PUBLIC-PRIVATE PARTNERSHIPS FOR RESEARCH AND INNOVATION: AN EVALUATION OF THE DUTCH EXPERIENCE

OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

FOREWORD

A major conclusion of the OECD Growth Study was that governments need to be more responsive to the rapid transformation of innovation processes and related business needs and strategies, and that greater use of public-private partnerships can increase this responsiveness and enhance the efficiency and cost-effectiveness of technology and innovation policy.

In the framework of its follow-up work on *micro-policies for productivity and growth*, the OECD is conducting peer reviews of member countries' public-private partnership (PP/P) programmes for research and innovation. This report examines and assesses PP/P initiatives in the Netherlands, with a special focus on the Leading Technology Institutes (LTIs).

It has been prepared by the OECD Secretariat,[1] in co-operation with the Dutch Ministry of Economic Affairs and in consultation with other stakeholders in LTIs. It takes into account the results of a peer review meeting which took place in June 2003 within the OECD Working Party on Technology and Innovation Policy.

It is published on the responsibility of the Secretary-General of the OECD.

1. The OECD project team was led by Jean Guinet, assisted by Michael Freudenberg and Byung-Seon Jeong.

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EXECUTIVE SUMMARY

Overall, the Netherlands' innovation performance is still satisfactory by international standards but there are indications that the Dutch Innovation system is "*losing momentum*", due to various bottlenecks that have an increasingly negative impact on its efficiency. This is worrying, because good innovative performance is a necessary condition for Dutch economic performance in the future. One of the most important weaknesses of the Dutch innovation system is inadequate interaction between science/higher education and industry.

The Dutch government faces the following main challenges in the field of science and technology policy:

- Increasing the incentives and improving the institutional frameworks for co-operation between public and private actors of innovation.
- Improving the attractiveness of the Netherlands as a top location for researchers as well as R&D and other innovative activities.
- Streamlining and improving the public support schemes for innovation and a complex innovation governance system.
- Improving interdepartmental co-ordination.

Public-private partnerships for innovation (PP/Ps) are an important part of the answer to such challenges. Different models of PP/Ps are already key components of the Dutch innovation policy tool kit. Their significance is qualitatively far more important than would suggest their rather modest share in the overall science and technology budget (around 6%). A key question is whether and how their contribution to boosting Dutch innovation and economic performance could be further improved.

This arises in a context where reforms are being contemplated which could complement PP/Ps in improving the interaction between public and private research. In particular, the bridging function of many public labs will be evaluated this year, with a view to improve their positioning, steering and funding. The government is also considering modifications of the financing mechanisms of university research, with the objective to increase the share of competitive grants relative to that of institutional funding, and to introduce more performance-based criteria (including applicability of research for innovation) in the allocation of institutional funding.

It is important that future decisions regarding the actual implementation of these reforms take into account the lessons drawn from practical experience with the management of existing PP/P programmes, which also provide insights regarding the possible improvement of these programmes.

Among those, the four Leading Technology Institutes (LTIs) represent one of the purest forms of PP/P, both in their rationale and organisation. The OECD peer review of the LTI programme concluded that it is a proven good practice in mobilizing public and private research towards common objectives of high importance for the economy and society. The four LTIs perform well, are based on a sound rationale and are implemented efficiently. Other OECD countries could learn from them, especially with regard to:

- The competitive process that has been used to select LTIs.
- The organisational arrangements and incentive structure (financing, IPRs) that ensure industry commitment and leadership in determining the strategic research orientation of each LTI, while securing the pursuit of public interest (public access the research results, strengthening of public research capabilities in fundamental research).

But the OECD evaluation also suggests that this new policy tool has not yet been used to its full potential. This would require addressing the following main issues:

- When streamlining its numerous schemes to promote innovation, the government should improve the balance between competitive and unconditional grants, as well as between project-based and programme-based support. It could consider concentrating more the use of competitive grants within the framework of true PP/P programmes, such as LTIs, ACTs or genomics.
- Whereas each LTI addresses a well identified market failure in an important research field where Dutch capabilities were so far under-utilized, LTIs collectively do not cover all areas of the highest "strategic importance" for the Netherlands, especially to the detriment of socially relevant multidisciplinary research. An answer could be the creation of new LTIs, through a new round of competitive selection that could involve existing LTIs seeking extension, and would better balance "bottom-up" and "top-down" criteria.
- An alternative could be to continue with the same portfolio of LTIs with increased support to the most promising areas in each field, and the creation of a learning and breeding platform for existing LTIs and other similar research organisations to exchange experience and identify opportunities for multidisciplinary research.
- Whereas it is doubtful that any LTI could be financially self-sustained in the foreseeable future, cost-sharing arrangements could be optimized. Some LTIs would already be viable with a reduced subsidy. Lowering budget contribution as LTIs mature should be considered.
- LTIs are well connected to global innovation networks in their respective fields, but their linkages with government-sponsored international co-operative ventures, especially the EU Framework Programme, could be improved. Participation in European projects does not appear to be very attractive for the LTIs, largely because of financial rules that should be reconsidered.

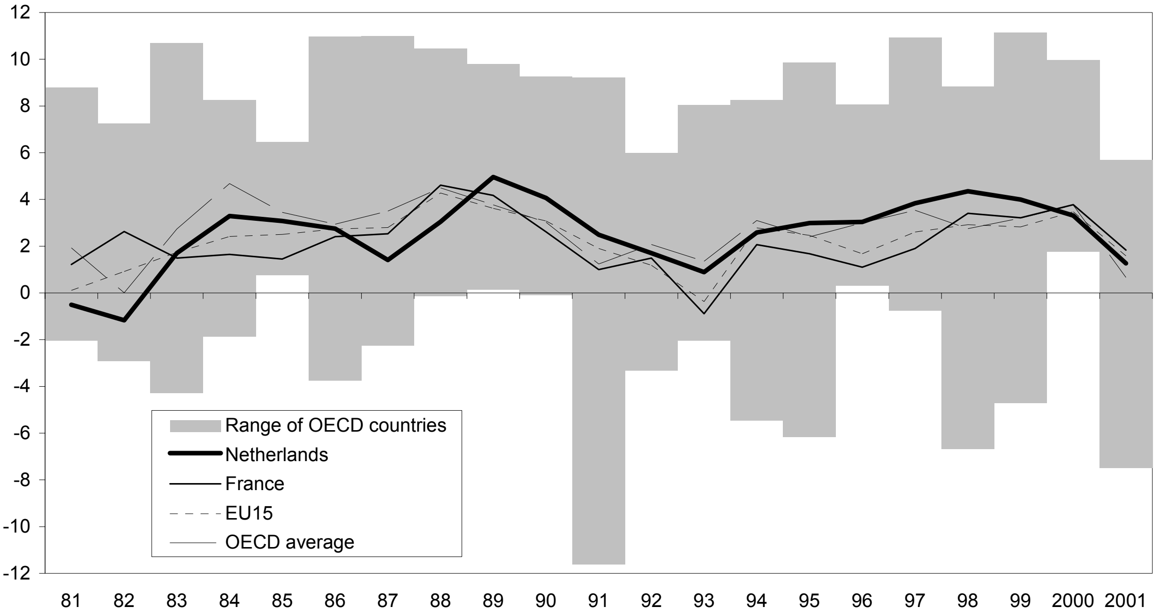
THE ROLE OF PUBLIC-PRIVATE PARTNERSHIPS IN THE DUTCH INNOVATION POLICY

Introduction

The economic performance of the Netherlands has deteriorated in recent years. For most of the 1980s and 1990s, growth in the Netherlands has outpaced the European Union and OECD average. The fact that this is no longer the case (Figure 1) raises questions regarding the right policy mix to address both the cyclical and more structural aspects of the downturn. As argued by the latest OECD Economic Survey of the Netherlands,[2] macroeconomic policy (*e.g.* wage moderation according to the traditional "poldermodel") can provide the short-term answer, but the major challenge is to raise productivity, through policies that address the micro drivers of longer term growth.

The OECD Growth Project demonstrated that innovation is a key determinant of sustained growth in productivity. It also suggested that an innovation-led growth is increasingly underpinned by more intensive collaboration between the different actors of innovation processes, challenging the efficiency of national innovation systems (NIS) in this respect.

Figure 1. Annual growth rates of GDP

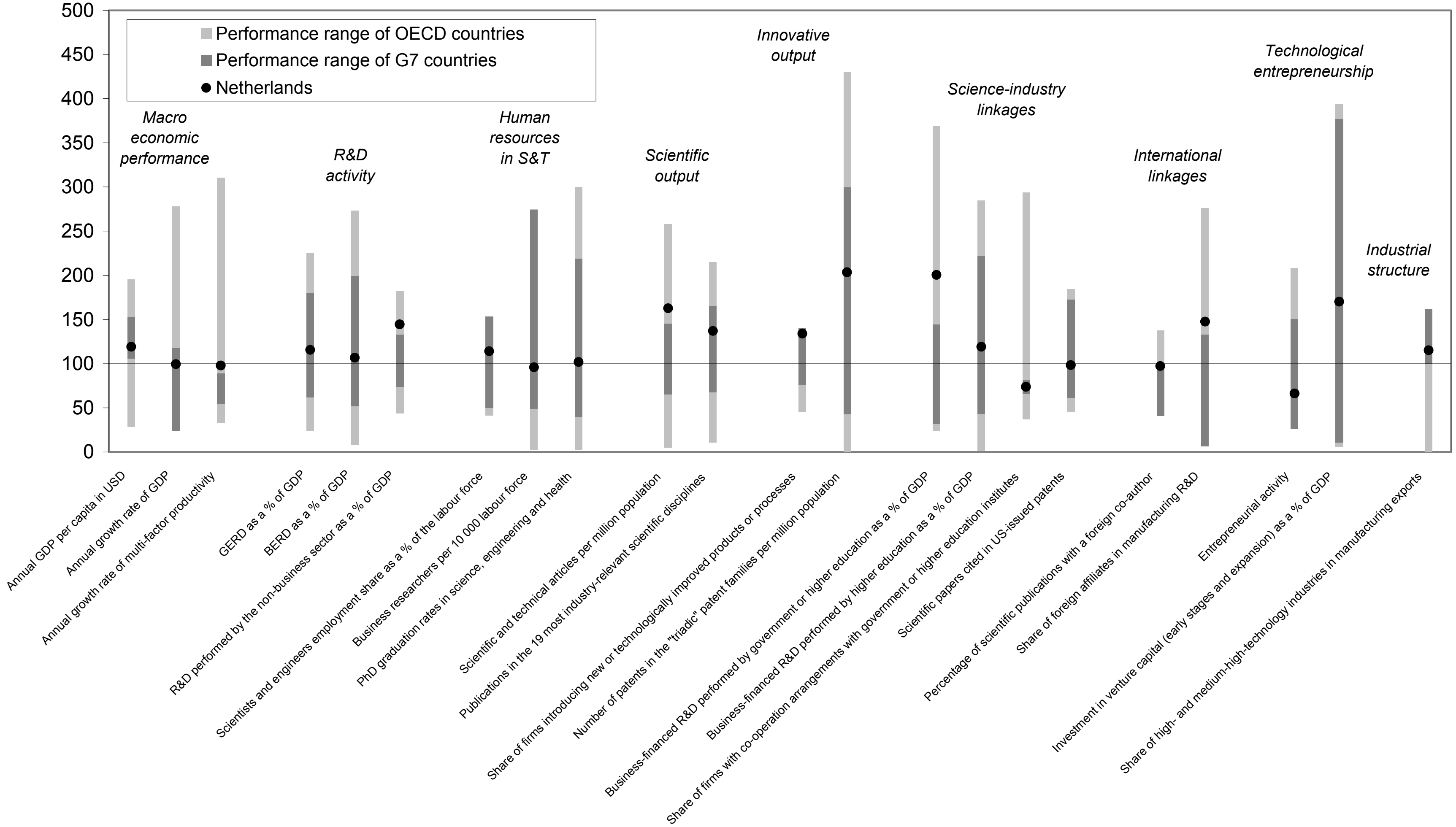


Source: OECD.

2. "As a result of population ageing, productivity growth is set to become by far the most important source of economic growth" (OECD Economic Survey of the Netherlands, 2002).

Figure 2. Profiling the Dutch innovation system

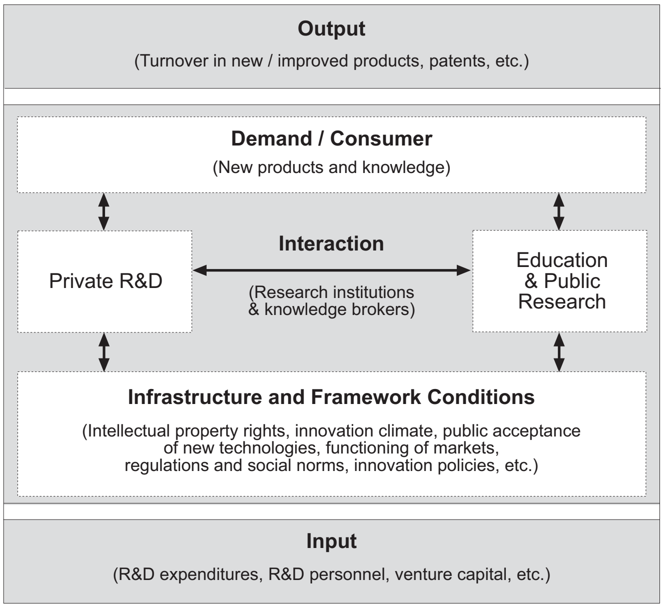
(2001 or latest year available)



The Dutch Innovation System: performance and bottlenecks

Overall, the Netherlands' innovation performance is still satisfactory by international standards (Figure 2), but there are indications that the Dutch innovation system is "losing momentum" (European Commission, 2001) due to various bottlenecks that have an increasingly negative impact on its efficiency in the emerging knowledge-based economy. A cursory examination of the various components of the Dutch innovation system (Figure 3) points to the following main problem areas.

Figure 3. Components of an innovation system



Source: Technopolis; Netherlands Ministry of Economic Affairs.

The *output* and productivity of both public and private R&D efforts – in terms of patents and publications – stand out favourably in international benchmarking (Figure 2). Output in terms of new or substantially improved products in sales, however, is substantially below EU average.[3] Overall, it can be concluded that the favourable score on (public) research output contrasts with the score on economic output (labour productivity growth, output in terms of new or substantially improved products in sales, etc.) pointing to inefficiencies in market and non-market interactions within the innovation system. In this regard, one of the most important perceived weaknesses of the Dutch NIS is *inadequate interactions between science/higher education and industry* at a time when such interactions become an even more important vector of knowledge creation, transfer and commercialisation[4]. This raises questions about the determinants and level of business interest in co-operating with universities, the responsiveness of higher education, and the effectiveness of bridging institutions and mechanisms, including TNO (Netherlands Organisation for applied Scientific Research) and Special

3. Community Innovation Survey.

4. For example, only 1% of the Dutch innovative companies in manufacturing consider universities as an important supplier of knowledge, compared to the 4% average in Europe, and the number of spin-offs from universities is quite low.

Technological Institutes, and relevant government incentive programmes. Box 1 gives some figures on the interaction between the science system and the private sector:

Box 1. Indicators on the interaction between the science system and the private sector
During the period 1998-2000, 5% of the innovative firms co-operated with universities in the Netherlands and 6% co-operated with a research institute. These figures have worsened in recent years, and with these percentages, the Netherlands is lagging behind the EU average (8% for both indicators).
24% of the innovative firms innovate in partnerships. Of this group only 20% innovate with a university.
Only 1% of the Dutch innovative companies in manufacturing consider universities as an important supplier of knowledge, compared to the 4% European average.
The number of spin-offs from universities is quite low (100). The Netherlands seems to lag behind other countries (30-40%).
The percentage of R&D at universities financed by industry is 6.5%, the same as the EU average.

Source: CBS, Eurostat, OECD and TSI.

Infrastructural and framework conditions for innovation in the Netherlands are good in comparative terms but could be improved, especially in the following areas:

- *IPRs and patents.* Like in the other European countries, the cost of patenting is three to five times higher than in Japan and the United States; in addition, there is room for improvement in the management of IPRs in the public research sector. IPRs could be better used for improving new innovative entrepreneurship.
- The *ICT infrastructure* is well developed, but as in all countries, it needs to be continuously upgraded (*e.g.* the accelerated creation of a super-fast internet infrastructure, the improvement of ICT in education and the strengthening ICT research).
- *High-tech entrepreneurship* in the Netherlands is not well developed. Although the number of start-ups significantly increased in the 1990s, the Netherlands still lags behind in terms of annual number of spin-offs of research institutes.[5] This is confirmed by the Global Entrepreneurship Monitor 2002, which makes clear that diffusion of knowledge through science-based or high-tech start-ups is one of the weak elements of the Dutch Innovation System.[6]
- *Labour mobility*, especially between the public and private research sectors, remains insufficient despite some improvement in recent years.
- The Netherlands has a good track record in securing *public acceptance of T*, but sustaining such acceptance over the long term in face of unpredictable radical technological changes requires further efforts to promote timely and objective information and a constructive dialogue between science, industry and society.
- More can be done to lower *administrative burden* for companies.

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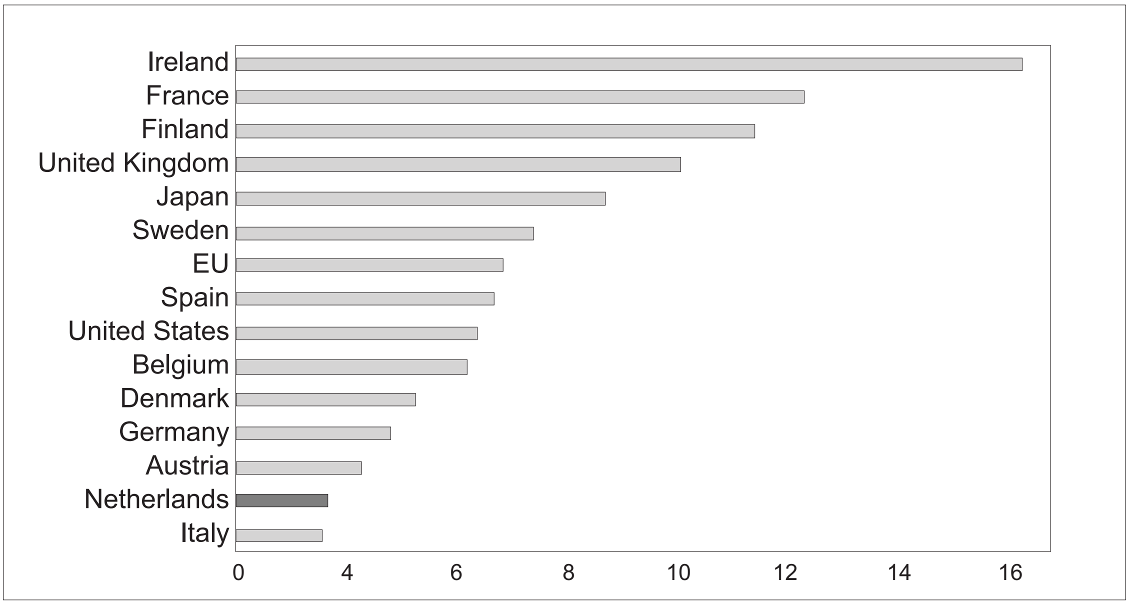
5. This figure comes from a recent research conducted by Top Spin International (Spring 2003). A summary in English is available.

6. Furthermore, Dutch venture capitalists and business angels are complaining about the low quality (and low number) of business plans from would be entrepreneurs in research institutions. This can be partly explained by a lack of attention to entrepreneurship in the Dutch educational system.

On the *input* side of the Dutch Innovation system, the limited availability of scientific staff, the relatively low level of spending on R&D and the shortage of (pre-)seed capital are major obstacles for the Netherlands' future performance in research and innovation.

Figure 4. Number of S&T graduates per 1000 inhabitants, age 20-34 (2000)



Source: European Commission.

- The shortage of scientific staff concerns not only public research institutes and universities but also the private sector, which is experiencing increasing difficulties to find a sufficient number of qualified researchers.[7] Furthermore, the availability of researchers and R&D staff will decline further in the future as a result of the small numbers of graduates in science and technical subjects (Figure 4).
- The fact that the business sector's propensity to spend on R&D is lower in the Netherlands than in most comparable European Union (EU) and OECD countries[8] is to a large extent due to structural characteristics of the Dutch economy, especially its industrial specialisation. However, when controlling for this factor, it remains that the Netherlands simply seems to underperform. Also worrying is the insufficient spending on innovation, notably in the service sector, as well as

7. In 2000 business researchers per thousand employment in industry amounted to 3.6 in the Netherlands as compared to 4.1 in the EU, 9.8 in Japan and 10.2 in the United States. See also Figure A.1 in the Annex which provides an international comparison of the number of researcher per thousand labour force employment.

8. In 2000 the industry financed business R&D expenditures as a percentage of value added in industry was 1.3 in the Netherlands as compared with 1.47 in the EU, 3.0 in Japan and 2.51 in the United States.

the changing perception of some major Dutch R&D companies about their homeland's attractiveness.[9]

- Regarding the availability of financial resources for technology-based start-ups, there is a sharp contrast between the situation concerning venture capital, where the Netherlands outperforms most other OECD countries, and that of seed capital, which is in shorter supply than in many other countries.

Policy challenges

Recent studies (including evaluations of Dutch innovation policy) and the new Dutch innovation agenda (the so-called *Innovatiebrief*) suggest that the Dutch government faces the following main challenges in the field of science and technology policy:

- Increasing the incentives and improving the institutional frameworks for co-operation between public and private actors of innovation.
- Improving the attractiveness of the Netherlands as a top location for: researchers, new technology-based firms, R&D and other innovative activities.
- Streamlining and improving the public support schemes for innovation and a complex innovation governance system.
- Improving the inter-departmental co-ordination.

One major challenge for the Netherlands is to reduce the number of instruments used in innovation policy and to achieve better co-ordination and division of labour between the actors involved in formulation or implementation.[10] There is a need for better interdepartmental co-ordination in policy formulation, better management and evaluation at the implementation stage and streamlining of the existing set of instruments. The forthcoming Innovation Agenda *(Innovatiebrief)* will announce a drastic cut in the number of innovation support schemes and will include a reshaping of Dutch Innovation

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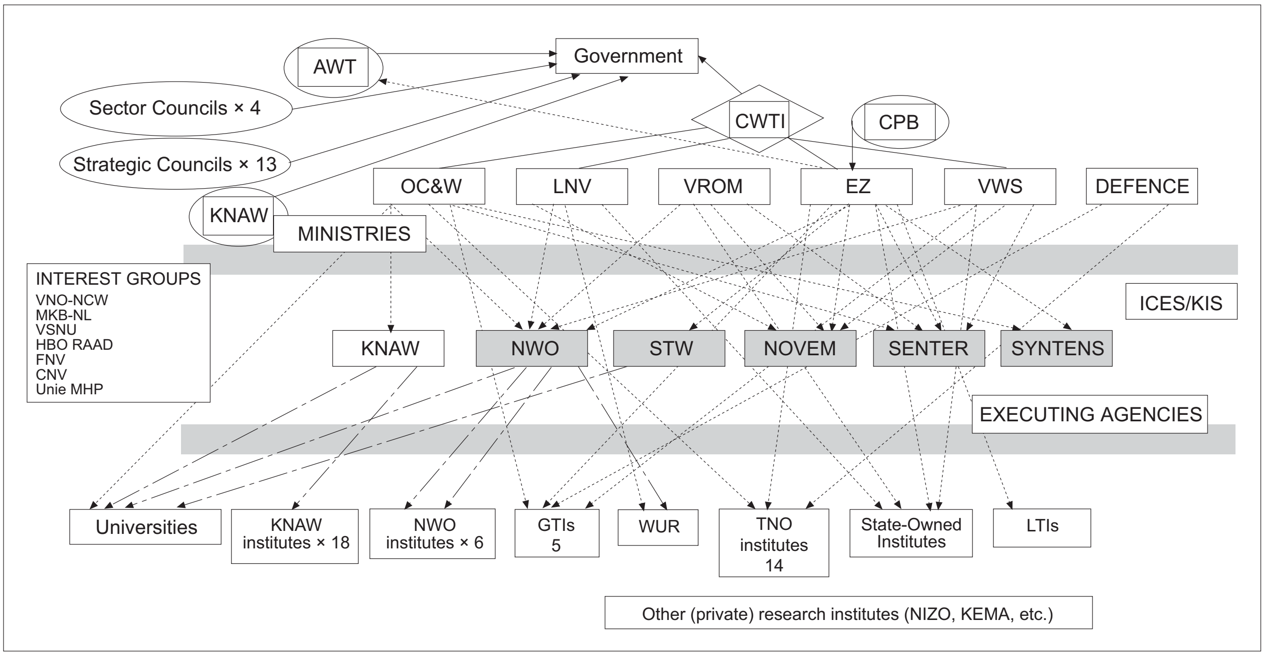
9. Some recent statements by Philips and Unilever point to possible problems in the medium to long term. The Chief Technology Officer at Philips recently said that it could not be ruled out that all R&D activities would have been moved from the Netherlands within 15 years (*Het Financieele Dagblad*, 8 October 2002). Unilever too has expressed concerns about the future of the Dutch knowledge economy (*Het Financieele Dagblad*, 1 November 2002).

10. The Interdepartmental Investigation on Innovation Policy (known in Dutch as *Interdepartementaal Beleid Onderzoek Technologiebeleid*) conducted in 2002 concluded that co-ordination and collaboration between Ministries has to be improved, especially between the science ministry (OC&W) and the innovation ministry (EZ). This would yield important benefits in areas such as intellectual property rights, university spin-offs and industry-university collaboration. Through better co-ordination, science and innovation policy in the Netherlands can strengthen each other.

policy. The intermediary structure of public research institutes, aimed at applied research will also be subject to careful scrutiny as to its added value for industry and science, in its role as go-between and matchmaker.[11]

Figure 5. Actors in the field of Dutch innovation policy



Source: Technopolis; Netherlands Ministry of Economic Affairs.

As stated above, an overriding objective of Dutch innovation policy is to improve the responsiveness to industry needs of public research organisations, especially universities, through new financing mechanisms, entrepreneurship and improved capability to manage IPRs. One reason for the insufficient co-operation between companies and universities lies in the financing of universities. Basic institutional financing accounts for a very large share (about two-thirds) of total university funding (Table 1). In addition, more than 80% of this total is based on a historical allocation over 13 public universities. The share of funds that are granted on a competitive basis by NWO is relatively low (less than 10%), as is the share of business in total contract research (about 20%) and in total funding (Table 2). In order for university research to be more responsive to innovation-driven demand for scientific and technological knowledge, the funding system should encourage more research public-private partnerships. Greater priority should also be given to measures that encourage spin-offs from public research, creation and operation of incubators and a more efficient management of IPRs by universities and public research institutes. The new government budgets for 2004 as well as recent statements made by the Prime Minister, the Minister of Economic Affairs (EZ) and the Minister of

11. Some initiatives have already been taken in this regard. For instance, in the summer of 2003, following the Finnish example, the new cabinet appointed an Innovation council (the so-called *Innovatieplatform*) consisting of business leaders as well as researchers and independent experts whose role will be to contribute new ideas to reshape and strengthen the Dutch Innovation and science policy and ensure that it better responds to stakeholders' needs.

Education, Culture and Science (OC&W) made it clear that the financing mechanisms of the science system (especially universities) will be revised bearing in mind the above-mentioned elements.

Table 1. Funding of University research (1999)

	€ million	%
Government lump sum funding (1st flow)	1 468	67.9
NWO Research Foundation (2nd flow)	179	8.3
Contract research (3rd flow)	515	23.8
Total	2 162	100.0

Source: CBS, *Kennis en Economie (Knowledge and Economy)*, 2001.

Table 2. Percentage of University research financed by industry

	1994	1996	1998	1999	2000
Netherlands	4,0	3,8	5,0	5,1	6,5
EU	5,8	6,1	6,4	6,5	6,5
OECD average	5,6	6,4	6,1	6,1	6,3

Source: Main Science and Technology Indicators, 2003-1.

Policy responses: the increasing role of public-private partnerships

The Netherlands has been struggling for some time with what is now known as the "European paradox": high-quality scientific research coupled with trailing application of public knowledge in actual innovations, despite the existence of a relatively large applied research infrastructure (Box 2).

Box 2. The Dutch S&T policy governance and public research infrastructure

The Ministry of Education, Culture and Science is responsible for science policy and the Ministry of Economic Affairs has responsibility for policy on innovation and ICT. Other ministries, such as the Ministry of Public Health, Welfare and Sport; the Ministry of Transport, Public Works and Water Management; and the Ministry of Agriculture, Nature Management and Fisheries each have their own science and technology budgets, focusing on their own fields. The total 2003 S&T budget amounts to € 3,590.6 million.

The Netherlands counts 13 public universities, one private university, one open university and 22 para-academic institutes. In addition, it hosts a number of public institutes for applied research. One of the missions of these institutes is to bridge the gap between scientific research and the private sector. This public applied research infrastructure is relatively large in comparison with other countries, consisting of the Organisation for Applied Scientific Research (TNO) and the five Large Technological Institutes (GTIs): the Maritime Research Institute Netherlands (MARIN), WL/Delft Hydraulics, the National Aerospace Laboratory (NLR), GeoDelft and the Energy Research Centre of the Netherlands (ECN). Government funding of these applied research institutes consists of basic (or institutional) funding and of programme financing for governmental purposes or for research for private companies.

The 1979 Innovation White Paper already noted this problem and introduced the Innovation Oriented Research Program (IOP) and the STW's scheme to stimulate fundamental research in response to industry needs. The Knowledge in Action Memorandum published in 1996 marked a further turnaround in policy concepts and announced various measures: 1) the introduction of co-financing for part of the funding of TNO and the GTIs (Large Technological Institutes) in order to make these institutes more responsive to private sector demand; 2) the creation of four Leading Technology Institutes (LTIs) focusing on business-relevant fundamental and strategic research of an excellent international level in an institutional partnership between the public research infrastructure and the private sector; and 3) the creation of two schemes designed to stimulate project-based technological partnerships between companies and research institutes, and between companies: the Economy, Ecology and Technology (EET) scheme and the Business-Oriented Technological Partnership scheme (BTS).

Since then promoting interaction between public research and industry has remained a top priority of the Dutch innovation policy. A number of new programmes have been started in recent years, such as the Netherlands Genomics Initiative and the Platform ACTS, aimed at catalysis research. PP/Ps now play a key role in the Dutch innovation policy, far more importantly than would suggest their rather modest share in the overall Science & Technology budget (Table 3).

Table 3. Budget for public-private partnership programmes (2003)

PP/P programmes	€ million
STW Technology Foundation	42.788
Innovation-Oriented Research Programmes (IOP)	13.430
Organisation for Applied Scientific Research (TNO) [12]	28.149
Leading Technology Institutes (LTI)	28.951
Technological Partnership scheme (TS) [13]	62.132
Economy, Ecology and Technology programme (EET)	33.000
The Netherlands Genomics Initiative	11.345
ACTS	2.333
Total PP/P programmes	222.128
Total S&T budget	3 520.494
Share of PP/P programmes in total S&T budget for 2003	6.3%

Source: The Netherlands Ministry of Economic Affairs.

12. This is only the financing which TNO receives from the Ministry of Economic Affairs, as this part of the financing has to be co-funded by companies. Besides the financing of the Ministry of Economic Affairs, TNO receives institutional financing from the Ministry of Education, Culture and Science and specific financing from other departments.

13. The Technological Partnership scheme also funds private-private partnerships. Starting on 1 January 2004 the Technological Partnership scheme and the Programme Economy, Ecology and Technology will be integrated in a new scheme for R&D partnership projects.

This role is likely to increase in the future. The government has reserved a sum of € 805 million for public-private research proposals in strategic areas (ICES/KIS3) for the 2003-2010 period. Decision on the final budget for ICES/KIS3 and the allocation of the budget for the prioritised knowledge themes and project proposals will take place at the end of 2003, based on the quality of the 67 project proposals submitted. The project proposals that are accepted will begin from early 2004. In addition, the forthcoming White Paper on innovation policy will soon propose initiatives that would accelerate the shift from subsidies for individual companies to stimulation of technological partnerships, including through new measures to promote project-based alliances and programme-based partnerships, as part of the streamlining of existing instruments.

In addition, the bridging function of TNO and the GTIs will be evaluated in 2003, with a view to improving their positioning, steering and funding in 2004. The Dutch government will also consider reforms of the financing mechanisms of university research, with the objectives of increasing the share of competitive grants (through NWO) relative to that of institutional funding, and introducing more performance-based criteria (including applicability of research for innovation) in the allocation of institutional funding.

It is important that future decisions regarding the actual implementation of these reforms take into account the lessons drawn from practical experience with the management of existing PP/P programmes. The following section examines this experience by focusing on one of these programmes, the Leading Technology Institutes (LTIs), with some references to the more recent Genomics Initiative (see overview in Box A.1 in Annex). This focus has been chosen for at least two reasons. LTIs represent one of the purest forms of PP/P in their rationale and organisation, and there are similar programmes in other OECD countries that provide an opportunity for international benchmarking. Although relatively new, they have been operating long enough to gather lessons from.

Table 4. Public-private partnership programmes in the Netherlands

Instrument	Description
STW Technology Foundation	Via the STW Technology Foundation, the Ministry of Economic Affairs stimulates the development of excellent demand-driven technical and scientific research at Dutch university research centres. Three aspects play a key role here: user involvement in the research, utilisation and the research yield. On the basis of an evaluation in 2002, contributions to the STW were renewed until the end of 2006.
Innovation-Oriented Research Programmes (IOPs)	The aim of the IOPs is to strengthen strategic research at Dutch universities and research institutes in relation to private sector innovation needs, via a programmed approach. IOPs are currently running in the following technology fields: image processing, genomics, industrial proteins, man-machine interaction, environmental technology/heavy metals, surface technology, precision technology and power electronics. The resources for each programme are made available for each programme for research and knowledge diffusion.
Organisation for Applied Scientific Research (TNO)	The objective of TNO is to translate scientific knowledge into applied knowledge that is useful for the private sector and government agencies. Through specific financing, the Ministry of Economic Affairs' contributions to TNO are made dependent on the extent to which the private sector is prepared to support TNO research projects. This is designed to promote more demand-driven strategic and applied research.
Leading Technology Institutes (LTIs)	With the LTIs the Ministries of Economic Affairs aims to increase the innovative capacity and competitiveness of Dutch companies in a number of selected fields. This takes place through company-relevant fundamental and strategic research of an excellent international standard, in institutional partnerships between the public research infrastructure and the private sector. The fields involved are telematics, food, polymers and metals. *(See detailed examination in the following section.)*
Technological Partnership (TS) scheme	Through the TS scheme, subsidies can be provided for technological projects by corporate alliances or partnerships between companies and between companies and research institutes, aimed at fundamental/ industrial research or pre-competitive development.
Economy, Ecology and Technology (EET) programme	Through the EET programme, subsidies are provided for major research projects conducted by corporate alliances or partnerships between companies and research institutes, which can lead to substantial advances in both ecological and economic terms through technological innovations. This contributes to improved economic sustainability.
The Netherlands Genomics Initiative	For the 2001-2006 period, the government has allocated € 189 million for genomics. The Netherlands Genomics Initiative (NROG), part of the NWO, selected four priority areas for genomics research in 2002: biosystems, industrial fermentation, cancer research and medical biological systems. National centres have also been set up for social research, bio-IT and proteomics. A number of new demand-driven research consortia consisting of companies, research institutes and social groups are expected to start work in 2004 in fields such as infectious diseases, soil detection systems and nutrigenomics.
Catalysis	The Advanced Catalytic Technologies for Sustainability (ACTS) platform, part of NWO, has worked since its formation by companies, research institutes and the Ministry of Economic Affairs in early 2002 to strengthen the Netherlands' international position in the field of catalysis. With the aid of active substances, micro-organisms or enzymes, catalysis can lead to new processes and products. Two research programmes are now in progress: "Integration of Biosynthesis & Organic Synthesis" and "Sustainable Hydrogen". A third, "Advanced Sustainable Processes by Engaging Technologies" (ASPECT), will start shortly. ACTS now plays a pioneering role within the EU.

Source: The Netherlands Ministry of Economic Affairs.

EXAMINATION OF THE LEADING TECHNOLOGY INSTITUTES (LTIs)

The Leading Technological Institutes (Box 3) constitute an innovative model for public-private collaboration. These (mainly virtual) institutes each bring together a number of public research organisations (*e.g.* universities, national research centres) and industrial partners. The resulting network combines the strengths of the best researchers in the Netherlands, engages them in industrially relevant programmes, and helps co-ordinate research activities in areas of strategic importance for the Dutch society.

Box 3. The four Leading Technological Institutes (LTIs)

The **Telematica Instituut (TI)** aims to become industry's long-term research and training partner to foster business innovation in telematics within and across key industry sectors.

The **Wageningen Centre for Food Research (WCFS)** concentrates on pre-competitive research on topics that are key to the future competitiveness of the Dutch agro-food sector. It provides the link between food and biosciences/biomedical research. The WCFS is uniquely positioned to capitalise on the new knowledge that will follow the sequencing of a range of genomes - including the human genome and those of selected key micro-organisms.

The **Netherlands Institute for Metals Research (NIMR)** aims to achieve leadership in research and education, in areas critical for the international competitiveness of the Dutch metals industry, by means of cross-disciplinary research and training programmes.

The **Dutch Polymer Institute (DPI)**, also known as LTI "3P" (Polymers & Polymer Processing) has the mission to "establish a leading technological institute in Europe in the area of Polymer Science & Engineering which is characterised by a multidisciplinary knowledge base". This involves: (a) establishing a fundamental knowledge base for industry, (b) developing new concepts for industrial development, and (c) training scientist and engineers.

The following examines the experience with LTIs, focusing on the following main issues:

- *Role and purpose:* Are partnerships central to the overall research approach of the country? Are they encouraging research which might not otherwise be conducted?

- *Participants*: Do research partnerships have competitive processes for selecting diversified participants? Do partnerships include small firms and/or foreign companies?

- *Financing*: Are the partnerships contributing to cost-sharing and leveraging of private funds?

- *Management*: What are the governance arrangements for partnerships? Have specific institutions or centres been established to conduct joint research?

- *Intellectual property rights*: What are the provisions for intellectual property rights for the results of joint research?

- *Evaluation*: Are partnerships regularly subject to evaluation? What are the procedures and criteria? What have been the results?

Role and purpose: which gap do LTIs fill within the Dutch NIS?

LTIs fill a gap in the Dutch NIS which was widening because of the evolution of large firms' research strategies, the insufficient responsiveness of university research to emerging opportunities, and the applied focus of industry-relevant research in most public laboratories. Large companies in the Netherlands have reduced or abolished their central research facilities. This has entailed a shift to more short-term and development-related work and the decline of business-performed basic research, making firms more dependent on the results of fundamental and long-term research performed in the public sector. But universities have the responsibility to carry out curiosity-driven fundamental research that cannot be oriented towards industry's needs through traditional research contracts. On the other side of the spectrum, a large fraction of the activities of TNO and DLO institutes is in the form of assignments from individual companies.

LTIs operate at the interface between academic research and industry. The industrial partners have a leading role in defining the research programme, thus ensuring that the programme is in line with the long-term needs of the industry and creating the favourable conditions for transfer of new knowledge from the academic environment to industry. On the other hand, the participation of competing companies in each consortium and the fact that the knowledge generated is available to each of them, ensure a wide diffusion of the research results, and thus the maximisation of the longer-term socio-economic benefits of the research programmes.

Understanding the mission of LTIs and judging their "additionality", *i.e.* whether they are really encouraging research which might not otherwise be conducted, require taking due account of the characteristics of the research process and of the Dutch industrial structure in each of the relevant technological fields. First, a too general and abstract definition of what distinguishes "fundamental', "generic" or "pre-competitive" research that should be subsidised from "industrial" or "close to market" research that should not be is at best useless if not misleading. Only competent actors can judge, under the control of independent real experts. For example, the time horizon of projects is not an absolute criterion. Legitimately, it differs strongly across LTIs, from only three months for some projects of Telematica to eight years or more for many NIMR projects. Secondly, the nature of the science base and the market structure of sectors influence objectives: Telematica has to bridge a deeper gap between science and the market/industry than the other LTIs because the relevant part of the science base is highly fragmented and because there are in the Netherlands only very few ICT companies with an own R&D department. In contrast, in polymer research, the outcomes of academic work are easily applicable to market needs by the DPI industrial participants themselves that have a strong own research capacity.

From a systemic perspective, "additionality" has several dimensions which ought to be all considered in assessing the rationale of PP/P programmes. The "behavioural" dimension is key for all types of PP/Ps. One implicit objective of the LTIs is to induce longstanding changes in the mindset of actors, and build mutual trust and develop appropriate routines for co-operation between research communities that have a different culture and pursue different main goals. Also from this standpoint, LTIs are a success if one judges by the sustained commitment of actors, and the emergence of a shared "corporate culture" in some of them. Another dimension is societal impact, when the PP/P programme does not only aim at bridging the gap between science and market but also at diffusing the resulting innovation throughout society. Societal embedment is, for example, an important and ambitious goal of the genomics initiative.

Participants

Selection process

In order to achieve greater synergies and linkages among the participants in public-private partnerships, the Dutch government invited consortia (of companies, research institutes and universities) rather than individual partners to submit proposals for the formation of LTIs. It requested business enterprises to file proposals for public-private partnerships in basic strategic research in consortia with public research institutes and universities. The government believed that joint industry and cross-institutional thrust in partnerships was the most effective way to maximise the networking possibilities and hoped to promote co-operation between the partners, within the academic system, and between the participating companies on pre-competitive research.

Table 5. Selection process of the proposals for LTIs

19 initial proposals	6 invitations for business proposals	4 LTIs finally selected
Food sciences	x	x
Metals technology	x	x
Polymers	x	x
Telematics	x	x
Sustainable energy	x	
Transport & logistics	x	
Bio-organic materials		
Catalysis		
Embedded systems		
ICT/Information on demand		
Innovation in medicine/health		
Knowledge management		
Mobile/telecommunication		
Multimedia engineering		
Oncology		
Optical/electro-optic materials		
Pyrotechnology of natural gas		
Telematics-European Design Centre		
Waterworks		

At the same time, the selection process between the proposals of the consortia can be considered competitive, as is suggested by the fact that only four out of 19 initial proposals were selected to become LTIs. The selection criteria proposed in the policy document entitled *Knowledge in Action* included: current strengths in the knowledge infrastructure; possibilities for scientific developments in the fields, especially the chances for "quantum leaps"; and the existence of a solid industrial base. The scientific quality was checked by the Royal Academy of Sciences and the economic relevance by an international consulting company. The so-called "van Wijzen Commission", a group of experts advising the Dutch government, received 19 outlines in 1996, of which it invited six to submit a business plan. In 1997, four of these plans were selected to become LTIs (Table 5).

The marked "bottom-up" character of the selection process probably gave greater chances to proposals that had a strong and credible "natural" leader (Corus for NIMR, and Unilever for WCFS), and/or could be articulated by a pre-existing network or co-operative research organisation (the "discussion forum on metals research" in the case of NIMR, and the "Telematic Research Centre" in the case of Telematica). This was likely to the detriment of more multidisciplinary proposals with a more diffused constituency in both the private and public sector.

Such a selection process and eligibility criteria guaranteed a strong commitment by industry, the quality of supported industrially-relevant research, and significant positive impacts on important parts of the Dutch industry and public research. They helped pick the proposals which had the highest chance to succeed in important research fields, but not necessarily those which were of the highest strategic importance for the Dutch economy and society.

To some extent, other PP/P programmes are answers to this problem. The genomics initiative represents one of these areas of strategic importance where various actors of the Dutch knowledge infrastructure and industry are mobilised towards common goals. However, LTIs, because of their proven efficiency, should not be ruled out as a model for addressing in the future other themes of strategic importance, especially when leadership from industry is key to success.

Participation of SMEs

The Dutch government does not provide any specific incentive for small and medium-sized enterprises (SMEs) to participate in the public-private partnerships to form a LTI. The share of SMEs as partners is limited (about 10%), due to the fact that the main target areas of the LTIs are generic or pre-competitive technologies whereas few SMEs are able/interested in strategic research (LTI Evaluation Report, 2001).

However, several policy tools for supporting SMEs have been implemented outside the scheme of LTI. For example, several actors (the Netherlands Organisation for Applied Scientific Research (TNO), Technical University of Eindhoven, and Fontys Hogescholen) established a service unit (the so-called *Kunstoffenhuis*) to make the results from academic polymer research available to polymer-processing SMEs. This organisation facilitates knowledge transfer by offering consultancy and training and helps SMEs to get aware of the developments in academic research, including the activities of the Dutch Polymer Institute (DPI), and of possible benefits for their own business.

Several spin-off firms have been created through knowledge transfer from LTIs to industrial partners. For instance, Telematica has actively promoted the establishment of spin-off companies and provided substantial support, and staff members of TICO *(Telematica Instituut Central Organisation)* started two spin-offs in 2000. These were based on the results from the test bed project with licenses from TI. The Netherlands Institute for Metals Research (NIMR) also created a new company in the area of software.

The participation of SMEs is clearly not perceived as an issue by the LTIs. They do not see the need for special efforts to increase this participation. TNO has here a key role to play in co-ordinating its action as a partner in all four LTIs and its mainstream activities in favour of SMEs.

Participation of foreign companies and public research organisations

Until recently only domiciled foreign firms (those with an R&D or production presence in the country) could participate in subsidised research partnerships, provided that they could demonstrate that results would be exploited locally. A number of foreign companies participate in LTIs, especially in DPI (see Table A.1 in Annex). Now non-domiciled firms can also participate under certain conditions, subject to government approval. Foreign knowledge institutes, mainly universities, are partners in DPI.

Table 6. LTIs' workforce in 2000

	Workforce (full time equivalents)	**Foreign researchers** (%)
Netherlands Institute for Metals Research (NIMR)	91	47
Dutch Polymer Institute (DPI)	90	20
Wageningen Centre for Food Research (WCFS)	87	19
Telematica Instituut (TI)	123	10
Total four LTIs	391	21

Sources: The Netherlands Ministry of Economic Affairs; LTIs' Annual Reports.

In addition to co-operating with foreign firms and knowledge institutions, LTIs also employ a number of foreign researchers. The percentage of foreign researchers in total researchers, however, varies strongly across the LTIs, ranging from 10% in Telematica to almost 50% in the Netherlands Institute for Metals Research (Table 6).

As suggested by the Evaluation Report (2001), the fact that many of the senior researchers involved in LTI projects have an international reputation and take part in joint projects with scientists abroad does not automatically imply international contacts for the LTI. The actual involvement of the LTI in international activities is increasing, but still quite limited, albeit to a different extent for the four institutes. The activities include publications in refereed international journals, hosting or attending international conferences, participation of LTI scientists in joint projects, short or extended stay of LTI researchers at foreign institutions, and visits of foreign scientists to the LTI.

A special case of international presence is in European programmes. Participation in European projects does not appear to be very attractive for the LTIs for several reasons. The rules for research funding severely limit the financial benefits of such projects. The government contribution is limited by the so-called "anti-cumulation rule" (see below in the section on financing). In addition, participation in European projects requires a considerable investment in time, often beyond what available human resources can afford.

Financing

From the very start, the Dutch government imposed strict rules regarding cost-sharing arrangements among the participants in a LTI. The government share in total funding is limited to 50%, but cannot exceed two times the lowest contribution of either knowledge institutes or industry. Public research organisations and business enterprises each have to contribute at least 20%. The size and modalities of industry contribution differ substantially across LTIs (Tables 7). DPI has a ticket system. Each ticket costs € 50 000 a year and corresponds to one vote in the programme committee and the possibility to appoint a number of contact persons for the area involved. Firms can buy more than one ticket per technology area in order to have more influence. This system contributes to making the project portfolio adaptive to industry needs. WCFS has a four-year rolling contribution system (every year, the firms agree to pay for another four years) which secures a stable financial base for long term research.

Table 7. LTIs' annual budget / turnover development (Mdfl; Euro in 2002)

	1997	1998	1999	2000	2001	2002
Netherlands Institute for Metals Research (NIMR)	**7.3**	**16.0**	**22.4**	**25.5**	..	**12.3**
Industry	(23%)	(23%)	(25%)	(23%)		
Knowledge institutes	(32%)	(30%)	(26%)	(32%)		
Government	(45%)	(47%)	(49%)	(45%)		(45%)
Wageningen Centre for Food Research (WCFS)		**11.8**	**19.1**	**28.1**	..	**14.9**
Industry		(31%)	(36%)	(37%)		
Knowledge institutes		(23%)	(21%)	(22%)		
Government		(46%)	(43%)	(41%)		(42%)
Telematica Instituut (TI)*		**17.4**	**29.7**	**32.4**	**35.2**	**15.6**
Industry		(40%)	(45%)	(48%)	(47%)	
Knowledge institutes		(19%)	(18%)	(17%)	(17%)	
Government		(38%)	(36%)	(33%)	(34%)	(32%)
Dutch Polymer Institute (DPI)	**1.2**	**8.0**	**15.1**	**19.0**	..	**12.7**
Industry						
Knowledge institutes						
Government						(43%)
Total 4 LTIs	..	**53.2**	**86.3**	**105.0**	..	

* Percentage distribution does not add to 100% due to the existence of other sources of financing.
Sources: The Netherlands Ministry of Economic Affairs; LTIs' Annual Reports.

The 50% budget contribution exerts considerable leverage on private investment. In concrete terms, in the case of DPI, with the additional government contribution one industry ticket pays for three PhDs per year instead of just one.

The government contribution is also limited by the so-called anti-cumulation rule, which decrees that the total subsidy from external sources cannot exceed 50% of the total budget. This rule makes it unattractive for the LTI to seek substantial additional funds, *e.g.* from the European Framework Programme, because such funds would not or would only marginally increase the total budget (Evaluation Report, 2001). In order to avoid a situation where the extra subsidy that Telematica acquires through European projects is creamed off through the anti-cumulation clause, the Ministry of Economic Affairs has increased the subsidy ceiling from 50% to 60%. This *ad hoc* arrangement should not dispense the government from seriously considering more radical solutions to the problem.

When launching the LTIs, the Dutch government announced that it would eventually stop funding them once they reached maturity. After four years, LTIs were renewed with unchanged financial arrangements, but the objective of making them self-sustained by the end of 2007 was reaffirmed. This does not seem realistic, although LTIs agree that the current level of budget subsidy (50%) is arbitrary and could possibly be lowered without deterring industry participation or distorting research orientation to the detriment of public interest. It would therefore be preferable for the government to consider implementing incremental decreases in the rate of public subsidy according to the growth stages of LTIs.

Organisation, governance and management

The government was very active in the initiation of LTIs but left each of them free to decide on their organisational set-up. The government imposed only minimum requirements: scientific excellence and industrial appropriateness. The organisational form of each LTI is specific. DPI and WCFS are purely virtual organisations, with a lean organisation at the core and research being done at the participating research institutes, whereas NIMR and TI do much research at their core and thus have a mixed form between the virtual and the central organisation. Each organisational mode has advantages and disadvantages (Table 8). While a central institute can easily integrate and motivate researchers, it runs the risk of not being supported by existing institutes because it takes promising researchers and funds away from them. The virtual institute can mobilise manpower and equipment while they stay at their own institutes, but may encounter weaker loyalty by the research partners because they have their own, separate missions to fulfil. In practice, LTIs have chosen organisational modes that seem quite well adapted to the characteristics of the science base and industry in their respective technological fields, and that exploit well the possibilities provided by the advanced development of ICTs in the Netherlands.

Table 8. Organisational models

	Central institute	Virtual institute
Advantage	• Easy integration • More corporate culture	• Researchers can work in their natural habitat • Flexible personnel policy
Disadvantage	• Pulls out researchers from universities • Can become isolated	• Difficult to organise • Double loyalty of researchers

There is no ideal organisational model that would prevent all conflicts between partners. For example, university participants are often very small groups of researchers with a tendency to focus on a narrow scientific area, whereas industry looks for comprehensive solutions to market problems. The possibility of such conflicting perceptions and incentives must be accepted and this challenges the management rather than the institutional framework. Minimising the risk of opportunistic or egoistic behaviour especially requires trust building, which helps to compensate for uncertainty about the future distribution of costs/benefits of research co-operation.

In addition to trust, another key factor in the success of co-operative research networks is good knowledge management. The LTIs have set up a variety of mechanisms for ensuring efficient knowledge flows among partners (Box 4). NIMR has installed an Internet-based system for knowledge storage and transfer between its partners ("MetNet"), and developed a "technology road map" to share mission and strategies among universities and industries. DPI has established an

Intranet system (based on database/web technology) that enables effective project control. This system includes financial as well as scientific information with different access levels, thus stimulating exchange of information in both science and administration. Telematica has so-called "mindshare meetings" to help the industrial partners of TI to absorb the research outcomes of the knowledge institutes.

The exchange of researchers between universities and business enterprises is another way to enhance knowledge transfer. Within the framework of a project of the Dutch Polymer Institute (DPI), several researchers from industry have spent time at the university whereas it is still rare for university researchers to spend time at the industrial partners' premises. This is a lost opportunity for academic researchers to get better acquainted with industrial needs and market-oriented research, and may reflect the fact that university researchers do not feel a sense of competition for additional research funding.

Box 4. Steering and knowledge management in LTIs

In a virtual organisation knowledge management is critical to success because partners are scattered across a variety of organisations. How are the LTIs managing codified and tacit knowledge?

Exchange of codified knowledge

All four LTIs set up an Intranet to share information and knowledge among partners. In DPI, the Intranet contains all project-related information (budgets, researchers, correspondence, etc.) and all the scientific publications. The NIMR uses MetNet as the internal communication platform where NIMR employees and partners can access a wide variety of information about projects.

Steering and exchange of tacit knowledge

Tacit knowledge is the knowledge that enters into the production of behaviours and/or the constitution of mental states but which is not ordinarily accessible to consciousness. It is embedded in human resources and face-to-face meetings are therefore the most efficient way to transfer it. Tacit knowledge forms an important element in any firm's knowledge base and has a central role in organisational learning. LTIs organise regular steering or working meetings.

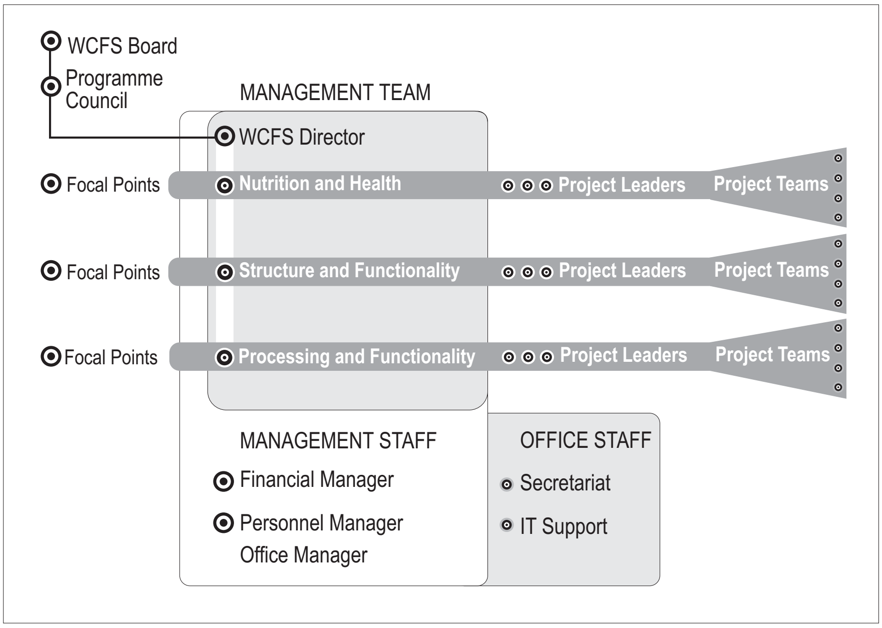
DPI holds a programme committee three times a year for each technology area. The programme committee is responsible for the research programmes. Partner companies appoint contact person(s). Annual review workshops take place in which academic and industrial researchers review the progress of projects. Once a year the entire organisation meets at a DPI congress.

NIMR has quarterly reviews and a yearly NIMR Congress. At these meetings, timely adjustments to the project plans can be made that can take into account the often rapid changes in technologies and business environments. In particular, in order to determine how the future research programmes should be structured. the NIMR has made use of Technology Road Mapping. The technology road map process brings researchers and engineers together to discuss the prospective needs of the metals industry.

The WCFS has a Programme Council composed of representatives from all partner organisations which has responsibility for the overall direction of WCFS research policy and programmes. The Programme Council meets four times a year. To enhance communication between companies and research institutes, each partner organisation has a Focal Point. Being key researchers in their own organisations with close contacts with WCFS scientific directors, the Focal Points are well placed to communicate the research objectives and results within their companies (see Figure 6).

The Dutch companies in the ICT sector do not have enough research capacity and there is therefore a strong need for companies to have discussions with the researchers of the Telematica central organisation concerning the possible importance and impact of new project ideas. For this reason, Telematica often holds "mindshare events" in addition to the regular meetings of the Project Supervision Committees, which are composed of representatives from all partner organisations.

Figure 6. The WCFS organisational diagram



Source: WCFS, Annual Report.

There is criticism in the Netherlands which emanates particularly from public research organisations along the lines that LTIs are too "institutionalised", adding complexity and rigidity to an already populated and complex Dutch NIS institutional landscape, and that they create unnecessary rivalry among different organisations with similar missions. They advocate more flexible and temporary partnership arrangements that could be hosted within existing public organisations such as TNO or NWO, as is the case for the Genomics Initiative or the ACTS (Advanced Catalytic Technologies for Sustainability). However, the experience of LTIs shows that in areas where strong leadership and commitment from industry is the key to success, PP/P arrangements need to acquire a "corporate" identity, as well as some independence from administrative routines regarding personnel and financial management.

Intellectual property rights (IPRs)

None of the four LTIs has an explicit agreement about IPR allocation among partners, but patents are generally filed by LTIs and IPR practices are decided on ad hoc basis in consultation with relevant partners. LTIs give priority to partners for licensing. If no industrial partner shows interest in the patent, the patent is open to other companies outside the partnerships. It is compulsory to make research outputs available either through patenting or by publishing.

LTIs currently do not have a standard dispute settlement procedure in case of conflicts related to IPRs or cost-sharing. The growing costs of litigation act as a disincentive for commercialising research results when IPRs are disputed by participating individuals and institutions. Firms may hesitate to enter into agreements where there is a risk of future litigation from one or more of the partners. The lack of clarity and diversity in national and institutional guidelines for IPRs increases the transaction costs of co-operation for industry, especially for smaller firms. The evaluation report (2001) found a lack of awareness among research staff from Telematica regarding the objectives, value and significance of intellectual property protection.

WCFS is currently working to improve its IPR management. Following two workshops -- one in April and the other in July 2002 -- attended by representatives of all partners and patent experts from the partner organisations, a draft patent procedure was prepared. This draft patent sets out the rights and obligations of the inventions and partners; the conditions of transfer of patents; the ownership of the patent; and the potential to sublicense to other partners and third partners; the roles of the various parties involved in the patent process; and conflict resolution procedures.

Evaluation

The Dutch government requires that LTI activities be regularly monitored (annually) and evaluated (every four years) by the Technology Foundation STW, a part of the National Research Council.

- *Monitoring* is annual and has so far taken place in 1999, 2000 and 2002. It was based on a one-day site visit by two external experts and a co-ordinating secretary for each LTI, and a study of the documents produced by the LTI.

- *Evaluations* take place every four years: the first was carried out in 2001 (after four years of operation) and the next will be in 2005. The 2001 evaluation was based on two-day site visits by an evaluation committee consisting of five foreign experts.

- In addition, each LTI was *surveyed by stakeholders* between 2000 and 2001, and the resulting conclusions were incorporated into the full evaluation report.

- From 2003, monitoring and evaluation will be based on a standard list of indicators (Table 9).

Table 9. Indicators for the evaluation of LTIs

Criteria	Indicators
Market orientation and (inter)national relevance to industry	# of industrial partners; % contribution of industry to total budget; # of established or transferred patents; # of licenses sold to 3rd parties; # of spin-off companies; # of institute researchers finding employment elsewhere in the field; Procedures for performance measurement by industrial partners;
International position	# of EU-projects with participation of the LTI; % EU-funds of total budget; % contribution of international partners to total budget.
Scientific/academic position	# of TTI-papers in internationally refereed journals.
Education	# of completed PhDs.
Governance, organisation, finance and efficiency	Ratio indirect costs/total costs; expenditures for knowledge transfer.

Site visits, which were similar for all four institutes, offered the committee opportunities to meet representatives of the different groups of stakeholders, including members of the management team, members of companies from the consortium, members of the management of the participating knowledge institutes and individual researchers.

Concerning the overview of the institutes during the site visits, the evaluation committee assumed that the management of each LTI would have a clear picture of the position of their institute compared to their business plan in terms of measurable indicators. They expected the management team to present a multidimensional picture: where the LTI started, how it has evolved and where it is going, including the identification of its main competitors. This would include a definition of indicators - quantitative as well as qualitative - for important dimensions such as "scientific performance" and "industrial relevance". However, the presentations to the evaluation committee only fulfilled this description to a limited extent. Only the Wageningen Centre for Food Research (WCFS) presented the outcome of a kind of self-evaluation, the strategic review held recently with representatives from all stakeholders.

Conclusions: major policy lessons and open questions

The launching and operation of the Dutch LTIs are an undeniable success, as assessed by the interim evaluation report and confirmed by the interviews of the main stakeholders in Dutch science, technology and innovation policy during the OECD mission. These government-sponsored partnerships currently meet the expectations of the main stakeholders. The main factors of success appear to be the following:

- *Sound economic rationale.* LTIs are founded on a sound PP/P concept of how to remedy well-identified systemic failures in the Dutch innovation system.
- *Customized implementation.* This concept has been applied in a flexible manner, with different organisational arrangements (from pure virtual networks to more hybrid arrangements involving both distributed and centralised research capabilities, as in the case of Telematica) to suit different the specific needs of different technological fields, taking into account the peculiarities of the Dutch innovation system in each of these fields.
- *Legitimacy*. They were launched as part of a broader movement to PP/P and network-based approaches to innovation policy, reflecting a new consensus between public and private actors regarding the best way to identify and achieve common strategic goals.
- *Legacy*. They were not created from scratch but built on pre-existing networks (*e.g.* the "discussion forum on metals research" in the case of NIMR; and the "Telematic Research Centre" in the case of Telematica).
- *Quality*. They emerged from a stringent bottom-up selection process where proposals had to compete, based on the quality of their scientific content, their industrial relevance and the soundness of their business plan.
- *Leverage and long-term commitment.* The cost-sharing arrangements ensure high reciprocal leverage. This is the key in ensuring sustained commitment from both public and private partners.

- *Leadership*. They include all leading enterprises and public research centres in each field, and their managers are well-known/respected figures that have a broad experience and good links with both academia and industry.
- *International openness*. Not only have LTIs opened up to foreign firms, but also to foreign knowledge institutes.
- *Learning hubs*. LTIs are platforms for learning about good practices in managing PP/Ps for actors that are well-positioned to diffuse the lessons throughout the Dutch NIS. The participation of TNO in all four LTIs is key in that regard.
- *Visibility*. The institutionalisation of the research networks in the form of "institutes" helps them acquire visibility in the Netherlands as well as internationally. This helps them attract competent partners, position themselves within international networks, and creates continuous "peer pressure" for improvement from "competing" forms of public-private relations.

However, the ongoing operation and future of LTIs raise a number of questions and challenges for policy makers that are summarised in the following table.

Table 10. Summary of observations and challenges on LTIs

Efficiency criteria	Observations	Challenge
Appropriateness *Are LTIs addressing sound and important objectives which can be related to clearly identified market failures?*	• Each of them addresses a well identified market failure in an important research field where Dutch capabilities are under-utilized. • Collectively, they do not cover all the areas that have the highest "strategic importance" for the Netherlands, especially to the detriment of highly socially relevant multidisciplinary research with weak constituency in industry and government.	• Consider the creation of new LTIs, possibly through a new round involving existing ones? • Reconsider the selection process to better balance "bottom-up" and "top-down" criteria? • Create a learning and breeding platform for existing (and future?) LTIs to exchange experience and identify opportunities for multidisciplinary research?
Own efficiency *Are LTIs cost-effective in achieving their stated objectives?*	• Self-sustainability is doubtful, even after two rounds. Networks preceded LTIs and would survive their dismantling. Some joint research programmes would not. • But financial arrangements could be optimized; some LTIs admit that they would be already viable with less than 50% subsidy from the government.	• Consider lowering the government contribution? • Consider cash contribution by public research organisations?

Table 10. Summary of observations and challenges on LTIs *(continued)*

Efficiency criteria	Observations	Challenge
Superiority *Are LTIs more effective than policy instruments which would achieve the same goals?*	• Industry votes for the LTIs. • Some public organisations have more nuanced views, especially when LTIs have their own research capabilities. • Some programmes that had been rejected in the LTIs' selection process have been subsequently successful under different arrangements (e.g. ACTS under NWO).	• Accept some degree of overlap/competition between different public programmes or organisations if this stimulates performance? • How to avoid unhealthy rivalry between LTIs and some research groups in participating universities?
Systemic efficiency *How do LTIs interact with other programmes or instruments?*	• Some (public) actors believe that the overall move towards conditioning govern-ment support to private matching funds have already gone too far. • LTIs do not consider increased SME participation as a real issue or important objective. But one of them (DPI) has a unique additional outlet to help small non-members: Kunstoffhuis. • LTIs have achieved a good balance in their knowledge management strategy which ensures a wide diffusion of results (e.g. the publishing or patent rule applied by DPI). • The relationships between LTIs and the European Framework Programme are problematic, partly due to financing problems.	• When streamlining government incentive schemes, check again the balance between matching and unconditional grants, as well as between project-based, and programme-based support? • Consider concentrating more the use of matching grants within the framework of true PP/P programmes, such as LTIs? • Reconsider the anti-cumulation rule?
Adaptive efficiency *To what extent have results from evaluation influenced LTIs, and how are LTIs flexible in responding to opportunities or unpredictable change?*	• The (rather positive) interim evaluation report has had only a minor impact on the evolution of LTIs, except regarding their increased openness to foreign companies. • Some LTIs have demonstrated good ability to adapt to changing circumstances in business (e.g. DPI did cope well with the changing R&D strategy of DSM). • But at least one of them (NIMR) is heavily dependant on the strategy of one dominant industrial partner. • Some (e.g. DPI) already experience some financial barriers to growth and foreseen budget restriction could aggravate the situation.	• Embed LTIs in broader national and international networks of research in similar or adjacent fields (e.g. through multidisciplinary catalytic programmes)? • Have a broader and more diversified portfolio of LTIs? • Attract more foreign participants? • Give more priority to LTIs with high-growth potential in central budget allocation? • Reinforce evaluation?

ANNEX

Box A.1. The Genomics Initiative

The Dutch government launched the Netherlands Genomics Initiative at the end of 2001 with the mission to combine the opportunities offered by genomics with the strong points of scientific research in the Netherlands in such a manner as to develop a world-class knowledge infrastructure within five years, which is firmly embedded in society and provides a springboard for pioneering and innovative research that yields a continuous influx of new commercial applications. The underlying objective is to raise the national genomics infrastructure to a world-class level.

The Genomics Initiative is an independent task force for the realisation of a national genomics strategy, carried out under the auspices of the NWO, the Netherlands Organisation for Scientific Research. It has a five-year budget of €189 million to finance Genomics Centres of Excellence and other genomics projects. The strategy targets the complete innovation chain, from basic research to applications, in the following areas:

- The relationship between food and health, including food safety.
- The mechanisms of infectious diseases.
- The origins of multifactorial diseases, in which both genetic and environmental factors play a role.
- The functioning of ecosystems, focusing on sustainable, environmentally safe and healthy vegetable and animal products.

Central to the strategy are the **Genomics Centres of Excellence** of universities and research institutes where fundamental and industrial research in the field of genomics. Firms participated in these Genomics Centres of Excellence by funding part of this research. They were selected through a competitive process which started in November 2001 by a call for proposals, which emphasised the following eligibility criteria: scientific top quality according to international standards, and promotion of innovation and its embedment in society. An International Committee of Experts selected four proposals in March 2002, and invited the relevant parties to formulate a business plan. The business plans were submitted in June 2002 and subsequently assessed by the International Committee of Experts. Finally four centres were appointed: Cancer Genomics Centre, Centre for Biosystems Genomics, the Kluyver Centre for Genomics of Industrial Fermentation, and the Centre for Medical Systems Biology.

Also part of the national strategy is the Innovation Oriented Research Programme on Genomics (IOP Genomics). The aim of the IOP instrument (see also table 4) is to strengthen strategic pre-competitive fundamental research at universities and research institutes in response to industry needs via a programmatic approach. Transfer of knowledge and implementation of research results, stimulation of long-term collaborations and formation of networks are other important targets of the programme.

Box A.1. The Genomics Initiative *(continued)*

In addition, the Netherlands Genomics Initiative aims at establishing **Innovative Clusters**, supported with €22.5 million by the ICES/KIS programme (one of the major national PP/P initiative), in which academic research groups address fundamental research issues raised by the business community, focusing on: assessing the living soil (ecogenomics); genomics of host-respiratory virus interactions (VIRGO); nutrigenomics; the Coeliac Disease; and genomics approach to AIDS and HIV for treatment and vaccines. The relevant projects are co-funded by the NWO (Netherlands Organisation for Scientific Research) and the Dutch innovation agency SENTER. They are selected according to the following procedure: a project proposal is submitted through a Letter of Intent that is prepared by a candidate research institute on behalf of a company. Foreign companies can submit proposals on condition that they carry out research in the Netherlands or are willing to open a research facility in the Netherlands in the context of Genomics Initiative. The evaluation of proposals is made by a committee of internationally-renowned experts.

The Netherlands Genomics Initiative supports and coordinates other national genomics projects that are carried out at various institutes. The two most promising fields are proteomics and bio-informatics, which are of vital importance if genomics research in the Netherlands is to achieve global excellence.

Finally, the valorisation activities are important for new business development within existing companies and start-ups on basis of the research outcomes of the Genomics Initiative. The Netherlands Genomics Initiative shall implement an ambitious valorisation plan comprising of elements as: awareness and training, scouting, IPR and licensing, initiating and coaching of start-ups, brokerage, etc.

Table A.1. Comparison of LTIs and ACTS

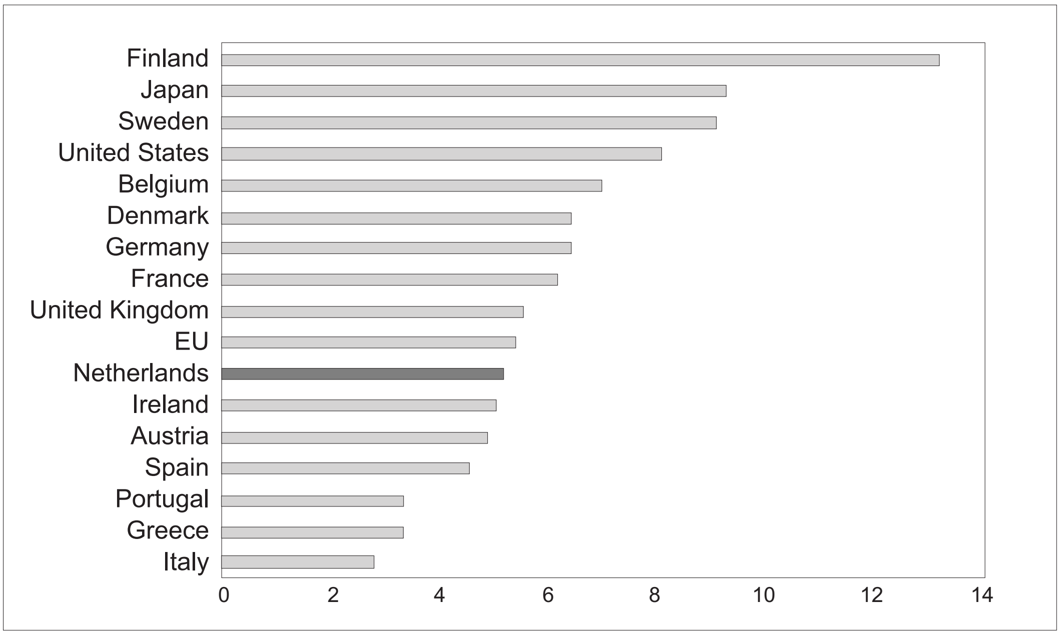
	Dutch Polymer Institute (DPI)	Netherlands Institute for Metals Research (NIMR)	Telematica Instituut (TI)	Wageningen Centre for Food Research (WCFS)	Advanced Catalytic Technologies for Sustainability (ACTS)
Role and purpose					
Mission	To establish a leading (multi-disciplinary) institute in Europe for Polymer Science & Engineering by establishing a fundamental knowledge base for industry.	To achieve leadership in research and education, in areas critical for the international competitiveness of the Dutch metals industry, by means of cross-disciplinary research and training programmes.	To become industry's long-term research and training partner to foster business innovation in telematics within and across key industry sectors.	To concentrate on pre-competitive research on topics that are key to the future competitiveness of the Dutch agro-food sector. Provides the link between food and biosciences/biomedical research.	To be the Dutch platform for pre-competitive research in the field of catalysis. Up to now, two research programs have been launched: IBOS (Integration of Bio- and Organic Synthesis) and Sustainable Hydrogen, while a third program, ASPECT, on Bulk Chemicals and Materials, is '"under construction".
Type of research	High level of research capacity in industry. The outcomes of academic researches are easily applicable to market needs.	Strong need for doing research on common basic problem.	Fragmentation of science, low level of research capacity in the industry side, and users' needs for total solution.	Strong industry background, but no contract research (Question is rather: "What is important five years from now?")	Strong industry involvement, but a forward-looking strategy aiming at the development of new technological concepts for the sustainable production of materials and energy carriers.
Time-horizon of projects	Many four-year projects.	Projects up to eight years.	Some very short projects (sometimes only three months.	Many five-year projects.	Short- to long-term research projects.
Organisation	Pure virtual organisation There are no researchers employed directly by DPI, and research is completely "outsourced" to the knowledge institutes.	Mixed form between the virtual and the central organisation The share of researchers directly employed by NIMR is very high (about 90%), because NIMR which	Mixed form between the virtual and the central organisation. The TI Central Organisation (TICO) combines the management tasks for the virtual institute with a	Pure virtual organisation	Pure virtual organisation under the umbrella of NWO

	Dutch Polymer Institute (DPI)	Netherlands Institute for Metals Research (NIMR)	Telematica Instituut (TI)	Wageningen Centre for Food Research (WCFS)	Advanced Catalytic Technologies for Sustainability (ACTS)
		wants to be independent from the universities.	substantial research capability which realises around 30% of TI turnover.		
Pre-existing networks		Discussion Forum on Metals Research	Telematic Research Centre		
Participants					
Industry partners	*Dutch participants (15)*: DSM N.V. AKZO Nobel Research B.V. Océ Technologies B.V. Nederlandse Philips Bedrijven B.V. Dow Benelux N.V. TNO Fasson/Avery Dennison ECN Avantium Kraton ATO/DLO Chemspeed Sabic Teijin St. Emulsiepolymerisatie (SEP) *Domiciled foreign firms (6):* Shell International Chemicals B.V. Basell N.V. (since 2001) General Electric Plastics B.V. NTI Europe Microdrop GmbH Analytik Jena AG	*Dutch participants (15)*: Alcoa Harderwijk BOAL International B.V. Corus Group plc. DAF Trucks N.V. Eldim B.V. ESAB B.V. FME CWM Hauzer Techno Coating Europe B.V. Impress Metal Packaging Koninklijke Nedschroef Holding N.V. Koninklijke Schelde Groep N.V. Nedal Aluminium B.V. Polynorm N.V. SKF ERC B.V. Stork N.V. *Domiciled foreign firms (1)*: Philips CFT.	*Dutch participants (4)*: ING Groep KPN Research Lucent Technologies B.V. Rabofacet Spectrum *Contributors (7)*: ABP/USZO Cap Gemini Ericsson Océ Ordina ID Research Surfnet B.V. Syllogic *Associates (7)*: Arcadis Heidemij CMG ECT NOB NS Origin VNU *Domiciled foreign firms (1):* IBM Netherlands B.V.	Dutch participants (6): AVEBE BA Cosun CSM N.V. DSM GIST BV Unilever N.V. Netherlands Dairy Industry Association (NZO): Campina B.V., Coöperatieve Zuivelonderneming CONO B.A./Coöperatieve Zuivelfabriek “Rouveen” U.A.; “DOC Kaas” B.A.; Friesland Coberco Dairy Foods B.V.; Koninklijke Numico N.V.; Leerdammer Company B.V. Cebeco Groep (until July 2002)	AKZO Nobel BTG Diosynth DOW Benelux DSM Engelhard ExxonMobil Gasunie NV NUON Organon Quest/Uniqema Sabic Shell Syncom Synthon VIRAN (Industrial Association on Catalysis, linked to NIOK)
Knowledge institutes	*Dutch Institutes (12):* Technical U. of Eindhoven U. of Twente	*Dutch Institutes (5):* TNO Delft U. of Technology Eindhoven U. of	*Dutch Institutes (5):* National Research Institute for Mathematics and Computer Science	*Dutch Institutes (4):* DLO NIZO Food Research TNO Nutrition and Food	*All Dutch universities* *Research Schools (Associations of Top Research Groups):*

	Dutch Polymer Institute (DPI)	Netherlands Institute for Metals Research (NIMR)	Telematica Instituut (TI)	Wageningen Centre for Food Research (WCFS)	Advanced Catalytic Technologies for Sustainability (ACTS)
	Technical U. of Delft U. of Groningen TNO –Eindhoven/Delft ECN – Petten U. of Wageningen U. of Utrecht U. of Amsterdam U. of Nijmegen U. of Leiden ATO/DLO – Wageningen *Foreign institutes (7)*: U. of Hamburg (Germany) U. of Napoli Federico II (Italy) U. of Stellenbosch (South Africa) Queen Mary U. of London (UK) NWO/Dubble – Grenoble (France) U. of Leeds – (UK) National Techn. U. of Athens (Greece)	Technology U. of Twente U. of Groningen *Foreign institutes (6):* U. of Trondheim, Norway Sintef, Norway U. of Ghent, Belgium U. of Leuven, Belgium RWTH Aachen, Germany U. of Sheffield, UK	in the Netherlands (CWI) Tilburg U. TNO-Multimedia and Communication U. of Twente TU Delft TICO	Research Institute Wageningen U. University of Maastricht	NIOK (Catalysis) ABON (Biotech research) OSPT (Process Technology) DISE (Sustainable Energy) *Large Technological Institutes (privatised, commercial):* ECN (Energy Research) TNO (Technology Development) ATO (Agriculture and Technology)
Industry financing	*Ticket system*: Firms pay € 50,000 a year per ticket. Each ticket corresponds to one vote in the programme.	*Ticket system* (see DPI, but there are some differences).	Contribution differs across firms.	4-year rolling contribution (every year, the firms agree to pay for another 4 years).	

Figure A.1. Researchers per thousand labour force

(2000 or latest year available)



Source: European Commission (DG Research), based on data from EUROSTAT, Member States and OECD.

Table A.2. LTIs' workforce characteristics (2000)

	TI	WCFS	NIMR	DPI
Workforce (fte)	123	87	91	90
Employed by the LTI (%)	62	4	87	0
Foreign researchers (%)	5	19	47	20
Senior researchers (%)	11	21	10	15
Postdocs (%)	44	23	16	15
PhD students (%)	28	39	34	57

Source: The Netherlands Ministry of Economic Affairs.

Table A.3. R&D spending of public research institutes (1999)

	€ Milllion	%
TNO (Netherlands Organisation for Applied Scientific Research)	332	26.6
GTIs	191	15.3
DLO (Agricultural Research Service)	n.a.	n.a.
NWO-institutes (Netherlands Organisation for Scientific Research)	n.a.	n.a.
KNAW-institutes (Royal Netherlands Academy of Arts and Sciences)	n.a.	n.a.
Public Institutes	1 250	100.0

Note: TNO, GTIs and DLO have the task to perform applied research for (mainly) societal needs. A significant part of their income is not publicly funded. The other institutes with a few exceptions (*c.f.* NWO-CWI, which does perform contract research) are wholly publicly funded.
Source: The Netherlands Ministry of Economic Affairs.

APPENDIX

List of the persons interviewed during the OECD mission[14]
(28-29 April 2003)

Ministry of Economic Affairs

- Mr. Roelandt, Director for Innovation Policy
- Mr. Broersen
- Ms. van der Linden

Dutch Polymer Institute

- Mr. Bakker, Financial Director

Wageningen Centre for Food Sciences

- Mr. Hautvast, Director

Netherlands Institute for Metals Research

- Mr. Radelaar, Director

Telematica Instituut

- Mr. Vissers, Director

The Netherlands Genomics initiative

- Mr. Cools
- Mr. van der Starre

NWO

- Mr. Coolen, Director
- Mr. Zijderveld

TNO

- Mr. Ekkers, Director of the Strategy and Program Division

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14. The OECD review team was composed of Jean Guinet (project leader), Michael Freudenberg, and Byung-Seon Jeong.