical because unnecessary overlapping investment and activity are reduced.

The advocates of the market-failure theory have not been very specific in their conclusions and recommendations concerning R&D and innovation policy. The recommendations can be summarized as follows:

- The role of government is to see to the creation of basic capabilities in R&D and innovation. Although the results of basic research are not immediately applicable, they are essential over the long term to the continuity of corporate operations. Basic research conducted at universities and government research institutes is a typical example of government activities.

- Government should complement the operations of capital markets by sharing in the risks and other uncertainties entailed in corporate research and development; it should provide increased incentive for research and development and reduce unnecessary overlapping investment in research and development. Tax relief for research and development expenditure, product development loans and grants, and the promotion of collaborative efforts between companies are typical means.

- It is the function of government to see that sufficient funds are invested in R&D related to the externalities of corporate activity, e.g. to research and development that promotes environmental protection and similar objectives. Examples are emission norms, pollution taxes and public support for research and development of environmentally sound products and processes.

The market-failure theory has been criticized from at least three angles (Metcalfe 1995). First, since the theory relies on the basic premises of neo-classical economics (equilibrium, free competition, perfect information, rational decision-making, homogeneity of various factors), scholars who take a critical view of these basic assumptions in general take a critical view of the market-failure theory as well.

Second, the theory has been criticized for being a poorly articulated and deficient concept of government, whose task according to the theory is to complement the operations of the market mechanism. It has been said that “government failure” may be as big a problem or an even bigger problem than

"market failure". How can civil servants have the knowledge and understanding of the needs and potentials of markets if the companies operating on them do not? In Chile the Innovation Council for Competitiveness functions as an expert organization to respond to this government challenge.

Third, although the theory would seem to legitimate government intervention in the form of technology policy, it is difficult to draw specific conclusions concerning the content, strength, etc., of intervention carried out on the basis of it. Its contribution to practical decision-making is allusive. Typical of the theory is that it can be used both to defend tax incentives and oppose corporate subsidies (product development loans and grants) and vice versa.

3.2.1 Market Failure Arguments in Chile

Market failure argumentation in Chile is a constructive and a valuable exercise. It is apparent that currently the freely operating markets in Chile carry only limited benefits to the National Innovation System (NIS). In essence, from the NIS point of view, there are several indicators and factors which point towards the structural failures of the market. Inadequate allocation of resources in R&D is perhaps the most apparent indicator of the inefficient market. R&D investment level, which stands at 0.7% of the GDP, is significantly lower than in the most dynamic economies. The investment level is also below many other emerging economies in Europe and elsewhere.

In addition to low R&D investments in Chile, there are several other identifiable market failures, which justify Government intervention and public funding of the Chilean PTI's:

- *Technical inefficiency,* Chilean exports consists mostly of natural resources and agricultural products, and there is limited value-added production in Chile focused few sectors.

- *Imperfect knowledge,* small produces a) are unaware of all the opportunities, b) have limited capacity to measure production, specifically in agriculture and fishing. Small producers do not have equal access to technology and information to
- *Environmental degradation,* industrial production threatens several industries, namely agriculture and fishing, and human well-being and equality.
- *Professional training,* of scientists and technicians depends on the PTI's and few research universities.
- *Resource immobility* is a fundamental challenge of the Chilean geography. The competitive factors, including human resources, are geographically very uneven. The regional presence of the PTI's offices and research centers narrow the existing gaps.
- *External costs/Barriers to enter,* Chile is dependent on exports and thus vulnerable to standards and other barriers that the main trade partners impose on imported goods.

3.3 The contribution of system of innovation approach

The new understandings of innovation have rejected the idea that innovation simply flows from some earlier process of scientific or technological discovery. These new views rest on two basic insights. First, innovation has come to be seen as a non-linear process, involving not just research but a complex set of many related activities, such as training, design, finance marketing and so on. Innovation relies on the creation of specialised competence in all of these areas, and successful innovation requires integration of these activities. Second, innovation is seen as a process of interaction between firms and their external environments. That is, firms do not innovate alone, but by interacting with universities, technological institutes, consulting companies, suppliers and even competitors. This external environment has usually been conceptualised in terms of national or regional 'systems of innovation' (Edquist 2005).

What can be concluded here, in terms of the scope and rationale for innovation policy? Firstly, that it is possible – particularly in small economies – that market systems will not provide the full range of support processes that innovating firms

require if they are to innovate successfully or to survive unsuccessful innovation projects. Secondly, just as innovation itself is a complex mixture of elements, so innovation policy support will have to involve many dimensions. So innovation policy actors are likely to be needed in a diverse set of functions – R&D, finance, training, marketing and so on. Of course such diversity is likely to raise further problems of coherence and coordination (Georghiou et a. 2003).

Some of the support mechanisms for innovation involve the kinds of long-lasting, expensive, collective inputs that we usually refer to as infrastructure. With respect to innovation, the key infrastructures include research systems (both universities, institutes and government labs), education and training systems (at all levels), IPR systems, as well as more general institutions in the economic process.

Although there is plenty of evidence that infrastructures can be successfully operated privately, they have only rarely been constructed without major public support of one kind or another. There are many potential reasons for this, the most important of which are scale, time frame, and finance. The infrastructures usually need to be constructed on a large scale, and with very long time horizons – each of these provides major problems in investment appraisal and in securing of finance.

Infrastructures are themselves systems, requiring intensive co-ordination efforts, and for this reason are often initiated by, or by part of, the public sector. Much of the recent research on innovation systems suggests that infrastructures can play a key role in the success or failure of specific companies and innovations. They are therefore a central component of innovation policy.

These issues tend to look different in large and small economies. In larger economies, the extent of the market often works to support this type of specialised division of labour. In smaller economies, where the demand for such

services is smaller and often occasional, such services are often in effect not provided. It may be that firms in smaller economies can seek support from market participants in larger economies, but here we need to bear in mind the diversity of economies. Smaller economies are often specialized in particular areas that do not lend themselves to support from firms active in larger economies.

A special need for government actions comes from the fact that firms attempt to specialize very much around their existing areas of competence. This means that they are extremely vulnerable to change in the underlying knowledge bases of production. Discontinuous technological change, at any level, poses major problems for firms and innovation systems, mainly because it leads to existing firms dying and being replaced by new entrants. For large economies this is not necessarily a problem, but for smaller economies it can be very serious.

This implies that small innovation systems need to pay attention to monitoring and adapting to radical new technologies, and that this is a function for public policy. Firms are notoriously bad at identifying and adapting to technological threats emerging from outside their existing areas of specialization and competence. So an important implication from innovations systems approaches is the need for some form of policy agency not only to co-ordinate other agencies, but also to engage in foresight and assessment of longer-term policy options.

3.4 Summary of theoretical arguments for innovation policy

The main aspects of the theoretical speculation above can be put together as follows:

Market-failure

- The role of government is to see to the creation of basic capabilities in R&D and innovation. Basic research conducted at universities and government research institutes is a typical example of government activities.
- Government should complement the operations of capital markets by sharing in the risks entailed in corporate research and development; it should provide increased incentive for research and development and reduce unnecessary overlapping investment in research and development.
- It is the function of government to see that sufficient funds are invested in R&D related to the externalities of corporate activity, e.g. to research and development that promotes environmental protection and similar objectives.

Innovation as an interactive process

- Innovation is a non-linear process, involving not just research but a complex set of many related activities, such as training, design, finance marketing and so on.
- Innovation relies on the creation of specialised competence in all of these areas, and successful innovation requires integration of these activities.
- Firms do not innovate alone, but by interacting with universities, technological institutes, consulting companies, suppliers and even competitors.
- This external environment has usually been conceptualised in terms of national or regional ‘systems of innovation’.

Several dimensions of innovation policy

- Market systems will not provide the full range of support processes that innovating firms require if they are to innovate successfully or to survive unsuccessful innovation projects.

- Just as innovation itself is a complex mixture of elements, so innovation policy support will have to involve many dimensions.
- Innovation policy agencies are likely to be needed in a diverse set of functions – R&D, finance, training, marketing and so on.
- Of course such diversity is likely to raise further problems of coherence and coordination.

The great importance of infrastructures

- Although there is plenty of evidence that infrastructures can be successfully operated privately, they have only rarely been constructed without major public support of one kind or another.
- There are many potential reasons for this, the most important of which are scale, time frame, and finance.
- The infrastructures usually need to be constructed on a large scale, and with very long time horizons – each of these provides major problems in investment appraisal and in securing of finance.
- Infrastructures are themselves systems, requiring intensive co-ordination efforts, and for this reason are often initiated by, or by part of, the public sector.
- Much of the recent research on innovation systems suggests that infrastructures can play a key role in the success or failure of specific companies and innovations. They are therefore a central component of innovation policy.

Foresight of longer-term policy options

- Small innovation systems need to pay attention to monitoring and adapting to radical new technologies, and that this is a function for public policy.
- Firms are notoriously bad at identifying and adapting to technological threats emerging from outside their existing areas of specialization and competence.
- An important implication from innovations systems approaches is the need for some form of policy agency not only to co-ordinate other agencies, but also to engage in foresight and assessment of longer-term policy options.

4 International analysis of the Public Technological Institutes

4.1 General viewpoints on the role of public research institutes in OECD countries

The international literature on Public Research Institutes[3] is small and sheds only a little light on what the institutes do in practice, while much of the international debate seems to have been conducted more on the basis of assumptions than of evidence (Arnold et al. 2007).

Table 7 gives some basic information on the volume and distribution of R&D expenditure in OECD member countries as well as in a few non-member economies (excl. Chile) in 2007 or latest year. In many countries, a major part or 60-70 % of R&D is performed in industry (in the business enterprise sector). E.g. in Korea, the industry is accounting for 77.3 %, in Sweden 74.9 %, in Finland 71.5 %, and in Ireland 66.8 % on gross domestic expenditure on R&D, but in Spain 55.5 %, in Mexico 49.5 %, in Hungary 48.3 %, in New Zealand 41.8 %, in Portugal 38.5 %, and in Greece 30.0 %.

[3] In the literature and everyday language there are different names to the research institutes which are – in different ways and degrees – part of the public sector: Public Research Institutes, Government Research Institutes, State Owned Research Institutes etc. For simplicity we mainly use the term Public Researc Institute, PRI. Of the Chilean institutes we use the term Public Technological Institutes.

Key R&D figures of OECD member countries and some non-member countries in 2007 or latest year

	Gross Domestic Expenditure on R&D 2007						Total Researchers 2006
		% financed by		% performed by			
	million current PPP$	industry	goverment	industry	higher education	government	full time equivalent
Australia	11 698,1	53,0	40,5	54,1	26,8	16,0	81 384
Austria	7 865,3	46,7	37,4	67,7	26,7	5,1	30 452
Belgium	6 472,4	59,7	24,7	67,9	22,3	8,6	33 924
Canada	23 838,9	47,8	32,8	54,4	36,0	9,2	125 330
Czech Republic	3 489,1	56,9	39,0	66,2	15,9	17,5	26 267
Denmark	4 651,6	59,5	27,6	66,6	26,1	6,7	28 653
Finland	6 283,3	66,6	25,1	71,5	18,7	9,7	40 411
France	41 436,2	52,2	38,4	63,3	18,2	17,3	204 484
Germany	66 688,6	67,6	28,4	69,9	16,3	13,8	282 063
Greece	1 734,6	31,1	46,8	30,0	47,8	20,8	19 907
Hungary	1 831,3	43,3	44,8	48,3	24,4	25,4	17 547
Iceland	293,0	48,0	40,5	51,5	22,0	23,5	2 155
Ireland	2 490,4	59,3	30,1	66,8	26,4	6,8	12 167
Italy	17 827,0	39,7	50,7	50,4	30,2	17,3	82 489
Japan	138 782,1	77,1	16,2	77,2	12,7	8,3	709 691
Korea	35 885,8	75,4	23,1	77,3	10,0	11,6	199 990
Luxembourg	542,1	79,7	16,6	84,9	2,4	12,6	2 346
Mexico	5 919,0	46,5	45,3	49,5	27,4	22,1	48 401
Netherlands	9 959,0	51,1	36,2	57,6	..	14,1	45 852
New Zealand	1 189,3	41,2	43,0	41,8	32,5	25,7	17 235
Norway	3 686,2	46,4	44,0	54,1	30,2	15,7	21 653
Poland	3 110,0	33,1	57,5	31,5	31,0	37,0	59 573
Portugal	1 839,5	36,3	55,2	38,5	35,4	14,6	21 126
Slovak Republic	467,1	35,0	55,6	43,1	24,1	32,8	11 776
Spain	15 595,7	47,1	42,5	55,5	27,6	16,7	115 798
Sweden	11 815,3	65,7	23,5	74,9	20,4	4,5	55 729
Switzerland	7 479,2	69,7	22,7	73,7	22,9	1,1	25 400
Turkey	4 883,7	46,0	48,6	37,0	51,3	11,7	42 663
United Kingdom	35 590,8	45,2	31,9	61,7	26,1	10,0	183 535
United States	343 747,5	64,9	29,3	70,3	14,3	11,1	1 387 882
EU-27	242 815,6	54,1	34,7	63,0	22,1	13,8	1 332 397
Total OECD	817 768,9	62,7	29,5	68,8	17,1	11,4	3 879 394
Non-Member Economies							
Argentina	2 317,9	29,4	66,7	30,4	26,5	40,7	35 040
China	86 758,2	69,1	24,7	71,1	9,2	19,7	1 223 756
Israel	7 985,1	69,0	23,3	78,3	13,2	5,1	..
Romania	1 066,8	30,4	64,1	48,5	17,7	32,3	20 506
Russian Federation	20 154,9	28,8	61,1	66,6	6,1	27,0	464 357
Singapore	4 782,5	58,8	36,4	65,7	23,9	10,3	25 033
Slovenia	784,1	59,3	34,4	60,2	15,1	24,5	5 834
South Africa	3 654,3	43,9	38,2	58,3	19,3	20,8	17 303
Chinese Taipei	16 552,9	67,2	31,4	67,5	12,2	19,9	95 176

***Table 7**: Gross Domestic Expenditure on R&D in OECD countries in 2007*[4]

[4] Source: OECD, Main Science and Technology Indicators, April 2008

The column R&D performed by government reflects the proportional size of the complexity of government research institutes. In practically all countries, government research institutes form a major part of the government sector. Also in this sector, there is variation between the countries. In Poland, the proportion of the government sector is as much as 30.2 %, in Slovak Republic 32.8 %, and in New Zealand 25.7 %. On the other hand, in Switzerland this sector accounts for only 1.1 %, in Sweden 4.5 %, in Austria 5.1 %, and in Japan 8.3 %. Usually in countries where the role of the government sector (i.e. government research institutes) is smaller than average, the role of the universities is correspondingly bigger than average.

4.2 Analysis by countries[5]

4.2.1 Austria

Austrian Research Centers

Austria's largest non-university research establishment, Austrian Research Centers (ARC) operates at the interface between basic research and companies, ensuring that Austrian industry benefits from its research. It does so

[5] The main information sources of this chapter are:

- Erawatch Research Inventory (http://cordis.europa.eu/erawatch/)
- Trend Chart Innovation Policy in Europe (http://www.trendchart.org/)
- E. Arnold, N. Brown, A. Eriksson, T. Jansson, A Muscio, J. Nåhlinder and C. Zaman (2007), The Role of Industrial Research Institutes in the National Innovation System, VINNOVA Analysis 2007:12
- J-F. van Giessel, M. de Heide, P. den Hertog, G. van der Veen, and R. te Velde (2006), Quick Scan (on the use of PPPs in) focus, mass and valorization in scientific research in eight European countries, Utrecht/Amsterdam January 2007
- OECD Reviews of Innovation Policy New Zealand 2007,
- Internet pages of the research institutes
- A few phone calls to the representatives of the institutes.

through research contracts from companies, technology transfer in small and medium-sized enterprises, its project partnership with industry in national, European and international research programs, and by training young researchers, who acquire not only excellent scientific know-how, but also the skills to manage research, which they are able to use innovatively once they move to industry. Moreover, ARC supports policy-making in various areas (RTD, Environment, Transport, Energy, IST, Life Sciences, etc.) at national and European level, and in various functions.

ARC is a limited liability company owned by the Republic of Austria (50.46 %) and the business sector (49,54 %). It is Austria's largest non-university establishment with 800 employees and consolidated operating earnings of € 100 million. ARC covers following fields of science and technology: Health Technologies, Material Technologies, Information Technologies, Mobility and Energy, and Nuclear Engineering.

Christian Doppler Research Association

The establishment of Christian Doppler (CD) Laboratories in 1998 has been an interesting attempt to directly link scientific research to industry needs. In a joint effort of the responsible ministry (BMVIT) and the Austrian industries (holding of state owned industries) a cluster of laboratories along technological fields of strategic relevance for the state owned industries has been set up. The majority of the so called Christian Doppler Laboratories are hosted by universities. The CD laboratories are established for a maximum of seven years, after which, in accordance to the statutes of the Christian Doppler Research Society they are ceased.

An important element of the CD model is the multi-phase evaluation procedure, which ensures the quality of the research conducted in the CD laboratories. A proposal for the set up of a CD lab is assessed in the framework of an international peer review procedure. A positive outcome of the peer review is a

prerequisite for the recommendation for funding by the CDG senate, which is composed of high-ranking research personalities from industry and science. The decision is ultimately taken by the board of directors. During the operation period of a CD laboratory, the scientific progress and the applicability of results are monitored by attendant inspection, and the future of the laboratory after the period of seven years is very much dependent on the results of the evaluations.

Financing of CD laboratories is provided in a public-private partnership model carried by the ministry and industry partners. Usually the public authorities bear 50 % of the costs of the laboratories. Even though reorganisation of state owned industries as well as tight budgets put the future perspective of CD laboratories under question, three years ago they have managed to position themselves successfully as a institutionalised form of industry lead scientific research. Christian Doppler Research Association is instituted as a non-profit organisation, association, with industrial companies, scientists and representatives of public authorities as members of the association.

The basic idea behind CD is that close cooperation between science and industry in a CD laboratory is profitable for both sides. The fundamental research receives valuable new impulses from the practical experience and can work on a topic with long-term financial security. The companies for their part can make use of the new science for industrial purposes and thereby enhance their innovative edge and competitiveness. Particular benefits for companies which CD laboratories are targeting are as follows:

- Acceleration of the innovative process by intensive transfer of knowledge between science and economy
- Ensuring sustainability in the innovation through the development of fundamental knowledge
- Minor financial risk in fundamental research
- Enhanced problem-solving capacity through access to the existing and new findings in fundamental research

- Opportunity to attain a competitive edge through basic innovations
- Opportunity to transform fundamental research findings into innovative products (technology-push innovations)
- Creation of strategic alliances with universities and research institutions
- Flexibility and straightforwardness through limited number of partners

Joanneum Research

As an innovation partner for business, industry and public administration, Joanneum Research focuses on applied research and technological development in cutting-edge key technologies. Its number of employees in 2006 was 384 (research staff 283 and administrative staff 101), and total annual budget € 31,25 million. At present, Joanneum Research receives 35 % of its contracts from business enterprises and 50 % from public authorities. The percentage of research contracts from international organisations amounts to 25 %, accounting for 25 % of its operating performance.

Since 1987 Joanneum Research has been a Limited Liability Company (GmBH) owned by Province of Syria (90 %) and a Dutch research institute TNO (10 %). The 14 Joanneum Research institutes are located in Graz, Vienna, Leoben, Niklasdorf, Frohnleiten, Weiz and Hartberg. Close cooperation with the Styrian universities allows Joanneum Research to concentrate on applied research and deal with customers' wishes in detail. About a third of the Joanneum Research heads of the institutes are university professors or university lecturers. This close link provides access to fundamental research on one hand and ensures a steady supply of young and highly talented university graduates on the other.

The fourteen institutes of Joanneum Research have been divided into six divisions: Sustainability and Environment, Information Technology, Materials and processing, Economy and Technology, Medical technology

Austrian Academy of Science

The Austrian Academy of Sciences is a legal entity under the special protection of the Federal Republic of Austria. According to the statutes of the Academy, its mission is to promote the sciences and humanities in every respect and in every field, particularly in basic research. The Austrian Academy of Sciences is the leading organisation performing non-university academic research with more than 1,100 employees.

Upper Austrian Research

The Upper Austrian Research (UAR) is a fully-owned subsidiary belonging to the Oberösterreichischen Technologie- und Marketinggesellschaft m.b.H. Its mission is to cluster and support R&D efforts in Upper Austria so that local businesses – regardless of their size - can profit from high-tech solutions. UAR provides scientists with a platform for purposeful, long-term cooperation with local businesses with the aim of producing marketable products and services. UAR is called in when businesses need new technology and research and development expertise not covered by their own facilities. UAR reinforces the potential for innovation within Upper Austrian businesses and makes a significant contribution to increasing the competitiveness of the entire region.

Salzburg Research

Salzburg Research Forschungsgesellschaft is the non-profit research organisation of the State of Salzburg. It is located within the grounds of Salzburg Techno-Z, one of Europe's largest information technology parks. Salzburg Research conducts applied research in the areas of information and communication technologies with a focus on creating and managing digital content, employing approximately 55 researchers.

Austrian Cooperative Research

Since its foundation in 1954, Austrian Cooperative Research (ACR) has offered specialised heterogeneous research and technology competences especially for the benefit of small and medium sized enterprises. ACR is a private research and technology organisation. It stimulates and enables innovation within trade and industry, thus improving the competitiveness of the Austrian economy. Currently, ACR has 18 full members. In 2003, they had a total of 435 full time equivalent employees and a turnover of € 39,4 million out of which 86,3% with SMEs. ACR is supported by the Ministry of Economics and Labour.

4.2.2 Denmark

Government Research Institutes

The Danish research institute sector has been changed dramatically due to the merger of research institutes with the universities in January 2007. Before 2007 there were 15 Danish Government Research Institutes, i.e. public institutes owned by Danish ministries, including institutes for food, the environment, space exploration and social research. In 2005 the institutes got € 201million in public funding, out of which €102.5 million was for research. After mergers with universities the number of idependent research institutes is eight.

Still independent research institutes are (turnover in € million):

- National Research Centre for the Working Environment, € 13.17 million
- Danish National Institute for Social Research, € 12.97 million
- National Eye Clinic, € 5,74 million
- Geological Survey of Denmark and Greenland, € 29.28 million
- Statens Serums Institut, € 129.17 million (in 2006)
- Danish Defence Acquisition and Logistics Organisation
- Danish Defence Acquisition and Logistics Organisation
- Danish Standards Association, € 21.06 million (in 2006)

Research institutes that have merged with universities:

- Danish Building Research Institute (now part of Aalborg University), € 8.54 million
- Health research (now part of the University of Southern Denmark), € 5.23 million
- National Environmental Research Institute (now part of the University of Aarhus), € 35.08 million
- Danish Institute of Agricultural Sciences (now part of the University of Aarhus), € 72.03 million
- Risø National Laboratory (now part of the Technical University of Denmark), € 70.22 million
- Danish National Space Centre (now part of the Technical University of Denmark), € 6.56 million
- Danish Institute for Fisheries Research (now part of the Technical University of Denmark), € 24.09 million
- The Danish Institute for Food and Veterinary Research has been split in two institutes and a commercial unit and are now part of the Technical University of Denmark (The National Food Institute, the National Veterinary Institute and Dianova), € 59.38 million
- Danish Transport Research Institute, now part of the Technical University of Denmark), € 2.72 million

The Government Research Institutes provide research and policy advice to their respective ministries. Government Research Institutes carry out about 20% of the public research in Denmark. There are three university hospitals carrying out the most substantial part of the health related research activities in Denmark, making up about 15% of the public research expenditures.

Technology Service Institutes

As a linking pin between knowledge institutions (universities, academic hospitals and Government Research Institutes) and Danish industry (with a special emphasis on SMEs), a network of GTS-institutes (Godkendte Teknologiske Serviceinstitutter) have been established. They provide knowledge and competencies to Danish business and industry on commercial

basis to enhance the development and application of knowledge related to technological, managerial and market issues. The institutes are intended to encourage firms to take innovative action. The GTS Institutes play a major role as producers and transmitters of application-oriented and technological knowledge, especially for small and medium-sized enterprises, which the institutes are encouraged to pay special attention to. As the industrial structure in Denmark is characterised by a large number of small and medium sized companies which on average do not engage in large scale research and development, it is essential that they have easy access to knowledge from knowledge institutions.

A GTS institute is a non-profit organisation that has been authorized by the Danish Ministry of Science, Technology and Innovation to use the appellation. Only firms with high professional and technical qualifications may be authorized. The authorization is given for a three years period and currently only nine organizations in Denmark are authorized. The authorization means that the organizations can apply for co-funding of competence-building activities that will enable them to supply the latest technological knowledge to Danish enterprises. In 2002 the total co-funding amounted to about € 32 million. The authorized GTS Institutes are as follows:

- GTS-Advanced Technology Group
- Bioneer (biomedicine, biomedical technology and biotechnology)
- Danish Institute of Fire and Security Technology
- Danish Institute of Fundamental Metrology
- Danish Technological Institute
- Danish Electronics, Light and Acoustics
- DHI
- Danish Toxicology Centre
- FORCE Technology

The GTS Institutes offer knowledge, technology and consultancy, co-operation on technological and market-related innovation, testing, optimisation, quality assurance, certifications and benchmarking. In total, GTS describes a fifth of its turnover as R&D. The total turnover of the grouping in 2005 was € 309 million of which the international turnover accounts for 35 %. The grouping employs approximately 2,900 employees. Half of them have a postgraduate academic degree, and 8 % of the staff hold at least a PhD. In 2005 the GTS institutes had a total turnover on € 309 million. The Institutes work for all types of private businesses and public authorities and serve customers in approx. 100 countries. The institutes have subsidiaries in 19 countries across four continents. The Ministry of Science, Technology and Innovation provides core funding for GTS on the basis of an annual performance contract. Core funding via these contracts accounts for about 10 % of turnover.

Since 1995, all GTS institutes have collaborated within a small umbrella organization – **GTS - Advanced Technology Group.** The GTS central body handles common interests of the institutes in relation to any outside parties and facilitates internal cooperation on technological, professional, administrative and managerial matters. The GTS Board of Directors consists of the CEOs of each of the nine independent GTS institutes. The Board of Directors elects its chairman and vice-chairman every year and appoints the Managing Director of the organization. GTS's daily tasks are handled by a four-person secretariat.

Danish Technological Institute (DTI) is one of the leading GTS Institutes. The Institute was founded as an independent institution in 1906 and is one of the oldest of its type in the world. The Institute now has 850 employees. It is supplying technological services such as consultancy, tests, certification and training for companies and public-sector organisations. Danish Technological Institute is an independent, not-for-profit institution approved by the Danish authorities to provide technological services to business and the community.

The Institute employs experts in hundreds of different fields at 34 centres organised under the auspices of the 5 organisational units that define the main parameters for their work:

- Building Technology
- Industry and Energy
- Business Development
- Materials
- Productivity and Logistics

DTI adopts an interdisciplinary approach to innovation and to the task of improving the ability of small and medium-sized companies to exploit new technologies and management tools. The Institute has a turnover of € 97.6 million. The Ministry of Science, Technology and Innovation invests € 10-12 million per annum in the Institute's R&D activities and the dissemination of R&D results. These funds are supplemented by the sums that the Institute contributes to self-financed joint development activities and investments in equipment. Around 18% of the Institute's turnover stems from activities abroad. The Institute participates in international programmes under the auspices of the EU, the UN and a variety of other national and international organisations. In recent years, the Institute has been particularly active in Eastern Europe.

4.2.3 Finland

There are in total 21 government research institutes in Finland, with a total research volume of € 501,8 million and total staff of 11 551 in 2007. Most research institutes are sector specific and provide information, testing, etc. for the fields and purposes of their relevant sector ministries, with one main exception – VTT. The Technical Research Centre of Finland (VTT) is by far the largest research institute with personnel of 2780 and a research volume of some € 224,8 million. It is also clearly a multisectoral contract research organisation.

Table 8 below lists the Finnish government research and gives information on funding of the institutes.

	Total funding million €	External funding % of total	Number of staff
Finnish Institute of International Affairs	1,6	6,3	25
National Research Institute of Legal Policy	1,5	25,8	24
Government Institute for Economic Research	4,7	19,1	57
Research Institute for the Languages of Finland	5,9	13,4	119
National Board of Antiquities	1,8	24,7	930
Finnish Geodetic Institute	4,3	22,5	60
Finnish Game and Fisheries Research Institute	14,9	18,2	321
Agrifood Research Finland	47,0	28,7	841
Finnish Forest Research Institute	44,9	10,9	925
Finnish Food Safety Authority	4,1	20,7	750
Finnish Institute of Marine Research	5,7	15,3	112
Finnish Meteorological Institute	15,1	27,5	610
Centre for Metrology and Accreditation	2,8	15,0	65
National Consumer Research Centre	2,6	26,7	40
VTT Technical Research Centre of Finland	224,8	67,3	2780
Geological Survey of Finland	13,5	19,3	796
National Research and Development Centre for Welfare and Health	19,0	22,1	474
Finnish Institute of Occupational Health	23,7	36,7	800
National Public Health Institute	36,0	27,8	882
Radiation and Nuclear Safety Authority	6,7	11,0	338
Finnish Environment Institute	21,2	50,8	602
TOTAL	**501,8**	**24,4***	**11 551**

*On average in the institute

Table 8: *Finnish government research institutes*

Table 9 below maps the Finnish institutes according to their activities and sector. Bolded marking refers to the main activity of the institute.

	Sector	R&D	Knowledge creation	Information Services	Tech. Transfer	Regulation/ Certification	Technical assistance/ training	Cluster activities	New business creation
Finnish Institute of International Affairs	International relations	**O**	x	x					
National Research Institute of Legal Policy	Legal policy	**O**	x	x					
Government Institute for Economic Research	Economic policy	**O**	x	x					
Research Institute for the Languages of Finland	Linguistic studies	**O**	x	x					
National Board of Antiquities	Cultural heritage	x	x	**O**	x	x			
Finnish Geodetic Institute	Geodesy	**O**	x	x	x	x	x		
Finnish Game and Fisheries Research Institute	Natural resources	x	x	**O**		x	x		
Agrifood Research Finland	Agriculture and food	x	**O**	x	x	x	x	x	x

Finnish Forest Research Institute	Forestry	**O**	x	x	x	x	x	x	
Finnish Food Safety Authority	Food safety	x	x	**O**	x	x	x		
Finnish Institute of Marine Research	Marine information	x	**O**	x		x	x		
Finnish Meteorological Institute	Eartth's atmosphere	x	**O**	x	x	x	x		x
Centre for Metrology and Accreditation	Measurements, tests and inspections	x	x	x	**O**	x	x		
National Consumer Research Centre	Consumer policy	**O**	x	x		x			
VTT Technical Research Centre of Finland	Industrial development	**O**	x	x	x	x	x	x	x
Geological Survey of Finland	Mineral resources	x	**O**	x	x	x	x	x	

National Research and Development Centre for Welfare and Health	Welfare and health	**O**	x	x		x	x		
Finnish Institute of Occupational Health	Occupational health and safety	**O**	x	x		x	x		
National Public Health Institute	Health and welfare	**O**	x	x		x	x		
Radiation and Nuclear Safety Authority	Radiation and nuclear energy	x	x	x	x	**O**	x		
Finnish Environment Institute	Environmental issues	x	x	**O**		x			

***Table 9*:** Sector and activities of the Finnish Institutes (**O** for main activity)

Funding and staff of Finnish government research institutes

On average, 24,4 % of the public research institutes' financing comes from external funding. The only two research institutes receiving over 50% of their funding from external sources are VTT and the Environment Institute of Finland. Being based on the institutes' target outcome, the share of external funding is an estimate. In terms of research volume, the largest institutes are VTT in the

Ministry of Employment and the Economy, the Forest Research Institute and the MTT Agrifood Research in the Ministry of Agriculture and Forestry, the National Public Health Institute and the Institute of Occupational Health in the Ministry of Social Affairs and Health, and the Environment Institute in the Ministry of the Environment.

In Finland, big changes are expected in the organisation and governance system of the government research institutes. A working group appointed by the Ministry of Education suggested in its report which was released in January 2006 that a totally new mechanism should be adapted in Finland for financing public research institutes. The basic idea is to pool part of basic government funds of the institutes and reallocate them to four research fields. These fields are living environment and urban structures, knowledge, work and well-being, sustainable development, and security. The reallocation of resources is going to be made on a competitive basis by an advisory board appointed by the Ministry of Education. The implementation of the proposal is going on.

Technical Research Centre of Finland (VTT)

Founded in 1942, VTT Technical Research Centre of Finland is the biggest contract research organisation in Northern Europe. It is a non-profit-making organization under the domain of the Ministry of Employment and the Economy. Its objective is to develop new technologies, create new innovations and value added thus increasing customer's competitiveness. VTT produces research, development, testing and information services to public sector and companies as well as international organisations. Table 9 lists VTT’s key figures.

VTT’s research fields are:

- Biotechnology, pharmaceutical and food industries
- Process industry and environment
- Electronics

- Energy
- Pulp & paper
- ICT
- Machines and vehicles
- Real estate and construction
- Services and logistics

Economic information	- turnover € 217 million - external income € 141 million (65% of turnover) - basic governmental financing € 76 million (35% of turnover) - income from abroad 28 M€ (13% of turnover)
Staff 2,780	- university degree: 75% of staff - doctors or licentiates: 23% of staff - 61 research scientists on assignment abroad - 91 foreign visiting research scientists at VTT
Customers 5,700	- domestic companies 3,400 - foreign companies 580 - public organizations in Finland and abroad 400
Effective research	- altogether over 1,100 patents during past 20 years - about 1,000 patent applications in Finland and about 1,300 abroad - over 2,000 notices of invention - 40,365 publications

Table 10: *VTT's key figures (in 2006)*

Agrifood Research Finland (MTT)

MTT Agrifood Research Finland is carrying out agricultural and food research, plus economic and environmental research related to agriculture. Operating under the Ministry of Agriculture and Forestry, MTT employs approximately 850 people, including more than 300 researchers and other experts. MTT operates at 14 locations across Finland, and participates actively in international networks and research projects both in Europe and worldwide. MTT's total expenditure in 2006 was € 47 million, one third of which comes from external

funding sources. MTT carries out research in four different research units (biotechnology and food research, animal production, plants, economics) and through two research programmes (technology programme, environmental programme).

In 2006, MTT produced 1,868 publications, which was 24% more than in the previous year. Exceeding the figures reached in 2005 by 10%, the number of refereed scientific publications totaled 172. In addition to research, MTT has tasks that serve authorities, the society and the research community in general. These tasks include supporting the preparation of agricultural, rural and environmental policies, supporting the guidance of plant and animal production, supporting the preparation of regulations and norms pertaining to agricultural and food technologies, providing topical services for agricultural entrepreneurs, and supporting the research community.

MTT adopted in 2006 a new management system and organisational structure. The objective of the extensive reform was to increase operational efficiency and impact on the development of various social segments and on political decision-making. The regional organization has also been streamlined. The reform involved moving the resources of four offices to one office located in the same area. This resulted in stronger regional MTT operators. The regional stations were also made part of the new organisation based on science branches, making the regional operators national.

Finnish Forest Research Institute

The Finnish Forest Research Institute (Metla) was established in 1917. Since then Metla has grown considerably; the current network of research centres, research stations and research forests covers the whole country. Metla is a governmental, sectoral research institute, subordinate to the Ministry of Agriculture and Forestry. Metla's mission is to promote ecologically,

economically and socially sustainable development of the forests and forestry through research. In order to meet these goals Metla

- conducts research and generates research information about forest nature and environment, and different uses of forests, as well as about forestry and the forest cluster
- serves the information end-users and acts as an expert in a wide range of forest-related statistical, monitoring and inspection tasks
- is responsible for forest-tree breeding at the national level, and conducts research in forest genetics
- performs the tasks assigned to it as a state authority
- manages the research areas and nature conservation areas under its jurisdiction
- publishes research results and serves information users by informing them about the latest results, events and other major topics related to forest research and forestry.

Metla's total number of personnel is more than 900. There are 336 researchers working at Metla, of whom about two thirds hold a degree in forestry. Other fields of expertise cover e.g., general and business economics, social sciences, natural sciences, and technology. 154 researchers have a doctor's degree (Ph.D.) Approximately half of the staff are working in the Greater-Helsinki area, and the other half at the Joensuu research centre, and at the research stations and other regional units in various parts of Finland.

The funding of operations of Metla comprise funding from budgetary provisions, commission-based income and shared project funding. Most of the funding is received from the operating provisions designated in the national State budget. In total, the research funding amounted in 2006 to € 52,4 million. The State budget provisions represented 74% and external funding 26% of the total funding. The most important national financiers for shared funding projects are the Ministry of Agriculture and Forestry, the Ministry of the Environment, the Employment and Development Centres, the Academy of Finland and the Finnish Funding Agency for Technology and Innovation (Tekes).

Geological Survey of Finland

The Geological Survey of Finland (GTK), established in 1885, is Finland's national geoscience agency. It is operating under the Ministry of Employment and the Economy. As the key government agency involved in the mineral resources sector, GTK is also active in promoting mineral exploration and mining in Finland. GTK's core activities range from geological mapping, through exploration, evaluation, and processing of natural resources, with a strong research effort in analysis of geological processes and mineral systems as well as in development and application of exploration and benefication technologies.

GTK'S vision is to evolve into a European centre of excellence for natural resources and their sustainable use and to consolidate its role as the national geoinformation centre. GTK maintains a balance of resources between its primary responsibilities for public domain mapping and geodata management, technological and conceptual research and development, and provision of commercial services to both public and private sector clients. GTK´s services are to a large extent based on methodologies and technical solutions developed and tested in house before being adapted to commercial projects. GTK is currently contributing to some twenty R&D projects within the European Commission and various other science and technology projects in different fields of earth sciences.

GTK employs 800 people of whom some 300 experienced scientists (more than 70 PhD's). Total costs of operations amounted to € 56.7 million in 2006 with income from contract services € 12.4 million. GTK's main focus is in applied science. Prices of undertakings by the GTK Services are clearly set apart from the public sector duties performed by GTK Survey.

KCL

KCL is a limited liability company owned by the Finnish pulp, paper and board industries. Founded in 1916, KCL is one the few private research institutes in Finland. KCL carries out research in the entire value chain of papermaking,

from raw materials to the printed end products and consumer habits. Of its activities, the proportion of industrial solutions, laboratory and pilot services, and knowledge applications is 49 %, joint research program 39 %, and public research funding 12 %. The public research funding consists of project specific funding from national, Nordic and European sources. KCL's budget is € 24 million, and the number of staff 290.

4.2.4 Ireland

Compared to large EU Member States, Ireland has a small number of public research organisations, but they are playing important role in their specific fields. The activities of these organisations are mostly focused on natural resources (food, agriculture, forestry and marine), health, energy and the environment. Prominent public research organisations in Ireland include the following:

Teagasc (parent government department: the Department of Agriculture and Food) provides integrated research, advisory and training services for the agriculture and food industry in Ireland. Around 75% of Teagasc's yearly budget comes from the Irish exchequer and EU funding with the balance generated from earned income. Some 40% of the budget is devoted to research with the remainder split half and half between advisory and training services. Teagasc employs over 1,500 staff at over 100 locations throughout Ireland. Employing 200 research scientists and 300 research technicians, Teagasc is the largest public research organisation in Ireland.

COFORD/National Council for Forest Research and Development (parent government department: the Department of Agriculture and Food) both coordinates and funds appropriate and cost-effective research to secure long-term industrial viability and optimise social, environmental and cultural developments associated with forestry.

The Marine Institute (parent government department: the Department of Communications, Marine and Natural Resources) is Ireland's national agency with the statutory remit to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development, that in the opinion of the Institute will promote economic development and create employment and protect the environment. One of the Marine Institute's two main roles is to support research, technology, development and innovation activity to create further employment and to underpin future innovation, growth and wealth creation in the marine area.

The Health Research Board (parent government department: the Department of Health and Children) improves health through research and information. Through its support for health research, the HRB seeks to strengthen the research capacity on the island of Ireland.

Environmental Protection Agency (parent government department: the Department of Environment, Heritage and Local Government) has a wide range of functions to protect the environment and among its principal functions is the undertaking of environmental research as effective management of the environment is increasingly science-driven.

Ireland's 3% Action Plan, "Building Ireland's Knowledge Economy," highlighted the low level of research been conducted in the Irish public sector. It pointed out that the measure of expenditure on public sector research known as GOVERD was only 0.13% GNP in Ireland, below that of Finland (0.37%), Denmark (0.31%) and the Netherlands (0.34%).

4.2.5 Netherlands

Research organisations in the Netherlands are relatively autonomous and define their individual development paths and strategies. The public science basis of the Netherlands can be divided into a number of types of organisations:

- A number of **Fundamental Research Centres** that are either governed by the Netherlands Research Council NWO or its affiliated organisations, e.g. Foundation for Fundamental Research on Matter (FMO) or the Royal Netherlands Academy for Arts and Sciences (KNAW).
- Other actors in the knowledge infrastructure are the agricultural research institutes of the DLO Foundation (part of the Wageningen University and Research Centre WUR), several state-owned research and expertise centres and several other **Governmental Research Institutes** in various fields of sciences.
- In addition the system has quite a number of non-academic public research organisations. The largest of these is **TNO**, the Netherlands Organisation for Applied Scientific Research, which is an independent contract research organisation. There are five so-called "Large Technological Institutes" that conduct applied research and related activities, such as advising industry and government, in specific fields.

Fundamental Research Centres

The Royal Netherlands Organisation for Scientific Research NWO acts as an umbrella organisation for nine so-called **NWO Institutes**. The institutes are permanently concerned with different aspects of scientific research in the fields of physics, mathematics and computer sciences, astronomy and space research, marine research, history and penal science. The institutes employ more than 1300 employees, and the institutes are wholly or partly funded by NWO.

The Royal Netherlands Academy of Arts and Sciences (KNAW) acts as an umbrella organisation for 18 so-called **KNAW Institutes**, which are primarily engaged in basic and strategic scientific research and disseminating information in the life sciences, humanities and social sciences. Some of the institutes also have a scientific service function by forming and managing biological and documentary collections, providing information services and creating other facilities for research. The Academy's institutes, which are located throughout the country, employ a total of approximately 1300 staff.

A **Leading Technology Institute** (LTI) is a partnership for innovation between the business world, knowledge institutions and government. The LTIs are a unique and successful instrument that the government has introduced to boost the Netherlands' innovative capacity and competitive strength. In 1998 four leading technology institutes were founded:

- Dutch Polymer Institute (Eindhoven) focuses on research and development relevant to the polymer producing and processing industry
- Netherlands Institute for Metals Research (Delft) enhances the competitiveness of the Dutch metal industry through strategic research into metal science, metal production and metal engineering
- Telematics Institute (Enschede) develops solutions for the innovative application of information and communication technology (ICT) in the business world and wider community
- Wageningen Centre for Food Sciences (Wageningen) aims to be the networker and facilitator of breakthrough research in food and nutrition

Recently, the Ministry of Economic Affairs decided to start some new LTIs:

- Dutch Separation Technology Institute (Amersfoort) develops knowledge and focuses on the demonstration and application of new improved separation technologies

- Top Institute Pharma (Leiden) aims to achieve leadership in research and education areas critical for the international competitiveness of the pharmaceutical industry in the Netherlands
- Wetsus (Leeuwarden), Centre for Sustainable Water Technology, focuses upon the development of treatment technologies for sustainable water
- TTI Green Genetics (Gouda) strengthens the knowledge base of the Dutch plant cultivation industry

Both in the Netherlands and abroad the LTI formula is regarded as one of a best-practice model of public–private cooperation for making that step from knowledge to innovation. This formula continues to be relevant today. The instrument has an important role to play in Dutch innovation policy. It is consistent with the thoughts of the "innovation platform" and with the increasing importance of networks, public–private cooperation, demand drive and programme funding.

Furthermore, there are five **Large Technological Institutes,** conducting applied research and related activities, such as advising industry and government in specific fields. These institutes are active in aerospace, water management, hydraulic engineering, maritime research, and energy research.

Governmental Research Institutes

There are several research institutes in the Netherlands that operate under a ministerial umbrella, although the number of these state-owned centres is decreasing. Some of them are directly connected with ministries, such as the Research and Documentation Centre of the Ministry of Justice, others are ministerial agencies, such as the Royal Netherlands Meteorological Institute (KNMI) of the Ministry of Transport, Public Works and Water Management. Most of the public research organisations in the Netherlands are semi-public in the sense that they rely on both public and private funding.

One of the larger governmental research organisations is the National Institute for Public Health and the Environment, which conducts research relating to government policy and the supervision of public health, the environment, and nature management. It is an independent agency of the Ministry of Health, Welfare and Sport, but it also conducts research for the Ministry of Housing, Spatial Planning and the Environment and the Ministry of Agriculture, Nature Management and Food quality.

The Directorate-General Public Works and Water Management of the Ministry of Transport, Public Works and Water Management has two research institutes: one for coastal and marine management (RIKZ) and one for inland water management and waste water management (RIZA). RIKZ is an advisor, researcher and data manager, firstly for its own Ministry, but also for other international, national and regional governments. RIZA is a leading international centre of knowledge for integrated water management. The institute collects data on and conducts research into water quality and quantity. On the basis of these data the RIZA makes recommendations concerning the management of inland water in the Netherlands and abroad.

TNO

TNO is an independent contract research organisation established in 1930. It is by far the largest (semi-) public research organisation in the Netherlands. TNO is an umbrella organisation with several research centres in five key areas: Quality of Life; Defence, Security and Safety; Science and Industry; Built Environment and Geosciences; and Information and Communication Technology. TNO employs 5000 people, and its turnover was almost € 600 million in 2007. A third of this - € 196 million– was made available via government funding for the development of new knowledge. This was done for the first time in 2007 via the demand-driven programmes within the twelve social and economic themes. Of the market turnover of € 383 million € 309

million comprises contract assignments from Dutch industry (42 %), international (33 %), and Dutch authorities (25 %). The other € 80 million of market turnover derives from commercialisation of knowledge by the 50 or so TNO Companies B.V.

4.2.6 Spain

From a historical point of view the Spanish Public Research Institutes (PRIs) play an important role and are involved in research areas of strategic importance for Spain's economy and society. Spain has, according to the official data of 2005, 357 such institutes with a total R&D expenditure of € 1.738 million, which is over 30 % of total Spanish R&D expenditure. More than half of these expenditures are allocated to ten largest institutes. A great number of local and regional PRIs (with 28 % of the budget) are more concerned with local economic and societal interests and many of them are active in traditional sector areas such as agriculture, fishing, textiles, etc.

More than 80 % of the funding of PRIs is directly assigned from the government budget for R&D. The rest is financed by contract research and public tenders of which 36 % is from “The National R&D Plan”, 25% from private firms, 20% from European funds and 9% from regional programmes.

The largest PRI is the Spanish National Research Council (CSIC) which employs 65 % of R&D personnel of PRIs and accounts for 33% of the their total budget. The CSIC has 126 own and 142 joint institutes with a total number of more than 12,000 people. Of these 8,700 are researchers and 3,800 research trainees. 8 % cent of the personnel work in humanities and social sciences; 23% in biology and biomedicine; 15% in natural resources; 10% in agrarian sciences; 12% in physical sciences and technology; 11% in materials sciences and technology; 6% in food sciences and technology; 10% in chemistry sciences and technology; and 5% in service centres.

Other important Spanish PRIs are listed in the table below. The biggest ones in terms of the number of personnel are the National Institute for Aerospace Technology, the Research Centre for Energy, Environment and Technology , and the Carlos III Health Institute.

	Personel	Budget (million €)
Canarias Astronomical Institute	309	56
Spanish Institute of Oceanography	560	129
National Institute for Research on Food and Agrarian Technology	967	194
Research Centre for Energy, Environment and Technology	1218	272
Head Office of Military Armament and Material	251	367
National Institute for Aerospace Technology	1353	375
Spanish Mining and Geological Institute	503	656
Carlos III Health Institute	967	720

***Table 11**: Figures of biggest Spanish Public Research Institutes in 2005 (excl. Spanish National Research Council). Source: Erawatch Research Inventory.*

In 2007, the CSIC was converted into a public agency, gaining flexibility thereby, especially in the management of their funds – which were constrained by annual budgets – and in labor relations and contracts. The new formal organisational structure implies management by objectives based on a four-year planning system reflected in bilateral contract between the state and the CSIC. Another trend in Spain has been improving collaboration between the regional level and the national. This has been a general trend applicable to the whole R&D and innovation system, and also to PRIs.

4.2.7 Sweden

The Swedish model of innovation and research funding has involved focusing resources on university sector. The institute sector in Sweden is fragmented and small. It represents only 3% of the available public R&D resources. Government research institutes are mainly engaged in research in fields of national importance, such as Swedish Defence Research Agency (with approximately 1250 employees), Swedish Institute for Infectious Disease Control, Swedish Radiation Protection Authority, and Swedish Meteorological and Hydrological Institute. The share of these and other government research institutes is around half of the whole research institute sector.

For quite many years, public funding for research institutes has been declining both in the form of core and state funded competitive research contracts. Despite their modest collective size, the research institutes have been successful intermediaries between research and industrial application, particularly for SMEs, thus playing a vital role in the innovation system.

Industrial Research Institutes with a strong focus on manufacturing industries constitute the other half the Swedish R&D in the institute sector. Swedish system of industrial research institutes, often called IRECO institutes, was established in 1997 with the objective to promote Swedish industrial growth and international competitiveness through ownership and support to industrial research institutes which formely were private or semi-private organisations. IRECO is a limited liability company owned by the Swedish government through the Ministry of Industry, Employment and Communications. The public funds are allocated by the Swedish Governmental Agency for Innovation Systems, VINNOVA. IRECO is a non-profit organisation in the sense that no dividends are to be paid to the owner.

IRECOs main tasks are to

- own shares in industrial research companies
- promote technical innovations and knowledge development within Swedish industry trough relevant R&D
- promote a relevant and suitable structure of industrial R&D institutes in Sweden
- promote and support long term competence development within the institutes
- promote cooperation between research institutes, universities and Swedish industry

IRECO is now a shareholder in three groups of applied research companies:

- STFI-Packforsk: R&D in pulp, paper, packaging and printing technology
- Swerea: R&D in material, process, product and production technology
- Swedish ICT Research: R&D in information and communication technology

Industrial companies are majority shareholders in each R&D company or Group either by direct ownership or – most commonly – indirectly through an association of Swedish and international member companies. Membership benefits include direct access to research findings, discounts and priority before non-members on contract research.

4.2.8 New Zealand

Crown Research Institutes (CRIs) were established in 1992 with the primary purpose of undertaking research for the benefit of New Zealand. In fulfilling this purpose CRIs are required to:

- undertake this research for the benefit of New Zealand;
- pursue excellence in all their activities;
- comply with applicable ethical standards;
- promote and facilitate the application of results of research and technological developments;

- be a good employer and exhibit a sense of social responsibility; and
- operate in a financially responsible manner so that they maintain their financial viability.

The CRIs are companies (registered under the Companies Act 1993) owned by shareholding Ministers, namely the Minister for CRIs and the Minister of Finance, under the Crown Research Institutes Act 1992. CRIs are also Crown Entities under the Crown Entities Act 2004. Each CRI has an independent board appointed by shareholding Ministers. All CRIs have an Output Agreement with the Minister of Research, Science and Technology. This sets out how they allocate the CRI Capability Fund to support capability. The Estimates of Appropriations set out what the CRI Capability Fund can be spent on.

The government owns CRIs to ensure that NZ maintains a critical mass and capability in strategic areas of science that are of long-term importance to NZ. CRIs are required to deliver a return to their shareholders. This return encompasses both a return on equity for shareholders and the contribution CRIs to the government's broader economic, environmental and social goals, including maintaining scientific infrastructure and capability.

CRIs revenue comes from both the public and private sector, with approximately half of their revenue coming from contestable funds administered by the Foundation for Research, Science and Technology. Further funding from the Crown also comes from the CRI Capability Fund which assists CRIs to build and maintain research capability required for the provision of public good science. This level of government revenue means that much of the research undertaken by CRIs is strongly aligned with the government's RS&T priorities. Each CRI was established around a productive sector of the economy, a grouping of natural resources or a particular public-good task, enabling each to have a clearly defined purpose and customer base. The nine CRIs are:

- AgResearch Ltd
- The Horticulture and Food Research Institute of New Zealand Ltd

- Industrial Research Ltd
- Institute of Environmental Science & Research Ltd
- National Institute of Water and Atmospheric Research Ltd
- New Zealand Forest Research Institute Ltd
- New Zealand Institute for Crop and Food Research Ltd
- The Crown Company Monitoring Advisory Unit

4.3 Summary

In table 11 we have summarised some of the main characteristics of PRIs, and described most recent trends in public research institutes in each country. The analysis clearly demonstrates that there is a lot of variation between the countries in how PRIs have been organised, what is their role in their economies and how the role has been changing, how they are funded and managed, what are their future challenges and perspectives etc. You may even conclude that there are more factors which set apart the institutes of various countries than relate them.

Country	Main characteristics	Recent trends
Austria	- minor role of PRIs - a group of independent, fragmented organisations - mixed funding and governance mechanisms	- increasing links of PRIs with companies and universities - decline in public basic funding - increasing role of funding agencies
Denmark	- minor role of PRIs - a great number of independent organisations - mixed funding and governance mechanisms	- integration of PRIs with universities - decline in the number of PRIs - growing role of competitive funding
Finland	- minor role of PRIs - significant role in certain fields - institutes linked with sectoral ministries - the share of basic funding bigger than on average	- pooling of PRIs - decline in basic government funding - increase in competitive funding - internationalisation
Ireland	- a small number of PRIs - significant role in their fields - linked with sectoral	- more attention to the development of PRIs as a whole - better integration among various

	departments - mixed funding mechanisms	actors
Netherlands	- fairly important role of PRIs as a whole - a few big independent institutes - mixed funding and governance mechanisms	- mergers with universities in agricultural research - increase in public-private collaboration - internationalisation
Spain	- important role of PRIs - a great number of institutes with various functions - dominant role of the institutes of the Spanish National Research Council	- integration of the regional level with the national level - development of governance systems of the institutes
Sweden	- a minor role of PRIs, strong role of the university sector - PRIs a heterogeneous group of institutes - industrial research institutes a special Swedish phenomenon - mixed funding and governance mechanisms	- focus on the development of industrial research institutes (IRECO) - internationalisation - development of producer-user models and new funding mechanisms
New Zealand	- important role of PRIs - Crown Research Institutes a unique national solution - independent but linked with ministries - mixed funding mechanisms	- enhanced commercial value from publicly funded research - rapid diffusion of new ideas and technologies from Crown Research Institutes (CRIs) into all sectors of the economy.

***Table 12**:*

Summary of PRIs and recent trends related to them in various countries

In terms of R&D expenditure the relative position and role of PRIs varies from country to country. They seem to be important in New Zealand, Spain, and also in the Netherlands, but small particularly in Sweden. However, this interpretation is somewhat misleading. Many of the institutes are specialised in specific sectors (food and agriculture, forestry, geology, certain fields of technology), and in their sectors they are nationally important, and in terms of the size can be even large by national and also by international standards. Particularly large and important for their economies are TNO in the Netherlands, Danish Technical Institute in Denmark, Technical Research Centre of Finland in Finland, and Crown Research Institutes in New Zealand.

A common feature to most countries is that PRIs do not form a coherent complexity or a system. On the contrary, as a whole the institutes resemble a fragmented mosaic with weak links with each others. Fragmentation has come up also in Chile, but as we can see it is not only a Chilean phenomenon. Most of the institutes are linked and governed by sectoral ministries and departments, but in most cases in fact the institutes function fairly independently on their parent organisations.

There are common features also in financing of the institutes. In most institutes the financial structure is three-fold: *basic financing* (or block funding) from the state budget either directly or through certain channels to the institutes; *competitive funding* from national and international funding agencies; *contract-based funding* from companies and other clients of the institutes. The relative importance of these three sources varies a lot from country to country and also from institute to institute within a country. Usually in technological research institutes with focus on applied research and development work and close co-operation with companies, the proportion of basic funding is smaller than in other fields and sectors.

The recent trends within the PRIs are mainly related to *financing, organisations and governance, collaboration and internationalisation.* Only a few of the countries are reducing public financing of the PRIs, but most of the countries have taken and are taking measures to increase the proportion of external funding of the institutes either in the form of competitive public funding or funding from contracts with companies and other clients.

Reforms in organisations and governance of the institutes have been implemented or will be implemented in a near future in Denmark, Finland, the Netherlands and Sweden. In Denmark and the Netherlands the trend has been to merge some of the PRIs with universities. Finland has been planning to pool the institutes in a more radical way. The Finnish idea is to pool an important

share of basic government funds of the institutes and reallocate them to four research fields on a competitive basis. Sweden has further developed its system of Industrial Research Institutes (IRECO). A common nominator in all these reforms is an ambition to upgrade the level of research in the institutes, and to make the use of resources more effective.

All PRIs in all countries of the sample of this study and also outside it are actively developing collaboration and networking at all levels and in all directions. This means better use of existing mechanisms and development of new mechanisms for collaboration within the institutes, with universities, other research institutes, parent organisations etc. Particularly great attention has been given to collaboration with companies and other clients and users of the results of the institutes. In a globalising world, the importance of international collaboration has been growing rapidly in all institutes in every country.

The lessons to be learnt from the international analysis for the development of Chilean Public Technological Institutes can be put together as follows:

- There is not a single international model for development of the Chilean system of PTIs. Practices and experiences of various countries can be an important and useful source of information and inspiration, but it is not feasible or rational to try to replicate one or a few of them directly in Chilean context, which is in many respects different from the eight countries in the analysis.
- Basically, the three-fold financial structure of the analysed institutes is applicable and has been applied in Chile. A clear lesson from international experiences is that the institutes have to have a certain amount or proportion of basic government funding for self-initiated R&D, but it is much more difficult to say how much this funding should be. Because Chile is in an earlier phase of development than e.g. more mature European countries, it is justified to argue, that the need for basic funding in Chilean PTIs is bigger than in European countries which have other public and private funding sources nationally and internationally.
- In terms of reorganisation of the PRI system the lessons are not congruent. Some countries are integrating the institutes by pooling resources and putting the

institutes together, but some are disintegrating them by merging the institutes with universities. This should be a matter of careful consideration in Chile.

- Whatever the structural solution is, development of collaboration and networking both nationally and internationally is not only an opportunity but it is a necessity. It can even be an alternative for more radical organisational reforms or a first step in that direction.

5 Reorganisation of the Chilean Public Technological Institutes

5.1 Challenges of the Chilean Public Technological Institutes

The Chilean PTIs do not form a homogenous group of research institutes. On the contrary, they are a heterogeneous group of organisations in terms of history, mission, size, performance, ownership etc. Also the justifications for the existence of the institutes come from different sources. In the institutes linked with technological R&D, the justification comes mainly from market-failure types of arguments, but in other cases the institutes are mainly generating information for public authorities, and in some cases they are handling both roles simultaneously.

Regardless of certain reforms and positive developments in recent years, there are several needs for further development in individual institutes as well as in the institute system as a a whole. The actual R&D intensity of most of the institutes is low as only few PTIs are actually active in R&D. Many of the institutes are mainly dedicated to the supply of “technological services” and the generation of information. Their performance remains quite uneven, and a number of them are generally seen as inefficient, and detached from the sectors they are meant to serve (OECD 2007).

The Chilean National Innovation Council of Competitiveness has pointed out that Chile has accumulated capital in the form of favourable framework conditions which can greatly enhance the effectiveness of innovation policy: quality and reliability of institutions and political stability; robust macroeconomic

performance; an open trade regime and favourable legislation for foreign direct investments. The last decade has witnessed the emergence of a significant core of firms and entrepreneurs able to creatively marry technological and market opportunities. In addition, Chile faces a number of opportunities for dynamising its innovation system: greater exploitation of new knowledge, building on strong clusters to develop new services and activities, turning logistic constraints into innovation challenges, further advance in selected niches, and exploitation of Chile's environmental advantages.

5.2 Strategic vision for PTIs

The growing needs of the Chilean economy and society as well as development of public policy require active reorganisation of the entire Chilean PTI system. It is necessary to understand and accept the new competitive environment and to define a coherent strategic vision for the whole system, and to redefine the missions of the institutes in this new context. This should go hand in hand with building up of a new governance system for the institutes and strengthening of the capabilities and competencies of the institutes.

Ambitious redesign of the whole PTI system and improvement of the performance of the institutes is a demanding task which takes time and requires as a point of departure a common long-term vision with certain strategic milestones. The ultimate aim of the development process is to enhance the industrial competitiveness of Chile and to speed up the reform of public sector. The time frame which is needed for the process is more than ten years.

Accordingly, in 2020, the characteristic features of the PTI system should be as follows:

- The quality and performance as well as R&D intensity of the institutes are reaching an average international level which has been proved by international evaluations.

- Mutual co-operation and integration of the institutes has improved substantially and produced synergies which have opened up new R&D and service opportunities.
- As a result of encouraging achievements, the institutes have been able to increase their financial resources both from public and private sources of funding, which has lead to a growth of the personnel in many of the institutes and to improvements in research facilities.
- The institutes are well connected with the users of their R&D and services, and the satisfaction of the users with the services and other outputs of the institutes has significantly increased which has been proved by client surveys.
- The institutes are well networked internationally in terms of joint projects and publications, exchange of information, and also funding from foreign sources.
- The institutes offer a stimulating working environment and competitive salary for their employees.
- The work done by the institutes has significantly improved the knowledge-base of public policy making and helped the public authorities to focus better their activities and financial resources, as a result of which the performance and quality of the public sector has improved.
- Thanks to improvements in quantity of resources and quality of R&D, the PTIs have helped Chilean companies to bring new products and services to the market place which has had positive effects on company performance measures such as sales growth and share price, jobs etc. Consequently, businesses have been in a better position to achieve and maintain competitive advantage in the increasingly global market place with sustained R&D and other related intangible investments at the right internationally competitive levels.
- The overall efficiency as well as socio-economic effects of the system have improved which have been proved by international economic and impact analysis.

5.3 Organisation and governance

From the point of view of organisation and governance of the institutes, current situation is more a result of sporadic historical development than based on analytical consideration of the roles of the institutes in the Chilean innovation

system, either individually or as a whole. The institutes are very much out of the steering mechanisms of the Chilean innovation system and innovation policy.

One of the fundamental issues for reorganisation of the PTIs is how the institutes should be incorporated as a part of the governance of the Chilean innovation system. So far the integration of the institutes has been weak. Currently the institutes have quite autonomous or semi-autonomous position in terms of missions, objectives, financing, stakeholders etc. Weak links with the innovation system has historical reasons, but very much it is due to the fact that the governance system in a real meaning of the word does not exist in Chile or has existed only partially. Therefore, the issue of governance has to be analysed from two angles: from the point of view of top-down coordination and from decentralised management.

Closely related to demand for a broader coordination, is the concept of horizontality which refers to the crossing boundaries between different policy domains and sectoral boundaries. The development of a horizontal policy involves putting a broader strategic approach above departmental goals through the integration of priorities and objectives across various policy sectors. In respect to innovation policy, horizontal governance has been seen to imply the integration of innovation oriented thinking into other policy domains and greater attention of the interfaces with policy sectors which use and apply science and technology.

The existing Chilean governance system of PTIs is close to the sectoral model, but even the sectoral governance in a real meaning of the word has been very much non-existent. Even in the case that the interest of the ministries would awake, sectoral model does not necessarily meet the requirements of modern innovation policy. Most probably, even advanced sectoral governance would focus only on specific, narrowly defined fields without any interest and motivation in intersectoral co-operation and in increasing connectivity with innovation policy.

In principle, there are following six alternatives to reorganise the Chilean PTIs:

1. *Continuation of the existing mechanism through incremental reforms in the institutes and relationships with their stakeholders (parent organisations, universities, companies, other clients etc.):* This is the easiest way to reorganise the institutes. This must be done anyway and also in connection with any other alternative.

2. *Establishment of temporary consortia or (strategic) alliances among the institutes or with universities or other appropriate organisations:* In this model, the institutes remain independent, but search actively opportunities for sustainable cooperation with other research organisations. This is very much done in various countries on a continuous basis.

3. *Mergers among the institutes or universities or other appropriate organisations:* This is the model which has been used in recent years and in different ways in many countries, like Austria (mergers among the institutes), Denmark (mergers among the institutes and with universities), and the Netherlands (mergers with universities).

4. *Pooling of financial resources of the institutes through a holding company or other corresponding mechanism:* This is very much the model which Finland is aiming at. The basic idea is to pool part of basic government funds of the institutes and reallocate them (back) to the institutes on a competitive basis. Also the The Crown Research Institutes in New Zealand, and the Swedish mechanism for industrial research institutes (IRECO) belong to this group with certain differences.

5. *Outsourcing or privatisation of the institutes:* In many countries there is a lot of debate on outsourcing and privatisation of public services, including public R&D services. However, very little has been done in practice. If

complete institutes have been privatised, like in New Zealand with the Crown Institutes, this has meant establishment of a state owned company. In the case of Sweden, creation of IRECO can be characterised as a nationalisation or semi-nationalisation of private institutes.

6. *Closing down of the institutes:* This is the most radical way of reorganising the institutes. If this alternative is used, as it has been used different occasions, it can cover just a few single institutes or more often parts of certain institutes.

The main lesson to be learnt from international experiences for PTIs is that there is not an ideal model or the best practice for reorganising PRIs. Rather, there are several options which are even combined in different ways. As we can see, even countries like Denmark, Finland and Sweden which are considered to be homogeneous in many respects, have adopted distinctive mechanisms to organise their PRIs. This means, that in every country, reforms must be built, whether you like it or not, on existing organisations, structures, resources, cultures etc., and particularly on unique national social and economic needs as well as societal and political objectives.

However, one important common nominator in all countries is a trend towards integration by pooling of existing resources more or less under common umbrella. Main motives behind this trend are a need to accelerate scientific and technological development in respective countries, to improve connectivity between the actors of the national innovation system, and above all to make the use of existing resources more effective. In most cases, the new arrangements have helped the institutes to deliver expected, useful outcomes and effects. In particular, governance of the institute system has been simplified and improved.

The conclusion which is to be made for Chile on is that the solution is not one of the alternatives described above, but it must be a combination of a couple of options. An important point of departure is pooling of the institutes under a

common umbrella organisation. This solution offers best opportunities for Chile to upgrade the level of know-how of the institutes, to improve connectivity of the instititutes, and to secure better exploitation of the resources of the institutes. Experiences of many OECD countries give strong support to this kind of arrangement.

After this basic structure has been created, mergers among the institutes or universities or other appropriate organisations are most probably needed. In this study, it has not been possible to make any more specific recommendations on potential mergers. This would have required more information on the institutes and other parts of the Chilean innovation system, and more exchange of opinions with the representatives and other stakeholders of the institutes. In addition, it is clear that reforms in the organisation, management, leadership etc. of the institutes have to be done continuously, and this is also true of active development of domestic and international cooperation in the form of consortia and alliances.

5.4 Financing

Financing is the most effective instrument to make desired changes in the orientation and performance of the institutes. However, the equation is far from simple. This is mainly due to the fact that the institutes are different and are operating in different contexts. What is applicable to an institute providing services to industrial companies is not necessarily as applicable to e.g. agricultural research, or for an institute which is related to a national infrastructure or big science like nuclear energy research. On the other hand, differences do not hinder from looking for general characteristics of innovation-friendly financing.

Also internationally there is a wide spectrum of models and practices without any consensus or well-established ways of organising financing of PRIs. There are countries like Finland where most of the PRIs are public agencies, and are

getting a major part (60-80 %) of their financing from state budgets. There are public research institutes which are more dependent on external financing coming from public research or technology programmes, and from contract research or other services for companies and other clients. In addition, there are semi-public and private arrangements supported by public funds. A general trend in many countries already for years has been decreasing the proportional share direct budget funding and increasing the share financing from external sources. Also in these circumstances, the direct budget funding may have grown absolutely.

Finland has for long time had an unofficial “rule-of-thumb”, that the more the institute is aimed at working directly for solvent private clients and for them, the higher must be the proportion of external financing of the total budget of the institute, or the other way round, the smaller the proportion of basic funding. If the institute is providing services to the public sector, or if it is producing public goods types of services and outcomes, a stronger hold of the public sector is needed. Public health and welfare programs, longer term research and development, national and domestic security, a clean environment etc. all have been labelled as public goods.

However, these kind of considerations are just points of departure. Other aspects which must be taken into account are e.g. availability of qualified private services, and composition of the private clientele of the institutes. If private clients are mainly small and medium-sized companies (SMEs), small farmers and forest owners etc, in many or most market economies (incl. Finland), a more dominant role of the public sector is regarded justified. Promotion of innovation in SMEs has been and still is a particularly topical issue in innovation policy in the EU and its member countries.

A necessary precondition for balanced financing of all PTIs is that they have a sufficient amount of basic financing (block funding) for self-initiated development and maintenance of basic knowledge and skills as well as for

research characterised by risk and uncertainties. In a modern world even the maintenance of a desirable level of knowledge requires determined actions and solid financing not to mention ambitious upgrading of the knowledge base. From international analysis we can conclude that a common proportion of basic financing of total financing of an institute is 30-40. In certain cases, if it is considered necessary for specific national reasons or for unavailability of other financial sources, the proportion of basic financing can be even higher. Another important aspect is stability in the growth of financing. Continuous fluctuations and uncertainty about future development of resources are most destructive for R&D institutes.

As important from national point of view is to create a well-functioning mechanism or complementary mechanisms for competitive R&D financing. International experiences indicate that national research and technology programmes are an efficient and successful mechanism to bring healthy competition, flexibility and target-orientation to R&D. In addition, Chilean PTIs have to create incentives, channels and practices for development of contract R&D and other information and technology transfer services. This can be given as a necessary condition for the development of other forms of financing.

An important point related to financing is the question on the critical mass of R&D. This is an issue which has been debated long time all over the world, but without an unambiguous solution. It is clear that in R&D, achievement of a high level of knowledge and competence requires a sufficient amount of resources, e.g. in terms of a number of researchers. However, the requirements for an optimal or minimal size of an R&D unit vary a lot by fields of science and technology. Therefore the estimates decisions have to be done case by case.

Critical mass is particularly significant question for small countries with small resources compared to the resources of bigger countries. The only solution which the small countries have is concentration on a smaller number of R&D fields and an effective use of scarce resources. Concentration means

concentration on fields of science and technology that are important to the future of the society, business and industry of the nation in question. This is very much the idea behind the new Finnish Strategic Centres for Science, Technology and Innovation which are described in the annex. In this context, a commonly used method to have an estimate on the sufficient volume of R&D resources is specific international benchmarking.

Diversity of the institutes has implications for e.g. allocation of basic funding. Finland has for long time had an unofficial “rule-of-thumb”, that the more the institute is aimed at working directly for solvent private clients and for them, the higher must be the proportion of external financing of the total budget of the institute, or the other way round, the smaller the proportion of basic funding. If the institute is providing services to the public sector, or if it is producing public goods types of services and outcomes, a stronger hold of the public sector is needed. Public health and welfare programs, longer term research and development, national and domestic security, a clean environment etc. all have been labelled as public goods.

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5.5 Management

Independent on the conclusions and recommendations in the previous issues, there is always room for improving management systems and practices at the institute level. Many of them can be realised without top-down guidance, but there are some, e.g. monitoring and evaluation which require intervention from upper levels of innovation policy. In many European countries, including the Nordic countries, ex-post evaluation of research organisations, research and technology programmes and other policy instruments has proved to be an effective indirect way of controlling and managing the research organisations. In Finland, the Science and Technology Policy Council has been playing important role in creating a general framework and incentives for evaluations.

5.6 Responding to new challenges

5.6.1 Globalization

Chilean economy is in terms of GDP growth became over the last two decades the best performing economy in Latin America. This is an impressive result, which can be largely attributed to determined liberalization of trade. Currently Chile is an outstanding example of a successful small open economy, with significant resource-base and very extensive and remarkably open foreign trade.

Whereas Chilean economy has clearly gained from liberalization of trade and increasing of international linkages, this has not been an R&D or innovation policy issue, this far. For instance, while during the last two decades Chile has started to attract foreign direct investment, most foreign investment still goes into relatively basic infrastructure investments in sectors of gas, water, electricity and mining.

Even though Chile has been a clear winner of globalization, it is also emerging as a major challenge as Chilean economy is striving to leap from resource-based to more knowledge and innovation based economy. This is at least a three-fold major challenge for Chilean economy. First, how to increase the innovativeness, newness and uniqueness of Chilean industrial production and, especially, how to increase the industrial R&D intensity. The final target, obviously, is how to increase the medium and long-term productivity of Chilean industrial production. Second, how to make Chile as an attractive target also to other than low-tech FDIs. And third, how to increase fruitfull collaboration between knowledge users, most importantly industries, and knowledge producers, most importantly universities and technological institutes. This third improvement need to be steered not only domestically but in an international if not global context.

5.6.2 Industry-Academia relationships

In Chile there are serious challenges concerning industry-academia relationships (OECD 2007, The Report of an International Mission 1998). The R&D intensity of Chilean companies is low. As a corollary, also R&D collaboration between industries and academia is limited. This is true for universities and for PTIs. In the mid 90's there was a major attempt to change a large part of public R&D funding to be allocated on a competitive basis. This financing reform was not successful in increasing industry-academia collaboration but, indeed, created competition between research institutes and industry for the same public resources. Second challenge is that there is only little professional mobility between academia and industry. Third challenge is that turnover of research staff is low and research staff is ageing.

5.6.3 Commercialization and IPR

A global megatrend in universities and research institutes concerns commercial utilization and exploitation of research results, technology transfer, protection of IPR and related financial, organizational and legal issues as well as required capabilities, processes, instruments and tools. This is an issue that needs to be addressed at Chilean PTIs and universities, too. There have also been concomitant changes in the economic contexts of all economies which have tended to weaken the effectiveness of the IPR system as it has operated previously (OECD 2007b):

- New technologies, initially not covered by patent systems, have emerged, notably in the fields of software and biotechnology.
- Globalisation has made imitation and counterfeiting both more rewarding (in expanded market) and more feasible, as a number of countries registered significant growth in technological capacities, without a corresponding development in their IPR system.
- ICTs, and notably the internet, have made copying of creative contents easier.

5.6.4 Open innovation

A new emerging issue that has raised exceptional interest within big enterprises concerns the ways how to expand the innovation process outside the firm borders (Chesbrough 2003). The generic term for this development is “open innovation”, which may include improved ways to search for new potential innovations, or wholly or partially externalised ways to perform innovation development. It is generally understood that universities and research institutes have specific assets to function as efficient platforms for different open innovation related activities. However, that cannot be done without very careful business planning and strategy work, targeted financing and professionally defined and implemented instruments and processes.

5.6.5 Proximity and regional development

R&D investments and innovation policies are not only subsections of economic policy but they have or at least may have also other targets. One important issue, and probably especially important in a large but sparsely populated country like Chile, concerns regional development. Investments in R&D and e.g. location of PTIs may have even a major impact on the region where they are targeted. In Chile the Santiago region has reaped the main gains of recent economic development. It remains as a major issues whether this concentration should be encouraged or cushioned.

5.6.6 Research and technology programmes as complementary assets for PTIs

National research and technology programmes have turned out to be effective mechanisms to create new knowledge and applications in nationally significant fields of science, technology and innovation. They can also be vitally important for intensifying cooperation and interaction between R&D performing institutes (universities, research institutes and companies) and other stakeholders of

public and private sectors. From the point of view of development of PTIs, research and technology programmes are a necessary complementary asset both financially and substantially. Attached to this report is a description of Finnish practices of research and technology programmes which represent, if not best practices, at least advanced practices internationally.

5.7 Other aspects

5.7.1 Transfer of information and technology

Transfer of knowledge from research organizations and higher education institutes into the market place has been identified in all developed and developing countries as a key issue in the development of a world class research and commercialisation environment (Bozeman 2000). Basically, technology transfer is a process of sharing of skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among industries, universities, governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services.

Transfer of information and technology is a main function of most Chilean PTIs instead of generation of new knowledge and applications through own R&D. Also in this respect the situation in Chilean institutes has similarities with many other countries, even if R&D intensity of e.g. European PRIs is higher on average than in the Chilean PTIs. Also in the case that an institute focuses on information and technology transfer, it is important to assure continuous development and accumulation of knowledge. Among the means to update competencies is internal training, collaboration with domestic universities, research and technology centres and technologically advanced companies, and international collaboration with leading institutes of the respective fields.

5.7.2 Confidence

Confidence between the institutes and its major stakeholders (incl. policy makers) is one of the key preconditions for continuous development of the institutes and their financial resources. Building up of confidence is not only dependent on the upper levels of the public administration and policy, but it is very much in the hands of the institutes and their management. Confidence originates from good quality of work and usefulness of results. Main tools of successful action are understanding of user needs, active collaboration with users, good foresight and management practices (incl. human resources management), as well monitoring and evaluation mechanisms. Building-up and implementation of new management tools and practices would be one of the key aspects of the management arrangements of PTIs in Chile, and an important argument for reforms in organisation and governance of PTIs.

5.7.3 Measurement of performance of the institutes

Evaluation becomes increasingly important as the competitive stakes for Chilean economy and industries increase, as the size of R&D budgets (hopefully) increases, and as demands for transparency, accountability and performance across Chilean R&D and technology institutes increases.

The facets of the evaluation usually include priority setting and ex ante impact appraisal, monitoring of progress (interim evaluation), as well as ex-post evaluation of results and impacts. Cumulatively they aim at measuring performance, supporting target or performance-based management and budgeting, enhancing accountability and transparency, and improving of communication of activities and outcomes of the institutes to policy decision makers and sponsors (Polt et al. 2006).

5.7.4 Competition

In principle, and to some extent also in practice, the PTIs are competing among themselves, as well as with universities and units of the private sector. As long as dependence of the institutes on external financing remains at current level or even increases, competition will most probably accelerate. Most important in this situation is that competition is open and fair, and that there are not funding or other mechanisms which distort competition. On the other, in the case of the SITEC, it is the task of the management of the SITEC to define the division of labour between the institutes, and to promote co-operation between the institutes, e.g. in the form of shared resources (buildings, research facilities) and joint projects and programmes. An attached report gives more information on Finnish practices for joint projects and programmes.

6 Summary and conclusions

After a long list of options and action lines for development of Chilean PTIs, we put together our main conclusions and recommendations as follows:

- Over the last two decades Chile has recorded an impressive economic performance. It has succeeded to achieve a remarkable “growth acceleration” with GDP per capita growing at 5-6 % per year in the 1990s, more than twice the long-term trend of 2.4 % of the preceding 40 years.Chile’s strong economic performance of the past two decades has been underpinned by the country’s effort in economic reform and building modern and stable institutions following best international practices regarding macro-economic management and the development of market mechanisms.
- The Chilean innovation system faces many challenges. Chile has a strong need to take a determined course of transition to a more R&D and innovation-based growth. In this context, an important role of the government is to correct market and system failures that keep the country from reaching its full innovation potential.
- From the point of view of market failures, government is needed to compensate, complement, support and take care of harmful externalities of the market economy. Briefly, government has to take main responsibility for long-term basic research and R&D infrastructures, it is needed to share the risks and other uncertainties entailed in R&D and innovation within companies and capital markets, and it is the task of the government to try to avoid harmful sideeffects of technologies to people and nature. Climate change has increased the importance of the last mentioned aspect.
- Chile has a range of Public Technological Institutes (PTIs) dedicated to applied research and technological development, technology transfer, the supply of technological services and the generation of information on natural resources. They provide the State with relevant information to comply with its regulatory functions in the area of natural resources and the environment, supply public infrastructure, especially in the area of standards and metrology, foster innovation through the generation of spin offs, transfer and development of technologies for firms, and the dissemination of technologies for SMEs, among others.
- Regardless of certain reforms and positive developments in recent years, there are several needs for further development in individual institutes as well as in the

institute system as a a whole. The actual R&D intensity of most of the institutes is low as only few PTIs are actually active in R&D. Many of the institutes are mainly dedicated to the supply of “technological services” and the generation of information. Their performance remains quite uneven, and a number of them are generally seen as inefficient, and detached from the sectors they are meant to serve.

- The growing needs of the Chilean economy and society as well as development of public policy require active redesigning of the entire Chilean PTI system. It is necessary to understand and accept the new competitive environment and to define a coherent strategic vision for the whole system, and to redefine the missions of the institutes in this new context. This should go hand in hand with building up of a new governance system for the institutes and strengthening of the capabilities and competencies of the institutes.
- From the point of view of organisation and governance of the institutes, the current situation is more a result of sporadic historical development than based on analytical consideration of the roles of the institutes in the Chilean innovation system, either individually or as a whole. The institutes are very much out of the steering mechanisms of the Chilean innovation system and innovation policy.
- The main lesson to be learnt from international experiences is that there is not an ideal model or the best practice for reorganising PRIs. Rather, there are several options which are even combined in different ways. As we can see, even countries like Denmark, Finland and Sweden which are considered to be homogeneous in many respects, have adopted distinctive mechanisms to organise their PRIs. This means, that in every country, reforms must be built, whether you like it or not, on existing organisations, structures, resources, cultures etc., and particularly on unique national social and economic needs as well as societal and political objectives.
- The conclusion which is to be made on the basis of international analysis is that pooling of resources and integration of the institutes under a common umbrella organisation is a good foundation in Chile. It is a solution which best meets the needs which Chile has to make better use of the institutes and create conditions for their further development. Experiences of many OECD countries give strong support to this kind of arrangement.
- The point of departure for balanced financing of all PTIs is that they have a sufficient amount of basic financing (block funding) for self-initiated development

and maintenance of basic knowledge and skills as well as for research characterised by risk and uncertainties. In a modern world even the maintenance of a desirable level of knowledge requires determined actions and solid financing not to mention ambitious upgrading of the knowledge base. From international analysis we can conclude that a common proportion of basic financing of total financing of an institute is 30-40. In certain cases, if it is considered necessary for specific national reasons or for unavailability of other financial sources, the proportion of basic financing can be even higher. Another important aspect is stability in the growth of financing. Continuous fluctuations and uncertainty about future development of resources are most destructive for R&D institutes.

- There are several other actions which are needed to make sure that the aims of the reforms are achieved. Organisational reform can be a necessary but not sufficient condition for this. Other important areas of development are management practices of the PTIs, monitoring and evaluation of performance, improving connectivity with other actors, commercialisation of results, and internationalisation of the institutes.

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Appendix 1

A REVIEW OF FINNISH RESEARCH AND TECHNOLOGPROGRAMMES

1 Programmes

1.1 General

The research and technology programmes are the mechanism bring together Finland's top experts in each field. The major part of research and technology programmes are set up by the Academy of Finland and Tekes. While the R&D projects being funded are naturally the primary focus, the most important aspect of the programmes is their role as forums for information exchange and cooperation both nationally and internationally. There are currently some 37 programmes in progress (Tekes 22, Academy 15), and new programmes are started every year. The programmes normally last about four or five years.

The third leg of Finnish instruments for programming R&D is the Centre of Expertise Programme coordinated earlier by the Ministry of the Interior alone but nowadays in collaboration with the Ministry of Trade and Industry. The history of this programme dates back to early 1990s. The latest development of R&D programming is represented by the Strategic Centres for Science, Technology and Innovation which are still in the initial phase of their development.

1.2 Technology programmes

Tekes uses technology programmes to allocate its funding, networking and expert services to areas that are important for business and society. It allocates approximately half the funding granted to companies, universities and research institutes through technology programmes. The basic aim of the technology programmes is to reinforce the national knowledge base, promote the renewal of business, services and industry and enhance cooperation between companies, research organisations and the public sector. Technology

programmes have been contributing to changes in the Finnish innovation environment for twenty years.

The technology programmes consist of research projects by companies, universities and research institutes, plus services that support companies' business operations, such as shared visions, seminars, training programmes and international visits. There are some 1,800 instances of corporate participation in the technology programmes every year and about 500 instances of participation by research units. The technology programmes provide opportunities for companies to network and develop business expertise and skills in international operations. In the programmes they receive Tekes financing for developing products, production, service concepts and business expertise and also the very latest information about different areas of technology and business.

1.3 Research programmes of the Academy of Finland

Research programmes are one of the key instruments of the Academy of Finland for research funding. Initiatives for a programme may be prompted by research needs within a new theme area or field of research, generated by topical research problems, important fields and scientific findings. Research programmes have the objectives of raising the scientific standards of research within a certain field of research; promoting multidisciplinarity, interdisciplinarity and international cooperation; of creating and strengthening the knowledge base; of promoting professional careers in research and the net working of researchers; of intensifying researcher training and of supporting the establishment of creative research environments. Research programmes are dedicated to special themes or problems. Other domestic and international funding bodies often contribute as well.

Centres of excellence in research The national centre of excellence policy is aimed at raising the goals and quality standards of Finnish research and at increasing its international competitiveness, exposure and the esteem of

research. The centre of excellence programme covers all fields of science and research. One of the key objectives is to promote interdisciplinary research. Units appointed to the program are research and researcher training units that consist of one or more high-profile research groups that are either at or very close to the international cutting edge in their own field of expertise. They will also share a clear set of objectives and work under the same management. A centre of excellence may operate within a university and/or research institute. The first six-year programme was launched by the Academy of Finland year 2000. In the beginning of 2006 there are altogether 39 centres of excellence. For more information see

1.4 Centre of Expertise Programme

The Centre of Expertise Programme is the main instrument of regional R&D and innovation policy in Finland. The Centre of Expertise Programme was launched in 1994 with the aim to pool local, regional and national resources to the exploitation of top-level expertise. The programme supports regional strengths and specialisation and furthers cooperation between the centres of expertise. Due to its subsequent success the Government decided to extend the programme in 1998 and 2002 by appointing new centres of expertise and by increasing the number of fields of expertise in the existing centres. For the period of 2003–2006 there existed 22 centres of expertise covering 45 fields of expertise.

The Finnish government has made a decision to launch a new programme era extending to the years 2007-2013. Altogether 13 nationally significant clusters of expertise and 21 Centres of Expertise have been approved into the programme for period 2007–2013. In the new programme the clusters of expertise function as the new platform for development of inter-regional co-operation. The new cluster-based operational model enables the more efficient utilisation of expertise resources scattered in different regions, and is also intended to increase the "critical mass" needed in research and product development to create centres of expertise with more international appeal. A

centre of expertise appointed to the programme may contain several fields of expertise, belonging to different clusters.

A total of EUR 8.7 million has been put forward by the Ministry of the Interior for the basic funding of the Centres of Expertise in the Budget for 2007. When applying for the programme the regions have undertaken to provide regional funding in the corresponding amount. A total of EUR 2.6 million has been separately put forward for the administrative branch of the Ministry of Trade and Industry for the purpose of funding the co-ordination of the clusters of expertise.

1.5 Strategic Centres for Science, Technology and Innovation

In June 2006, the Science and Technology Policy Council decided to establish in Finland international Strategic Centres for Science, Technology and Innovation in fields that are important to the future of Finnish society and business and industry. The aim of the strategic centres is to create a new, more efficient framework for collaboration between companies, universities, research organisations and sources of funding. The first phase will see the establishment of five strategic centres in the fields of *energy and the environment*, *metal products and mechanical engineering*, *the forest cluster*, *health and well-being*, and *the information and communication industry and services*. Tekes bears the main responsibility for organising the establishment of the centres. Tekes, together with the Academy of Finland, has begun discussions with various stakeholders.

The actual establishment of the strategic centres will be the responsibility of the partners, that is, companies, universities and research institutes. The plan will aim to meet the application needs for practical application by companies within a 5-10-year period. In addition to shareholders, public funding organisations will commit themselves to providing funding for the centres in the long term.

2 Characteristic features of Finnish R&D programmes

2.1 Design and management

There is some variation between the programmes how they are designed and managed. However, a characteristic feature to all of them is a bottom-up approach and a broad-based collaboration between the major stakeholders from early phases of the programmes. The research programmes of the Academy of Finland are academic programmes with a focus on *basic research* carried out within universities. Therefore key actors in the design and management of these programmes are researchers and research communities. The focus of Tekes technology programmes is more on *applied technical research* with participants from companies, research institutes and universities. The Centre of Expertise Programme is aiming at pooling local, regional and national resources to the *exploitation* of top-level expertise.

Apart from differences in the focus and nature of the three programmes, same people and research groups may be involved in all programme types at the same time. This trend has been strengthening in recent years. Tekes and the Academy of Finland are designing and running joint programmes, and in the new era of the Centres of Expertise Programme the collaboration between Tekes and the Programme will most evidently increase. The biggest difference in the design of Tekes technology programmes and research programmes of the Academy is the fact, that in the case of the Academy, the decisions on programmes and individual projects are made by research councils consisting of scientists. At Tekes, the decisions are made by Tekes' civil servants.

Tekes technology programmes are operated by external companies (usually consultants) or other operators who are selected on the basis of an open call for tenders. The research programmes of the Academy of Finland are usually coordinated by senior university researchers. The Centres of Expertise are operated by local science or technology parks or other local intermediary

organisations. The organisation form of the new strategic centres will be a public company.

Tekes technology programmes have been a central way of action in Tekes from its establishment. The technology programme activity has experienced big changes during the decades. However, the changes have taken place mainly in small steps.

The development which has taken place in the technology programme activity reflects the change in the internal strategic thinking of Tekes and the changes in the external operating environment to which the technology programme activity has attempted to answer. The operating environments of technology programmes have become more complicated. The challenges of strategy work in the technology programmes and the technology programme management have become more complex. The need for active, anticipating and proactive strategy and management practices has increased.

2.2 Evaluation

Tekes technology programmes are always evaluated at the end of the programme and often also halfway through. The aim of the evaluation is to provide feedback on how the programme aims have been realised, to find out how relevant the programme is and to produce information to support the strategic development of programme activities and the activities of Tekes in general.

The impact analysis unit uses external experts to carry out the evaluation of technology programmes in order to compile varied and independent effectiveness data. The evaluation provides information and understanding on the dynamics of research and development practice and the factors contributing to its success or failure.

One evaluation can cover several programmes if they belong to the same field of technology, or cluster, or if they have similar goals, or some other common denominator. Impact assessments also try to provide answers to current queries and make it easier for all those concerned to respond to changes. Group evaluations can cover

- all programmes within a field of technology (for example, energy technology programmes have already been assessed in one go, as a whole)
- the long-term development of a certain field of technology (for example, digital media programmes have already been assessed in one go from this perspective)
- a programme group determined by a programme-type (for example, programmes for developing operational methods have been put into one group for collective evaluation)

Also the *Academy of Finland* has paid more attention to monitoring and following up programme implementation, to evaluating programmes and to making the best possible use of the results of evaluation. Follow-up and evaluation plans shall be drafted from the early stages of programme planning: these plans shall set out the timetables and preliminary objectives for follow-up and evaluation as well as identify the material that shall be collected. It is particularly important that jointly funded programmes agree upon the principles of follow-up and evaluation in advance. Peer review has been the most used evaluation method in the Academy.

In its evaluation principles, the Academy stresses that programme evaluations shall be closely integrated with other Academy operations. Evaluations of research programmes and individual disciplines shall be planned with a special view to coherence and consistency. Research programmes shall be evaluated against the starting-points of the research, its objectives and funding volume. The main focus shall be on the performance of the programme as a whole as well as on the added value it has generated, but evaluations shall also be carried out at the level of individual thematic areas and projects. Programme evaluations shall include assessments of the societal (social, cultural, political),

economic and technological impacts of the results achieved, in so far as these have been incorporated in the programme's objectives.

The Academy has been involved in developing methods for the assessment of research impacts. Impact assessments should ideally be carried out some while after the programme has ended. This will make it possible to see the programme's short-term impacts. Research Councils shall systematically make use of the recommendations made on the strength of the evaluations. They shall draw up an after-care plan for the programme, including proposals on the implementation of the recommendations in so far as they are considered justified. Evaluations of research programmes can serve as one element in ongoing efforts to identify future research needs and directions.

Assessment of the *Centres of Expertise* focused on the value added through co-operation, the amount and quality of top-level expertise, particularly the usability of expertise from the point of view of business life, and on the participation of SMEs and regional commitment to programme basic funding. The State, as well as cities and municipalities within the region, contributes to programme basic funding.Programme proposals were assessed by a team of experts from business life, the Finnish Funding Agency for Technology and Innovation, research and education, and central, regional and local government. Central government was represented by the Ministry of the Interior, as well as the Ministries of Labour, Education, Trade and Industry, Agriculture and Forestry, and Social Affairs and Health.