Netherlands Observatory of Science and Technology (NOWT)

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Complementary copies of this report can be obtained at:

Ministry of Education, Culture and Science
Department of Research and Science Policy
PO Box 25000
2700 LZ Zoetermeer
The Netherlands
Tel: +31(0)79 3233650
Fax: +31(0)79 3232525

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For more detailed information about NOWT or the 1998 S&T Indicators Report please contact:

Dr. Robert Tijssen
Centre for Science and Technology Studies (CWTS)
Leiden University
PO Box 9555
2300 RB Leiden, The Netherlands
Tel +31(0)71 5273960
Fax +31(0)71 5273911
E-mail tijssen@cwts.leidenuniv.nl

Hugo Hollanders
Maastricht Economic Research Institute on Innovation and Technology (MERIT)
Maastricht University
PO Box 616
6200 MD Maastricht, The Netherlands
Tel +31(0)43 3883873
Fax +31(0)43 3216518
E-mail h.hollanders@merit.unimaas.nl

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NETHERLANDS OBSERVATORY OF SCIENCE AND TECHNOLOGY

1998 Science and Technology Indicators Summary

produced by

Dr. Robert Tijssen (CWTS)
Hugo Hollanders (MERIT)
Thed N. van Leeuwen (CWTS)
Prof. Dr. Bart Verspagen (MERIT)

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Foreword

Science and technology are generally recognized as important strategic factors that determine the socio-economic and cultural future of highly developed nations. The profound influence of scientific knowledge and technologies can be found across the entire societal spectrum, ranging from industry, transportation and logistics, health care, educational services, sports and entertainment, to the arts. Technological progress is now considered the major driving force in the economic development of modern market-oriented industrialized societies. The growing importance of science and technology has spurred the demand for more and better information about the performance and internal workings of S&T systems and their societal impacts.

S&T policy-making by the Dutch government has a long tradition of using quantitative data and statistics describing the state of the S&T system in the Netherlands. The *Netherlands Observatory of Science and Technology* (denoted by its Dutch acronym *NOWT*) is one of the sources of factual information. This Observatory was founded in 1992 by the Dutch Ministry of Education, Culture and Science to meet the need for comprehensive and systemic data on the performance and international standing of the Dutch S&T system. NOWT is a semi-independent virtual organization comprising of a small team of analysts based at two Dutch universities: the *Centre for Science and Technology Studies* (CWTS), a research department of the University of Leiden, and the *Maastricht Economic Research Institute on Innovation and Technology* (MERIT) of the Maastricht University.

The Observatory's mission is to provide an overall reference of general characteristics of the Dutch S&T system in an international perspective. NOWT engages in data collection and analysis of the system's structural features, capabilities and performance in order to describe its current state and recent trends. The resulting indicator-based profile comprises of statistics and quantitative data describing key features of the system's input and output. The findings are disseminated externally to a wide readership through a series of bi-annual S&T indicators reports that are designated at S&T policy units within governmental organizations, research councils, public agencies, industry, and academia.

This summary version of NOWT's *1998 S&T Indicators Report* is the third in its series. It provides a brief synopsis of the tables, graphs and related texts from the original Dutch version of this report that was published earlier this year.

1 Highlights: general features of the Dutch S&T system

The Netherlands is one of the highly developed nations that is characterized by a modern market-oriented industrialized society and an advanced science and technology system. The national S&T system comprises of an interlocking network of R&D funding and R&D performing organizations which covers all relevant quarters of the public and private sector. The Netherlands is also the home base of several of the world’s largest science-based multinational enterprises such as Philips (electronics sector) and Unilever (food sector), Shell, Akzo Nobel, and DSM (chemicals sector).

The Dutch government acknowledges the importance of the domestic S&T system by allocating a significant part of its financial resources to organizations devoted to scientific research and technological development. The Dutch science base encompasses a well-developed public sector research system and related higher education system. As regards to scientific knowledge production, the Dutch S&T system ranks ninth in the group of OECD member states, placing the Netherlands alongside scientifically active countries such as Sweden, Spain and Australia.

Government funding of basic research has declined significantly in the past few years and further budget cuts are forthcoming. Public expenditure on R&D from other national and foreign sources compensates the declining share of government spending. As a consequence, universities and public research institutes are now more dependent on contract research funds and their research is becoming more application-oriented. The business sector R&D is relatively weak compared to other medium-sized OECD countries, mainly because the decreasing R&D expenditure of the large multinationals which is not counterbalanced by a growth in expenditure within other R&D-intensive Dutch companies.

The output performance of the Dutch research system in terms of publications in international scientific and technical journals bears further witness of the system’s relative strengths and weaknesses. The number of these research articles shows a slight decline in recent years after a decade of vigorous growth. Moreover, the publication productivity (papers per public sector researcher) is only average compared to other Western European countries.

S&T activities in a medium-sized EU member state such as the Netherlands have never been isolated from other European countries and from on-going international developments. The internationalization of Dutch science is clearly visible in the relatively large share of research papers that are co-authored with foreign colleagues. The high scientific impact of Dutch research papers is largely due to these international co-publications. However, the steadily increasing share of these co-publications seems to have come to a halt. The international partnerships are increasing focused on other EU countries, which is no doubt partially due to the co-operation promoting Framework programmes of the European Commission.

The Netherlands is also a major contributor to patented technological knowledge as embodied in international patents. It ranks second in Europe, surpassed only by Switzerland, when measured in terms of European patents per capita R&D personnel in the private sector. Relatively high patenting levels are concentrated in the agricultural sector, the food sector, and in electronics. The Dutch technological specialization in these industrial sectors is dominated by substantial shares of international patents originating from the above mentioned R&D-intensive multinational enterprises.

2 Human resources: higher education and employment

An average higher education sector with good employment prospects for university graduates and PhDs

The Netherlands spends 1.2% of its GDP on the higher education system (see Table 1), which accounts for nearly a third of government expenditure on education. At present, 21% of the Dutch adult population have completed tertiary education. About 11 out of each 1000 workers in the adult Dutch labor force are now engaged in scientific research or technological development, which equals the average OECD participation rate and is comparable to the rates of other smaller Western European nations like Denmark and Norway.

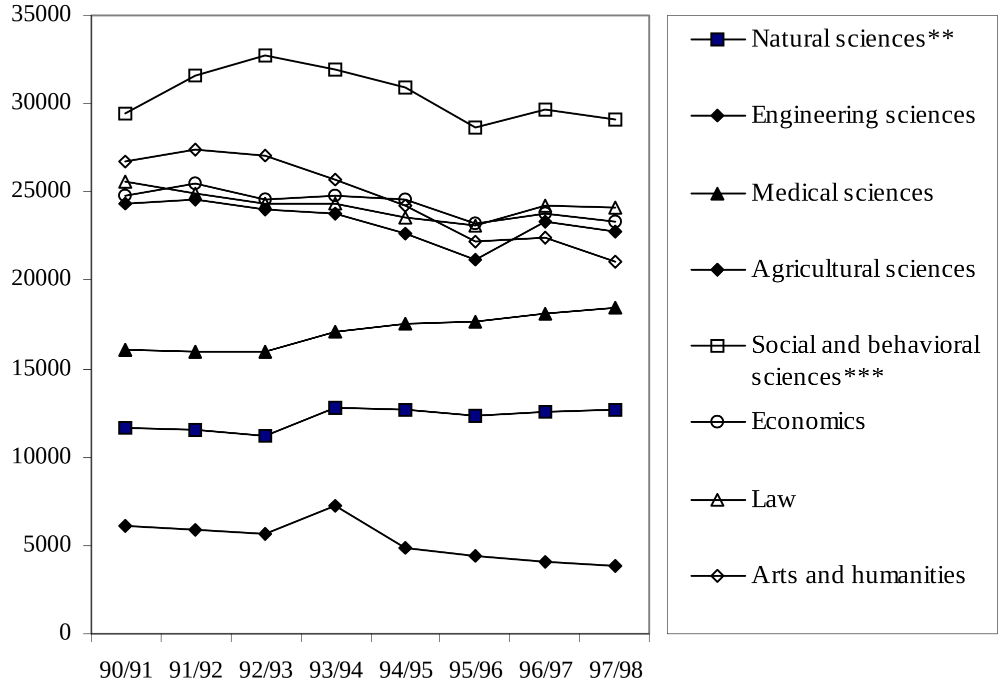
Table 1: Higher education statistics, 1994.

	Share of graduates in adult population (age 24 to 65)	Direct public expenditure (% of GDP)*	Average expenditure per student (US $)**	
			incl. R&D	excl. R&D
Australia	24	1.2		
Belgium	25	1.0	n.a.	5,095
Canada	47	1.6	12,350	10,584
Denmark	20	1.4	6,710	4,865
Germany	23	0.9		
Finland	21	1.5	n.a.	7,408
France	19	0.9		
Greece	17	0.7		
Ireland	20	1.0	7,270	6,210
Italy	8	0.7		
Japan	n.a.	0.5		
Korea	18	0.3		
Netherlands	21	1.2	8,720	6,210
Norway	29	1.4		
Austria	8	0.9	5,820	3,653
Portugal	13	0.8		
Spain	16	0.8		
United Kingdom	21	0.7	n.a.	8,533
United States	33	1.1		
Sweden	28	1.5		
Switzerland	21	1.1		

* Excluding private and international expenditures, and subsidies to households. Including expenditures on government funded university research.
** Selected countries with OECD data (estimates) on R&D expenditure in the higher education sector.
n.a. Data not available
Source: CWTS, data: OECD

The Dutch higher education system (higher vocational studies and university studies) accommodated a significant rise in the number of students during the eighties and early nineties. An increasingly large share of students studying the arts and humanities, and the social and behavioral sciences marked this influx. Increasing shares of female students drove both trends. The student enrollment in university studies has now dropped by some 20% compared to the early 1990’s, especially in the arts and humanities, the social and behavioral sciences, but also in the engineering sciences. The social and behavioral sciences still account for the largest share of the undergraduate university students (see Figure 2). The 30% decline in first year students in the engineering sciences has recently been reverted into a slight increase, which is partially due to government campaigns promoting these studies. The average spending on university students is about average within the group of OECD (see table 1.1).

Figure 2: Enrolled university students in the Netherlands by field of education, 1990/91-1997/98.*



* Full-time and part-time undergraduate students excluding auditors and extranei.
** Including mathematics and computer sciences.
*** Excluding economics.
Source: CWTS, data: CBS.

Meanwhile, the economic situation in the Netherlands has improved considerably which has spurred a large demand for highly qualified personnel in many sectors. The unemployment rates of the higher educated labor force have declined significantly since the mid-1990’s and are now down to about 5% of the working population. In many cases, the demand for highly qualified personnel exceeds the outflow of graduates from the Dutch higher education system. University graduates with a degree in the engineering science, or the economic and business sciences have particularly good prospects in finding suitable jobs. Those with a degree within the arts and humanities have a poorer outlook.

PhD graduates are also benefiting from the relatively low unemployment rates. About 40% of the graduates in the engineering sciences, and a quarter of those with a PhD degree in the natural sciences, move into jobs in Dutch industry. Universities employ most of the PhD graduates – often temporarily and part-time. 55% of the PhD graduates in the social sciences and the humanities work in the university sector.

The early and mid-1990’s were also characterized by a decline in the number of graduate students (trainee research assistants, trainee researchers, and trainee design engineers), particularly within the natural and engineering sciences. Recent years however show a slight increase in the number of graduate students. The Dutch universities are facing an ageing problem, despite the influx of this new generation of researchers. Lack of tenured positions and career prospects for PhD graduates have resulted in an over-representation of research staff of 50 years or older with life-long contracts whom account for a third of university research personnel.

3 R&D expenditures and R&D financing

3.1 International performance

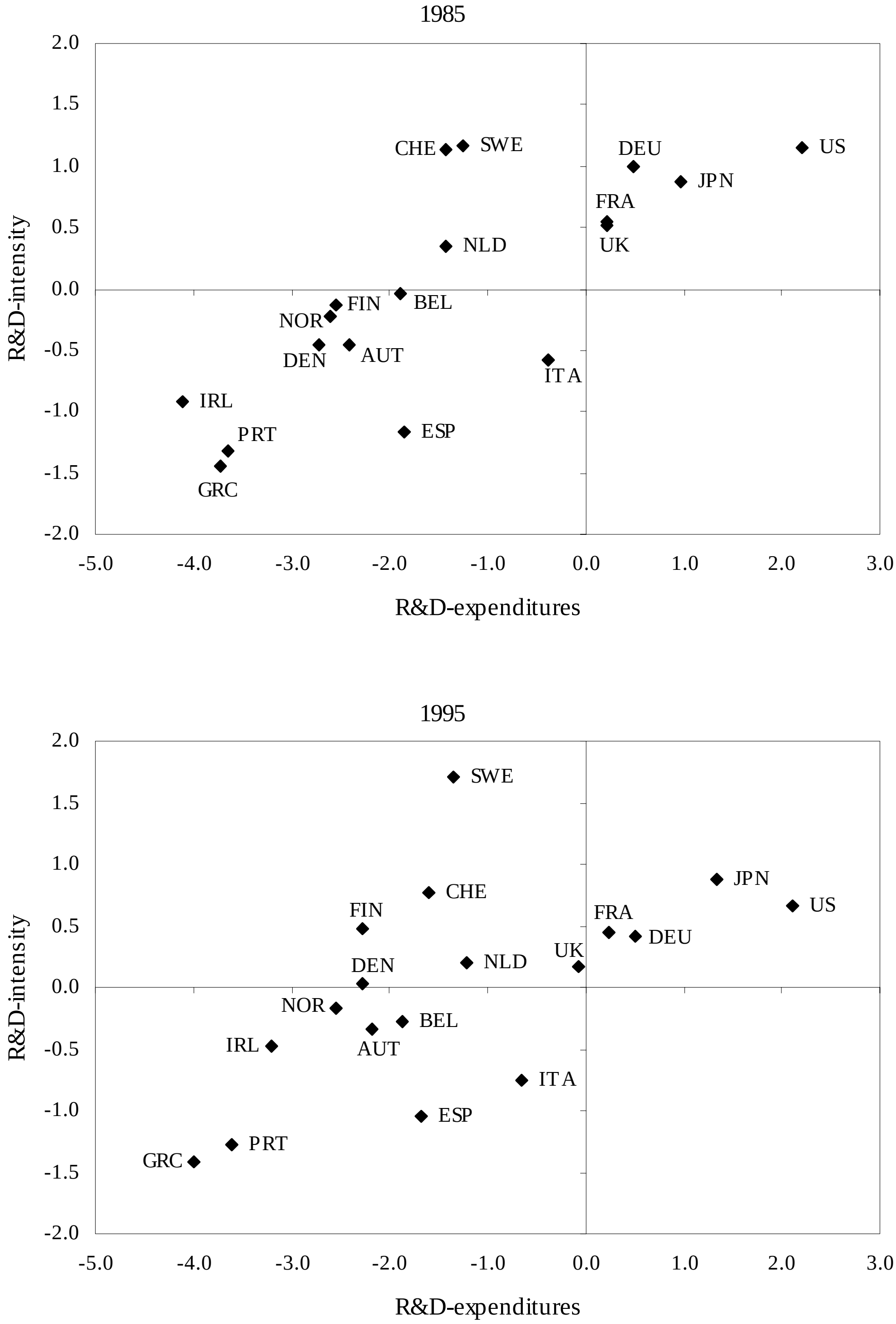
Relative R&D expenditures still above OECD average but deteriorating over time

A country's scientific and technology input are usually measured in terms of its R&D expenditures. In this report we use two expenditure indicators to compare the Netherlands and 17 other OECD countries. As complex scientific and technological problems demand a certain threshold or minimum size of the R&D expenditure, scale effects play an ever more important role in the R&D process. Moreover, the success rate usually increases with the size of the R&D project. Larger countries thus have an advantage as compared to smaller ones. The difference between a country's absolute R&D expenditures and the average R&D expenditures of our sample of 18 countries is an indicator of this scale effect. However, as scale effects are not so much a macro- but more a micro-effect, it is also necessary to adjust for country size. The second indicator relates to R&D intensities, defined as R&D expenditures as a percentage of GDP. Both indicators are presented in Figure 3 for each country relative to the average of the 18 OECD countries in our sample.

Figure 3 shows that these countries can be classified into three groups on the basis of their total 1995 R&D expenditures. The group of leading countries consists of the United States, Japan and three major European countries: France, Germany and the United Kingdom. These countries are the largest R&D spenders and have above average R&D intensities. It seems that the major European countries are falling behind to the United States and Japan. Figure 4 shows that on average more than 60% of these countries' R&D expenditures are financed by the business enterprise sector. The government finances almost one-third of total R&D expenditures. The government sector is a main contributor to national R&D funding in Japan with a funding percentage of more than 40%. The business sector is strongest in Germany contributing more than 70% of the funding.

The Netherlands belongs to the middle group consisting of smaller and medium-sized European countries: Austria, Belgium, Denmark, Finland, Norway, Sweden and Switzerland. Although these countries do not spend as much on R&D as the leading countries due to their size, their R&D intensities are well above average and very close to those leading countries. Dutch R&D intensities are above average in this middle group, and Dutch R&D expenditures

Figure 3: Total R&D expenditures as percentage of GDP*, absolute R&D expenditures**, 1985 and 1995.***



* Measured as the difference between the R&D intensity of a specific country and the unweighted average of all countries.

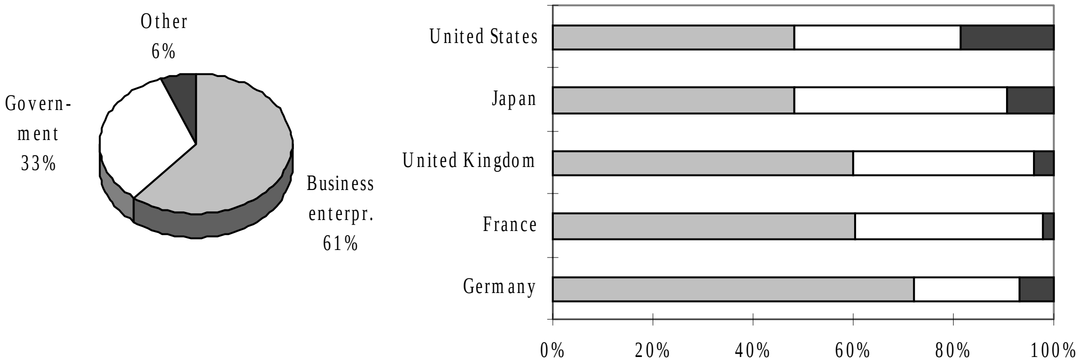
** Measured as the difference between the R&D expenditures of a specific country and the unweighted average of all countries (1990 US dollars, logarithmic scale).

*** For some countries data for these years was not available. We thus used 1986 data for Greece, Portugal and Switzerland, resp. 1992 data for Switzerland and 1993 data for Greece.

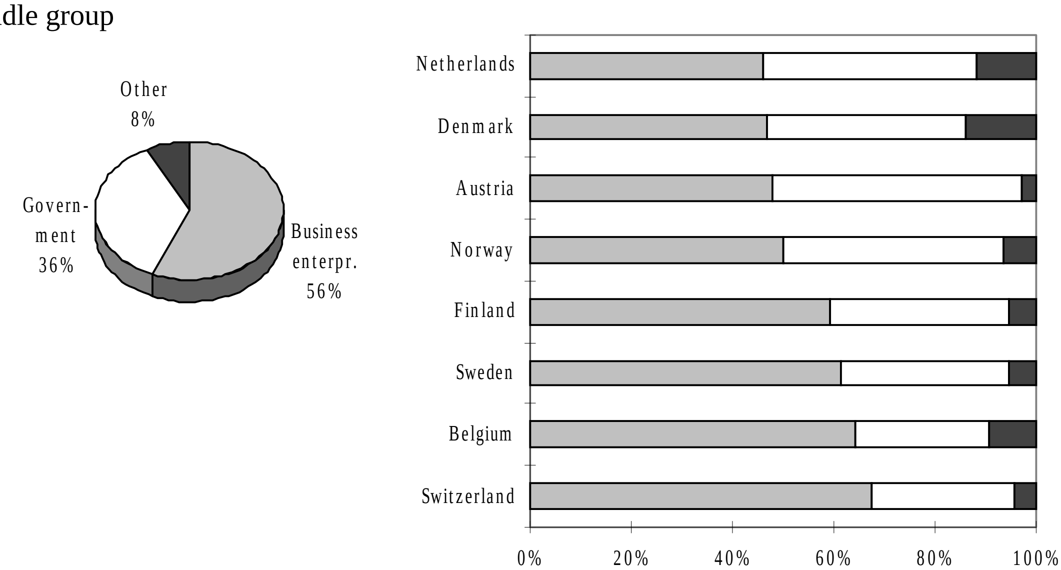
Source: MERIT, data: OECD.

Figure 4: Source of funding of total R&D expenditures, percentage distribution, 1995.

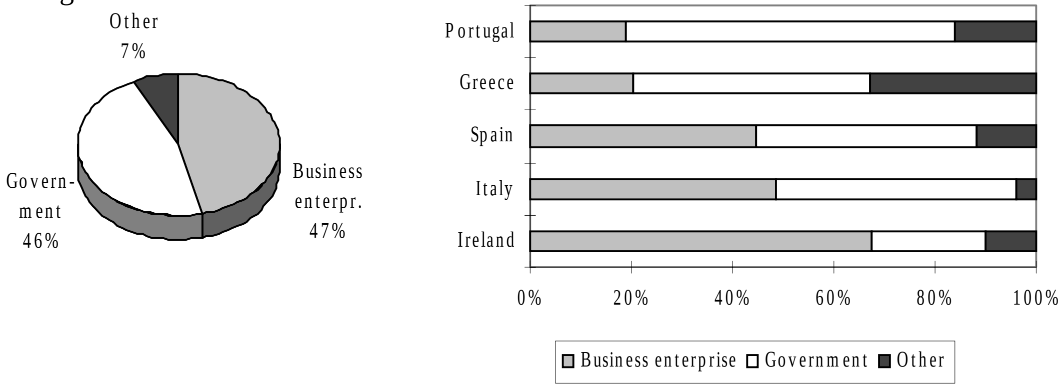
Leading countries



Middle group



Following countries



Source: MERIT, data: OECD.

are among the highest in this group. Sweden and Finland have improved their relative ranking between 1985 and 1995, whereas the Dutch R&D intensity has deteriorated.

The countries in this middle group show almost the same patterns of funding as those in the leading group. Business enterprises finance 56% of R&D expenditures and the government 36%. Switzerland, Belgium and Sweden have a relatively strong business sector with a funding percentage over 60%. Austria, Norway and the Netherlands have a relatively strong government sector with funding shares over 40%. These last three countries have a finance structure that is similar to that of the countries in the third group, which is made up of countries that can be seen as technologically lagging behind.

This group of followers consists of Greece, Ireland, Italy, Portugal and Spain. These countries have both relatively low R&D intensities and R&D expenditures. Italy is an exception - due to it's size - with relatively large R&D expenditures, and business enterprises and government financing an almost equal share of R&D expenditures. There are large differences in the finance structure for these countries. Portugal and Greece depend strongly on their government where the business sector finances only about 20% of total R&D. Ireland's finance structure is more similar to that one of the leading countries, with business enterprises financing almost 70% of total R&D. Ireland is also the only country which seems to be able to close to the gap to the middle group.

3.2 Distribution of Dutch R&D funding

Declining role for business enterprises, sharp increase in foreign financing

The Dutch S&T system has seen some important changes since the beginning of the nineties. The government is financing an ever-smaller amount of total R&D expenditures. The same applies for the business enterprise sector. The higher education sector and foreign sector are the rising stars in the Dutch S&T system.

Table 5 displays the money flows between performing and funding sectors for Dutch R&D in 1990 and 1995. Over the last 10 years, there has been no change in the distribution over the performing sectors. Business enterprises perform more than 50%, the government (and governmental institutes) almost 20% and the higher education sector almost 30% of total R&D. The financing structure however has seen some significant changes. Business enterprises finance 48% of total R&D in 1995, 2% less than they did in 1985. The government's financing percentage has even dropped with 6% to 42% in 1995. This loss has largely been compensated by an increase in foreign financing from 223 million guilders (or 2% of total R&D) in 1985 to 1235 million guilders (or 9% of total R&D) in 1995, an annual percentage increase of 40%.

Table 5: Financial flows to the R&D performing sectors (in mln. guilders).

1990	To performing sector:				
	Business enterprise	Govern-ment	Higher education	Non-profit	Total
Funding from:					
Business enterprise	5001	285	27	27	5340
Government	698	1513	3002	156	5369
- State	698	1513	177	156	2544
- University funds	0	0	2825	0	2825
Abroad	151	36	11	25	223
Other	23	61	71	21	176
Total	5873	1895	3111	229	11108
1995	To performing sector:				
	Business enterprise	Govern-ment	Higher education	Non-profit	Total
Funding from:					
Business enterprise	5537	399	155	13	6104
Government	454	1763	3285	97	5599
- State	454	1763	260	97	2574
- University funds	0	0	3025	0	3025
Abroad	913	180	133	9	1235
Other	10	54	240	10	314
Total	6914	2396	3813	129	13252

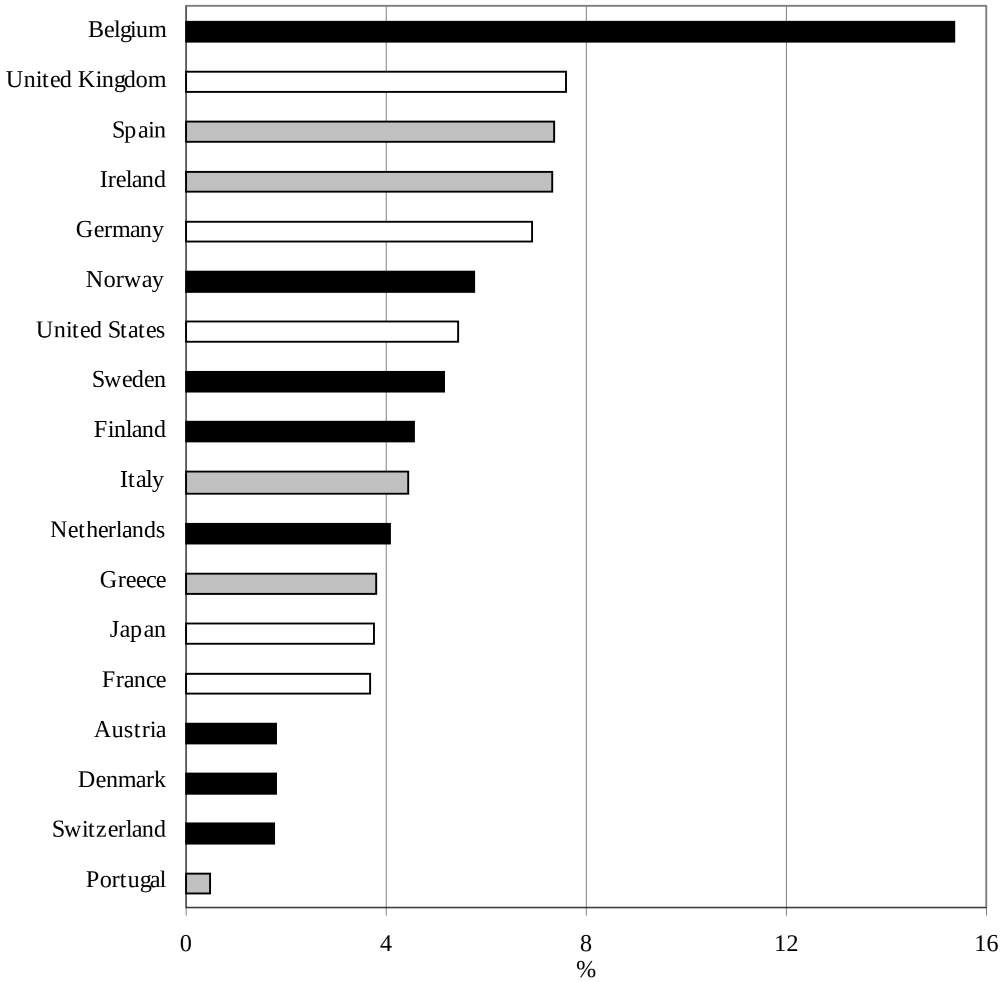
Source: MERIT, data: OECD/CBS.

Dutch enterprises finance a relatively small amount of the R&D expenditures in the higher education sector as shown in Figure 6. With a funding percentage of 4%, the Netherlands is just below the average for the countries in the middle group. The fact that businesses finance only a small amount of the R&D expenditures by universities seems to indicate that the interaction between universities and business enterprises is relatively weak as compared to the major European countries and the US. However, Figure 7 shows that Dutch enterprises are interacting primarily with the non-profit sector. Dutch (and Irish) business enterprises finance more than 16% of the R&D expenditures in the non-profit sector, a percentage far above those of the other countries.

The main contractors in the non-profit sector are the *Netherlands Organization for Applied Scientific Research* (TNO) and *Netherlands Organization for Agricultural Research* (DLO). Figure 8 shows that both institutes performed more than 50% of the R&D in this sector in

1990. Due to an increase in the category 'other' this percentage has dropped to 45% in 1995. Both TNO and DLO focus on applied research, with DLO focusing on the agricultural sector. The five Large Technological Institutes focus more on applied research and perform about 20% of Dutch R&D.[1] The *Royal Netherlands Academy of Arts and Sciences* (KNAW) and the *Netherlands Organization for Scientific Research* (NWO) have increased their share from 19.6% to 23.0%. The research institutes of these organizations focus mainly on fundamental research and have strong ties with Dutch universities, e.g. by financing university-based research. The funds channeled through the NWO's research councils to the universities have increased from 133 to 187 million guilders between 1990 and 1995, an annual percentage increase of 7%.

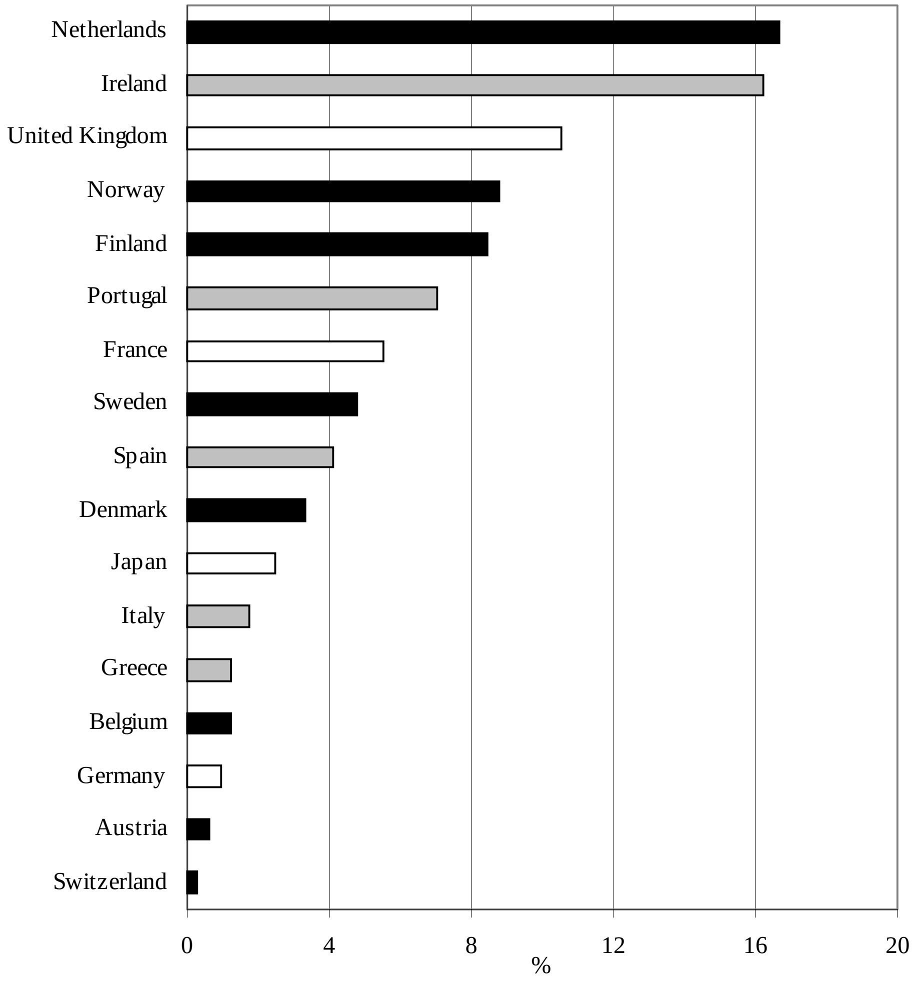
Figure 6: R&D expenditures higher education sector, percentage financed by business enterprises, 1993.



Source: MERIT, data: OECD.

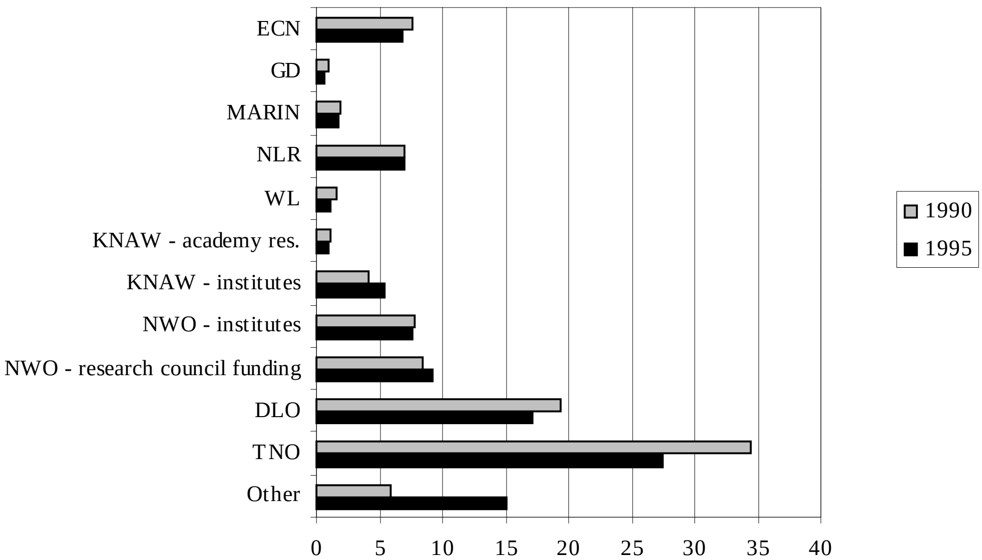
[1] The group of institutes, often denoted by the acronym GTIs, comprises of: Netherlands Energy Research Foundation (ECN); Delft Geotechnics (GD); Maritime Research Institute Netherlands (MARIN); National Aerospace Laboratory, (NLR); and Delft Hydraulics (WL).

Figure 7: R&D expenditures non-profit sector, percentage financed by business sector, 1993.



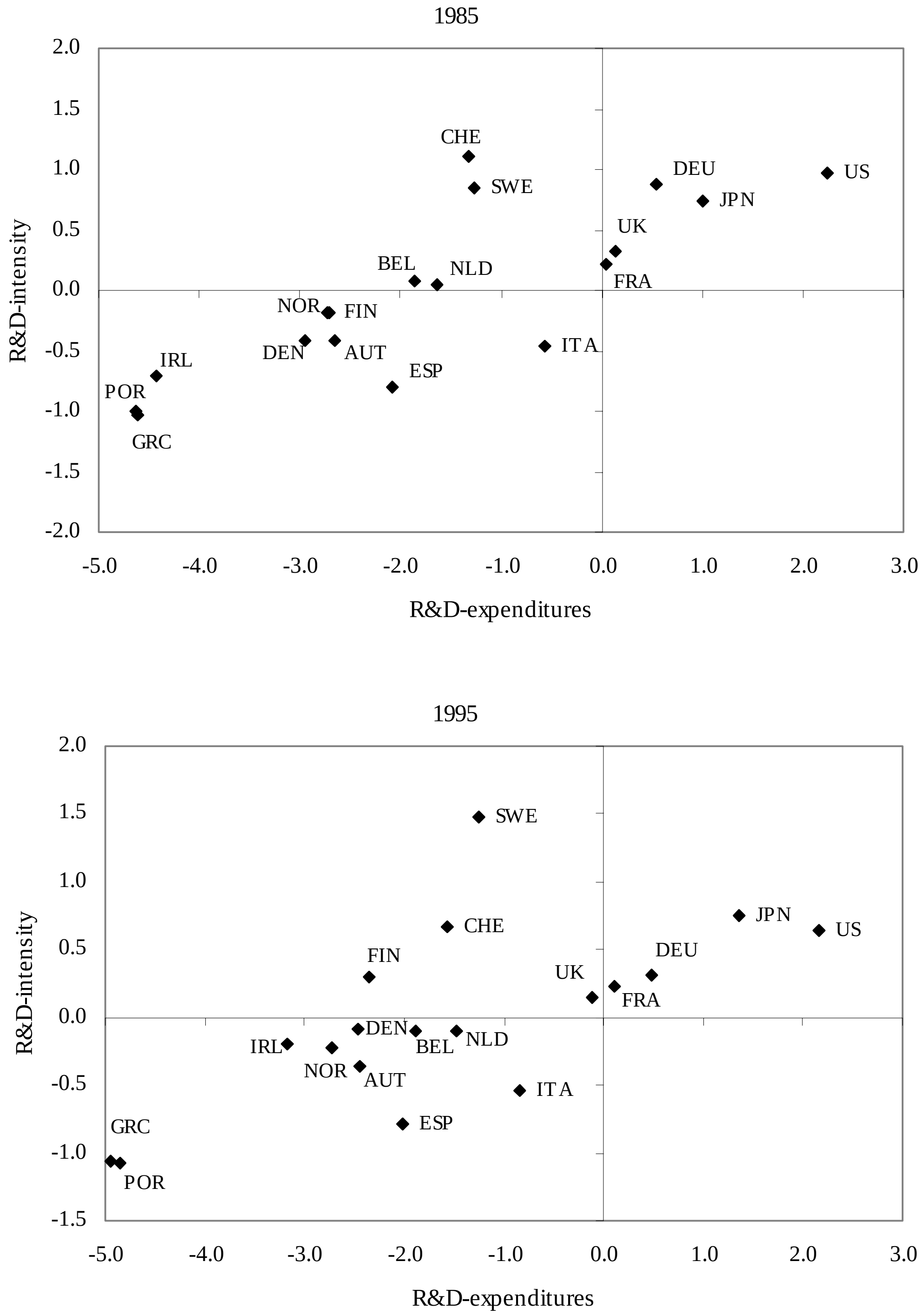
Source: MERIT, data: OECD.

Figure 8: Percentage share of institutes in the non-profit sector R&D, 1990 and 1995.



Source: MERIT, data: Min. of Education, Culture and Science, annual reports institutes, CBS.

Figure 9: Business R&D expenditures, percentage of GDP*, absolute R&D expenditures**, 1985 and 1995.***



* Measured as the difference between the business R&D intensity of a specific country and the unweighted average of all countries.

** Measured as the difference between the business R&D expenditures of a specific country and the unweighted average of all countries (1990 US dollars, logarithmic scale).

*** For some countries data for these years was not available. 1986 data for Greece, Portugal and Switzerland, 1992 data for Switzerland, and 1993 data for Austria and Greece.

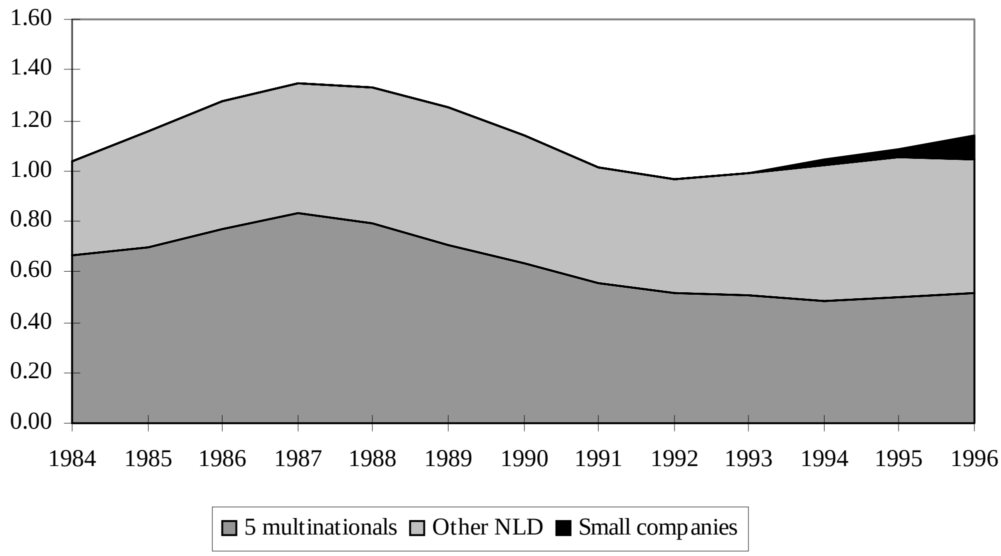
Source: MERIT, data: OECD.

3.3 R&D expenditure by the business sector

Business enterprise sector performs below average, large multinationals losing ground

Dutch business enterprises performed below average in 1995 compared to the other OECD countries both in terms of R&D-intensities and in absolute terms (see Figure 9). In 1985 business R&D intensity was just above average. In 1995 the intensity has dropped below average as a result of both an increase in other countries R&D intensities and a decrease in Dutch R&D intensity. Absolute business expenditures still remain relatively high, with only Sweden outperforming the Netherlands in the middle group. Given the fact that the business sector is strongly involved in the economic applications of science and technology, this relatively weak position of the Dutch business sector seems to imply a relatively weak interaction between scientific knowledge and the economic performance of the Dutch economy.

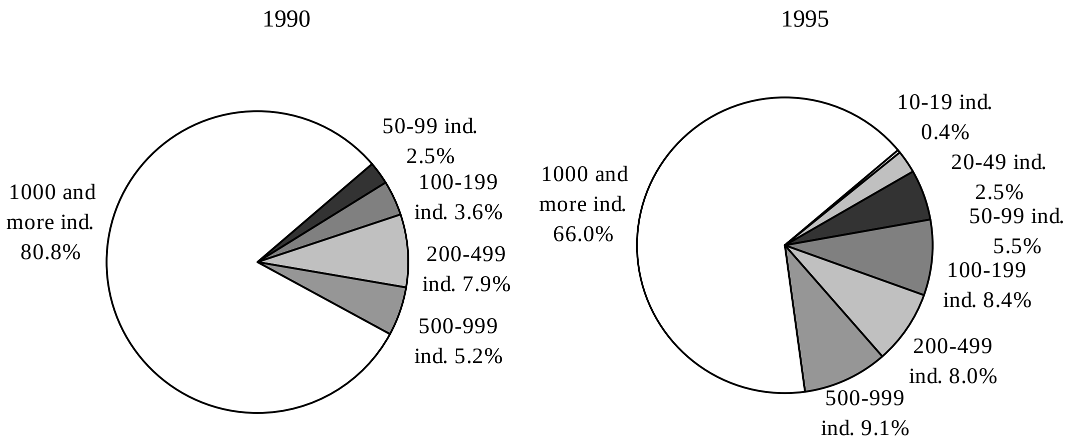
Figure 10: Share of the five large multinationals in Dutch business R&D, percentage of GDP, 1985-1995.



Source: MERIT, data: OECD, CBS.

Within the business sector, the importance of the five large R&D-intensive multinationals is declining. Akzo Nobel (chemicals), DSM (chemicals), Philips (electronics), Shell (oil refining and chemicals) and Unilever (chemicals and food) performed less than 50% of total business R&D as compared to more than 60% in 1985, although there seems to be a small improvement in the two most recent years (see Figure 10). Smaller companies perform an increasing share of business R&D. The companies with 50-99 and 100-199 employees have increased their shares significantly between 1990 and 1995 as can be seen in Figure 11.

Figure 11: R&D performed by Dutch business enterprise, classified by company size, 1990 and 1995.



Source: MERIT, data: CBS.

3.4 Government R&D funding

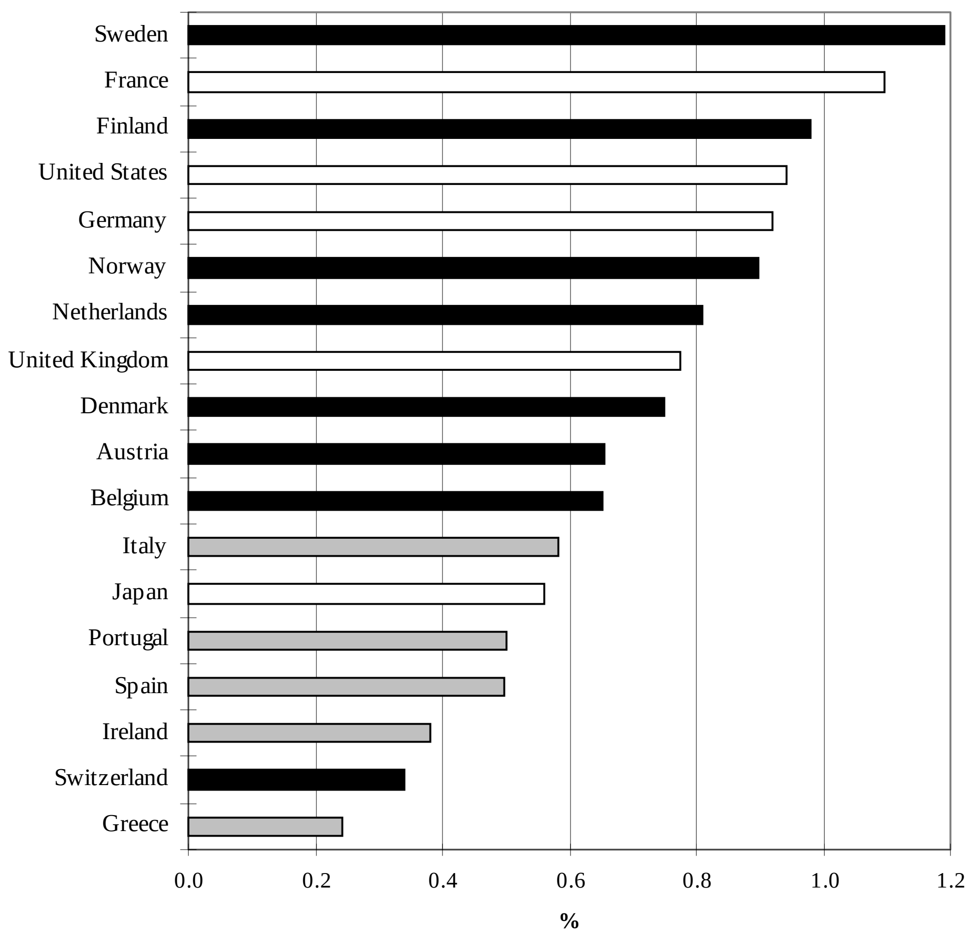
Government R&D financing declining over time

The Dutch government is still financing a relatively large share of total R&D expenditures compared to the other OECD countries. Figure 12 shows the government budget appropriations for R&D as a percentage of GDP. For the leading countries, with the exception of Japan, the Scandinavian countries and the Netherlands we see a relatively large government budget. These differences between countries are partly due to institutional structures. In federally organized countries as Switzerland and Belgium the central government is relatively small and will thus have small R&D budgets.

Although the Dutch government R&D budget is relatively large in absolute terms, its share is decreasing over time. In contrast to the 10 OECD countries where this percentage has been increasing between 1985 and 1996, the Dutch percentage has decreased significantly from 0.92% in 1985 to 0.81% in 1996. The fact that the government is decreasing her share in the financing of Dutch R&D was also shown in Table 5. Although the total amount of nominal financing increased with 230 million guilders, the expenditure in real terms reveals an annual decrease of 1.25%.

This reduction in direct government financing was accompanied by a shift in the financing of the higher education sector. With direct government financing (block funding) decreasing from 63% to 56% over the last decade, and real R&D expenditures increasing by 2%, the significance of funding from other sources has increased. The share of government funding via the research councils of NWO has dropped only slightly to 17% in 1996. The share of contract research funding – from industry, charities, national and international public bodies - has increased from 22% in 1986 to 27% in 1996. Figure 13 depicts the trends over the last decade in terms of the fractions of university staff funded by NWO research council grants or from contract research. Contract research has become a major source of funding in the Agricultural sciences and the Medical sciences. The Natural sciences are still quite dependent on research council funding.

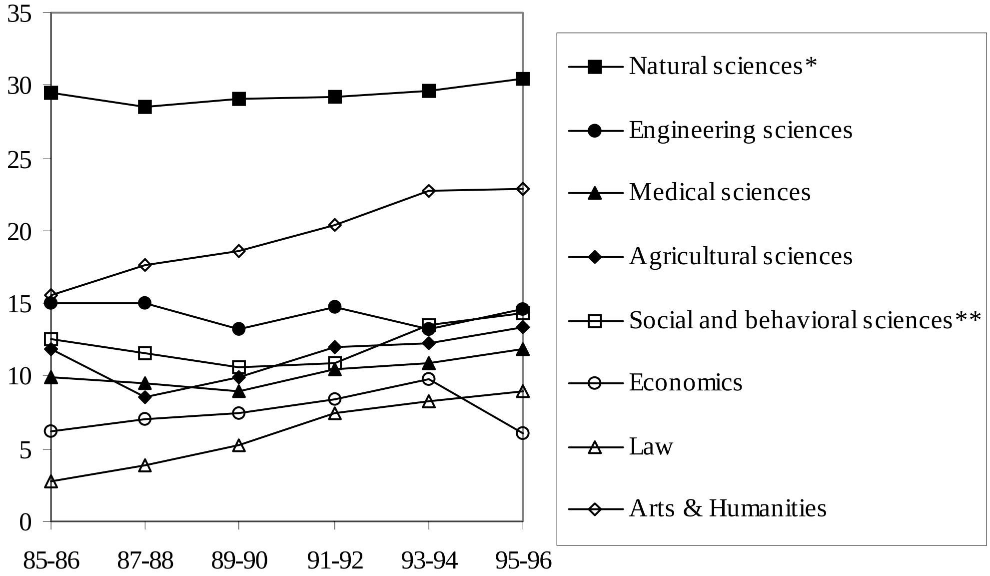
Figure 12: Government Budget Appropriations or Outlays for R&D, GBAORD, 1985-1995 of GDP.



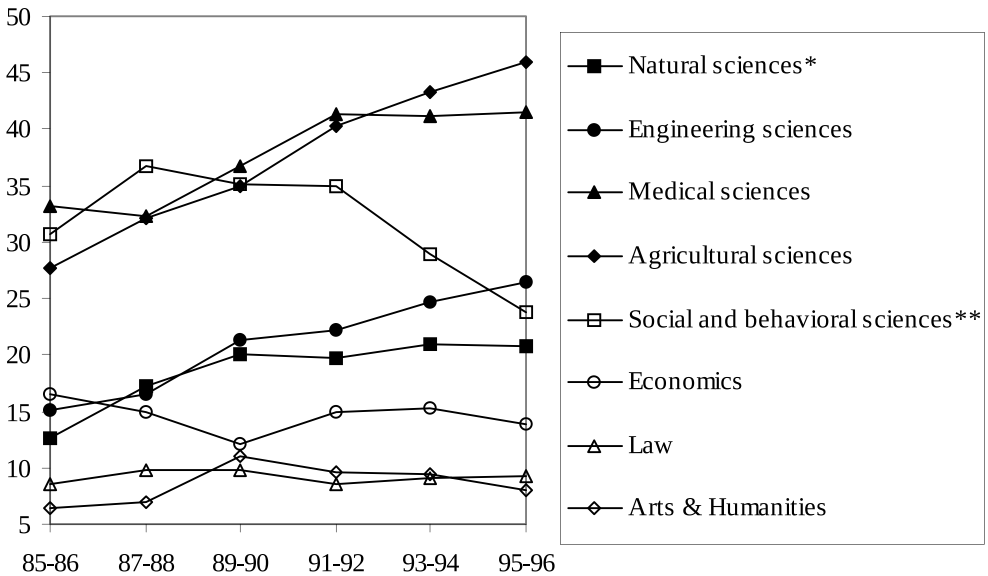
Source: MERIT, data: OECD.

Figure 13: Distribution of university research staff by source of funding, percentage of fte's per scientific field, 1985-86 to 1995-96.

Research council funding



Contract research funding



* Includes Mathematics and computer sciences
** Excluding Economics
Source: CWTS, data: VSNU, Ministry of Education, Culture and Science.

4 Scientific and technological output

The S&T output measures are based on sets of research papers and patents that were extracted from two international sources of publicly available information which document results of scientific and technological activity. Each source provides sufficiently large numbers to produce a reliable macro-level view of Dutch scientific and technological output in an international comparative context. The research papers were obtained from the comprehensive international bibliographic databases compiled by the American *Institute for Science Information* (ISI). These databases cover relevant information from all publications that appeared in some 5,000 international scientific and technical journals.[2] Each paper is assigned to one or more scientific subfields and disciplines according to the journal in which it was published. The number of Dutch papers is computed according to a dual fractional counting scheme that assigns each paper to (1) the countries involved and (2) the institutional sector of main organizations, in accordance to the affiliate address(es) of the (co-)author(s).
The patent data are extracted from the databases of the *European Patent Office* (EPO). The EPO data refer to inventor countries and priority years, where each patent was fractionated proportionally according to all countries involved. The technological areas related to the patents are defined by IPC codes (International Patent Classification).[3]

4.1 Scientific knowledge production and specialization

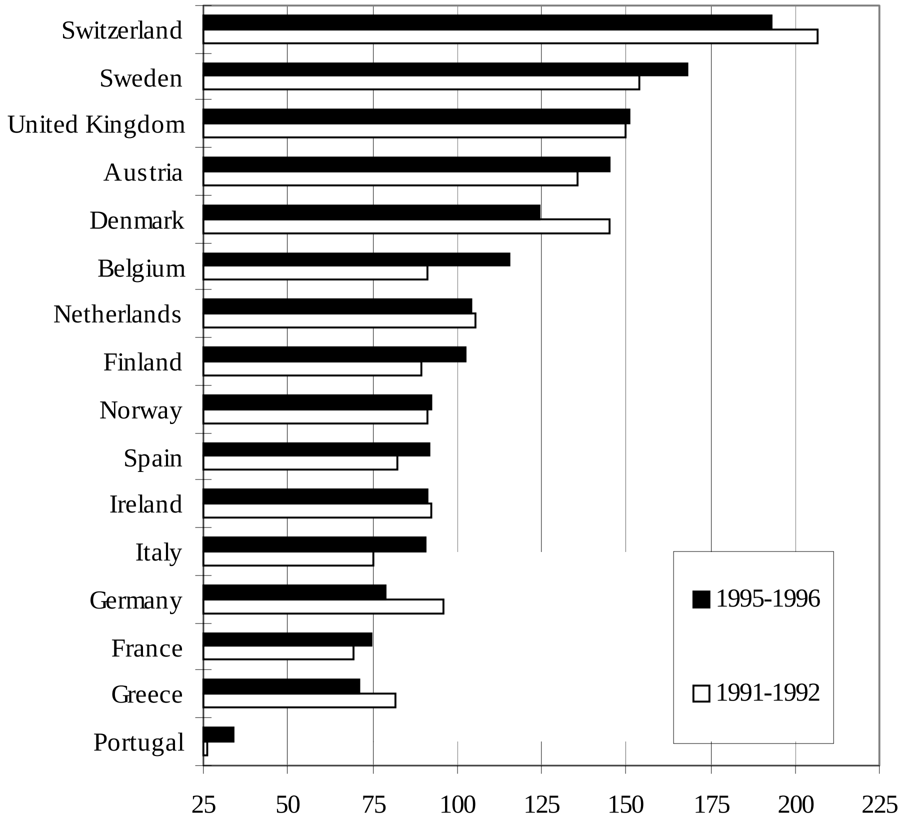
A broad and international-oriented science base in transition

The number of papers in international scientific and technical journals is an internationally comparable indicator of a country's scientific output and related research capabilities. Although Dutch researchers account for only about 2% of the global publication output in these journals, the Netherlands is ranked ninth amongst the most important knowledge producing countries in world science and therefore one of the major actors in the global science system. The total output of international research papers has increased by 50% over the last 10 years as a result of three factors: (1) the internationalization of Dutch research, (2)

[2] The ISI data comprises of *the Science Citation Index* (SCI), the *Social Sciences Citation Index* (SSCI), and to a small extent the *Arts & Humanities Citation Index* (AHCI). These databases are known to be biased in favor of English-language journals, in particular those from the USA. ISI claims that the SCI database covers about 90 per cent of the most relevant serial literature in the natural and life sciences. The coverage of the SSCI, and especially the AHCI, is significantly lower, particularly for journals and research papers from non-Anglo Saxon countries.

efficiency promoting measures by the government, and (3) the influx of university research staff. However, the continuous growth of number of Dutch (co-)authored research papers in these journals has come to a halt in recent years and shows signs of decline. The total publication output has dropped by 0.5% since 1995.

Figure 14: Scientific productivity of Western European countries: relative publication output per capita in the sciences*, 1991-92 versus 1995-96.**



* Excluding the disciplines of the social and behavioral sciences, and the arts and humanities.
** Productivity index: average number of research papers in 1991-92 and 1995-96 per R&D workers active in the public sector in 1989-90 and 1993-94 respectively. Scores of countries relative to the non weighted average score of all selected countries. Mean productivity score for selected countries equals 100.
Source: CWTS, data: Science Citation Index.

The 4% decrease in university research staff since 1994 is one of the most likely reasons for this downward trend. Another possibility relates to the declining number of researchers currently engaged in basic science – as signified by the increasing share of contract research in university funding (see Figure 13) – which is likely to bring about a reduced propensity for publishing papers in the peer-refereed international journals covered by the ISI databases. The increase in university publication output was particularly high in smaller, or more

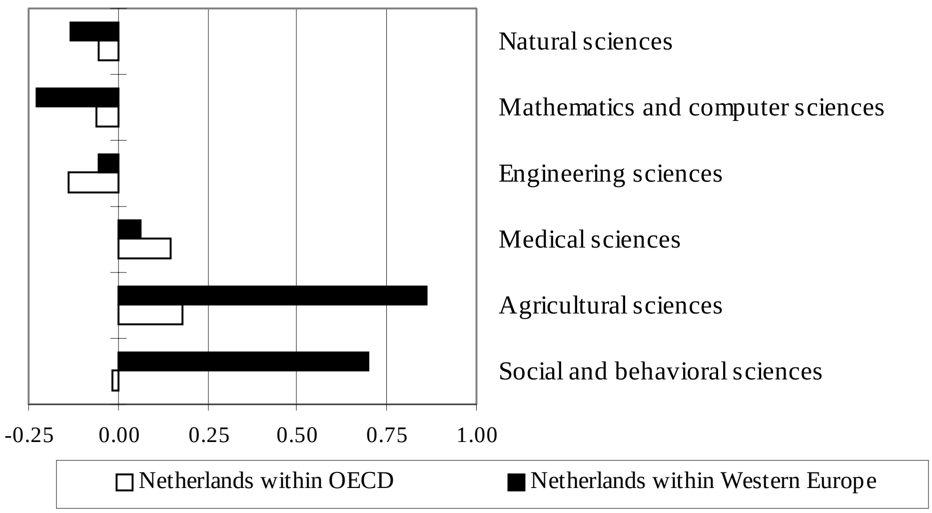
[3] See Engelsman, E and A.F.J. Van Raan, The Netherlands in modern technology: a patent-based assessment. Report for the Dutch Ministry of Economic Affairs. Report Series "Policy Studies Technology-Economy", no 5a, 1990.

recently established, universities such as the Maastricht University. However, the expansion and general performance of the Dutch university research system now seems to have entered a new stage which shows some signs of a steady state, or perhaps even a gradual decline judging by a decrease in research staff and lack of growth in publication output.

These recent developments have left their mark on the number of papers per capita in the public research sector, as indicated in Figure 14. The Dutch publication productivity rate sits only slightly above Western European average. Although the relative productivity has remained stable over the last five years as compared to the overall score of Western Europe, Dutch productivity shows a decline compared to European countries such as Sweden and Finland, which have more or less similar scientific profiles.

The Netherlands has broad scientific capabilities and performs high level research across a wide range of scientific domains. An analysis of the Dutch science base in terms of numbers of papers across the various scientific fields and disciplines indicates a specialization pattern with a strong emphasis on the Agricultural sciences, and the Social and behavioral sciences - and to a lesser extent in the Medical sciences (see Figure 15).

Figure 15: Scientific specialization of the Netherlands, 1995-1996.*



* Specialization index: share of Dutch research papers in a scientific field compared to the corresponding shares of all OECD countries and Western European countries respectively. Scores > 0 denotes an over-representation of the Netherlands, scores < 0 an under-representation.

Source: CWTS, data: Science Citation Index, Social Sciences Citation Index.

Table 16 provides an overall view of the Dutch scientific performance, including additional information on scientific specialization at the disciplinary level.[4] Dutch researchers appear to be highly prolific in Health sciences, Dentistry, Economics, Psychology, Educational sciences, and Chemical engineering. There is a significant de-specialization in the Natural sciences and Engineering Sciences, especially in Electronics and in Materials science.

4.2 Scientific impact and quality

High quality research benefiting from international co-operation

The number of citations received by an international research paper can be considered an indicator of its impact on the international scientific community. Citation counts can therefore be used as a proxy measure of its international visibility and related scientific impact.[5] Results of this citation analysis indicate that Dutch research papers in the international serial literature are cited quite often in the global scientific community. In fact, the citation impact score is about 20% above worldwide average, which makes the Netherlands one of the most highly cited countries.[6] Quite a substantial share of those papers is published in the prestigious peer-reviewed international journals. The excellent performance of the Netherlands in the global science base highlights the quality of Dutch research capability and its knowledge outputs, which enables Dutch researchers to participate at the international frontier of science.

The high citation impact scores in Table 16 reveal a comparatively large international scientific impact of Dutch research in Physics, Earth and environmental sciences, Chemical engineering, Agricultural sciences, and Veterinary sciences. In contrast, the citation impact scores in the social and behavioral sciences are not significantly above worldwide average – which is due to the dominance of the Anglo-Saxon countries in the English-language international journals covered by the SSCI, and lack of internationally accepted scientific paradigms in these disciplines.

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[4] The scientific fields and disciplines in Table 16 are listed and grouped as much as possible in accordance with the standard classification scheme for research input categories (students, funding) used in Dutch government statistics reports. The emphasis is placed on the performance of The Netherlands relative to other countries within Western Europe. The relative standing of the Netherlands is described by one of five categories, varying from a score far above average (++) to far below average (--).

[5] Note that citations represent an established practice of knowledge diffusion and utilization in large parts of the natural and life sciences, but are (much) less common in the other fields of science where those citation indicators should be applied with appropriate caution.

[6] The citation impact score is based on the comparison of the ratio of the citations received by each paper and the average number of citations received by all papers in the respective journal and related discipline. This standardized impact measure removes journal- and/or disciplinary-dependent biases in citation counts.

Table 16: Performance of Dutch science by discipline, 1995-1996.*

	Specialization within [1]		International impact [2]	International co-operation [3]	Domestic co-operation [4]		
	W-Europe	OECD			Intra.	Inter.	Publ.-priv.
Natural sciences							
Biology and biochemistry	0	0	0	0	++	0	-
Chemistry	-	-	+	0	++	+	++
Physics	-	-	++	+	+	+	++
Astronomy & astrophysics	0	+	0	+	+	++	-
Earth & environmental sciences	0	0	++	0	0	++	++
Mathematics & computer sciences	0	0	+	+	++	++	++
Engineering sciences							
Electrical engineering	- -	- -	+	++	+	0	++
Materials science	- -	- -	+	+	0	+	++
Chemical engineering	++	+	++	0	++	++	++
Mechanical engineering	-	- -	0	.	.	.	.
Civil engineering	0	-	0	.	.	.	.
Other engineering sciences	0	0	+	+	0	-	-
Medical sciences							
General medicine	0	0	0	+	++	0	- -
Clinical medicine	0	+	+	0	++	0	- -
Health sciences	++	0	+	0	+	0	0
Pharmacology	-	-	0	+	++	+	- -
Dentistry	++	++	+	.	.	.	.
Veterinary sciences	+	+	++	.	.	.	.
Agricultural sciences	++	+	++	0	++	++	+
Multidisciplinary**	- -	- -	++	++	++	++	0
Social and behavioral sciences							
Psychology	++	+	0	0	++	-	-
Economics	++	+	0	0	++	++	++
Political sciences	- -	- -	-	.	.	.	.
Educational sciences	++	- -	0	.	.	.	.
Sociology	0	-	0	.	.	.	.
Other social sciences	++	-	0	+ +	++	++	++

* Based on fractional publication counts.
** ISI subject category “Multidisciplinary sciences”, covers large general journals such as *Nature* and *Science*.
. Insufficient data / data not available / data not applicable.
1. Share of Dutch research papers in a discipline divided by the corresponding average percentage of all Western European countries (i.e. EU-15, Switzerland, Norway) and of all OECD countries.
2. Average number of citations received by Dutch papers in 1992-96 divided by average score of all countries.
3. Share of international co-publications in a discipline divided by the corresponding average percentage of all Western European countries (i.e. EU-15, Switzerland and Norway).
4. Share of Dutch domestic co-publications in a discipline divided by the corresponding average percentage of Germany, Denmark, Belgium and the United Kingdom: all intra-sectoral co-publications, all inter-sectoral co-publications, public-private inter-sectoral co-publications. Sectors: higher education institutes, other public institutes, business enterprises.

Relative scores:
++ more than 30% above average
\+ 10-30% above average
0 average
\- 10-30% below average
-- more than 30% below average

Source: CWTS, data: Science Citation Index, Social Sciences Citation Index.

Levels of research output and international impact scores are only partially correlated. As indicated, Dutch specialization in certain disciplines does not necessarily imply remarkable scientific strength in those areas – or vice versa. The relatively high impact scores in disciplines such as Physics, Electrical Engineering, and Materials Sciences provide illustrative examples of the strength of the Dutch science base in areas with relatively low levels of Dutch publication output by European or OECD standards.

The relatively high citation scores of Dutch papers can be attributed to the subset of papers that resulted from international scientific co-operation. Papers based on intra-EU collaboration gain the highest impact scores - these papers are in fact the main cause of the slight increase in the total citation impact in recent years. European co-operation is clearly an important factor in the Dutch research system and contributes significantly to the international visibility and scientific quality of Dutch research.

4.3 Scientific co-operation

Domestic and international co-operation plays a key role, an increasing focus on European partners

International collaboration has become a key characteristic of many modern scientific research systems, especially in the smaller countries or less developed nations that lack a comprehensive and high quality domestic science base. Countries like the Netherlands show an international orientation: they are more inclined to seek complementary knowledge and expertise abroad, to participate in bilateral scientific agreements, and to join international R&D networks. Joint research papers listing authors based in different countries provide some empirical evidence of the success rate of transnational collaboration.[7] Almost 30% of the Dutch research papers are of this type, which is a relatively high compared to other Western European countries. The share of foreign addresses in (partly) Dutch publications increased from 10% to 17% of all affiliate addresses during the period 1983-1996. However, the steady increase over the last 15 years seems to have leveled off in recent years. The scores in Table 16 indicate relatively large shares of internationally co-authored research publications in many disciplines, particularly in Electrical Engineering and the journal category ‘Multidisciplinary’.

[7] Not all international co-authored publications reflect genuine joint research, but may also stem from formal collaborative agreements primarily aimed at obtaining access and use of foreign research facilities and instruments.

In terms of the sheer volume of bilateral co-publications, the United States remains the most important international scientific partner of the Netherlands. This attractiveness of the US is no doubt related to its dominance in world science as a result of its large and diversified research base. However, the European Union has become the dominant factor in Dutch international co-operation: the share of co-publications with the other EU member states has continued to increase significantly over the last 10 years, now accounting for 60% of all international co-authored papers involving Dutch researchers. The strengthening of collaborative relationships with both neighboring countries – Germany and Belgium (Flanders in particular) – constitutes a key element in what appears to be an on-going process towards further "Europeanization" of Dutch research.

Similarly to the internationally co-authored papers (see above), one may safely assume that co-authored research papers listing authors from two or more different Dutch institutions provide insight into features of successful domestic collaboration. On the whole, about 19% of Dutch publications are domestically co-authored. The Medical sciences top the list in the Netherlands where domestic co-publications account for 25% or more of all research papers in this large research area. The shares of both intra-sectoral and inter-sectoral domestic co-publication have dropped significantly in recent years. Paradoxically, this decline is partially due to increased co-operation among academics whereby a growing number of researchers attach only the affiliate address of their common institution to their papers (e.g. an inter-university department or a national research school) instead of their main institution. The second reason for the decreasing domestic co-publication output relates to the substantially reduced numbers of research papers from Dutch industry, especially those from the laboratories of large R&D intensive multinational enterprises – Philips, Shell, Akzo Nobel, Unilever, and DSM. Many of these papers were co-authored with public sector researchers.

Table 16 provides an international perspective on domestic co-publication rates by comparing the Dutch figures with similar data for Germany, Belgium, Denmark and the United Kingdom.[8] A distinction is made between three categories (1) domestic collaboration within the same institutional sector (intra-sectoral), (2) collaboration between different sectors in general (inter-sectoral) and (3) the subset of inter-sectoral co-publications involving public and private organizations. The high scores for the Medical sciences are largely the result of

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[8] The results of this comparison are primarily meant to provide a general overview of differences between the Netherlands and its surrounding countries. In view of the fact that levels of international and domestic co-operation are also affected by the size, scientific specialization and institutional structures of national science systems, these findings should be treated with caution when used for more detailed comparisons across disciplines.

intra-sectoral co-operation, especially between university research units and university hospitals.

In the main, these results show that Dutch researchers are more prone to collaborate as compared to the average level of domestic co-operation in those four EU countries. Each discipline is characterized by its own distinct pattern of domestic collaborative interrelationships within and between the three institutional sectors. For example, Dutch research in Biology and biochemistry shows (1) relatively strong intra-sectoral links - mainly within the university sector, (2) an average level of inter-sectoral domestic co-operation - largely between universities and other (semi-)public research institutes, and (3) less developed inter-sectoral links. Relatively high levels of both intra- en inter-sectoral co-operation occur in Mathematics and computer sciences, Chemical engineering, and Economics. In contrast, Biology and biochemistry, Psychology, and various disciplines in Medical sciences show – by comparison – low levels of Dutch inter-sectoral co-publication output. Note that most disciplines in the natural and engineering sciences show fairly high levels of public-private co-authored papers, indicating relatively strong collaborative links and related knowledge flows within the Dutch science-technology interface.

4.4 Scientific performance of institutional sectors and universities

A science system dominated by the university sector, significant differences in scientific performance between universities and institutional sectors

Table 17 displays the distribution of the international publication output across the diversity of institutional actors in the Dutch science base. These research-performing organizations are classified into four main institutional sectors: (1) higher educational sector (universities and higher vocational institutions), (2) other (semi-)public institutes, (3) business enterprises, and (4) international organizations. Analysis of the author affiliations listed in the headings of publications shows a large variation in the share of each (sub)sector across the various scientific disciplines. The universities are clearly the main actors in the Dutch science system, accounting for 71% of the research papers in international scientific and technical journals. Government research laboratories, contract research organizations, and other institutions (partially) funded by the public sector contribute a further 22% of the total international publication output. The remainder of the Dutch papers originates from the private sector (5%) and international research organizations based in the Netherlands (1.4%).

Table 17: Publication share of institutional subsectors by discipline, 1995-1996*

	Higher Education	Other (partially) publicly funded (research) institutions						Private enterprises		Intern. inst.
Subsector**	a	b	c	d	e	f	g	h	i	j
Biology and biochem.	71	5	10	2	3	3	1	2	2	
Chemistry	72	4	3	4	1	2		10	3	
Physics	72	14	1	2	1			8	1	1
Astronomy & astroph.	53	23	1		3				1	20
Earth & environm. sci.	55	11	14	5	2		3	2	4	4
Math. & computer sci.	84	7	2	2	1	1		2	2	
Electrical engineering	61	5	1	2	1			16	8	5
Materials science	71	1	1	4				17	3	3
Chemical engineering	73	1	1	4				16	5	1
Mechanical eng.	75	3	2	4	2		1	7	3	3
Civil engineering	47	2	13	12	7		5	2	13	
Other engineering sci.	62	6	8	6	2	1		6	4	3
General medicine	72	3	4	3	5	9		1	2	
Clinical medicine	75	2	1	2	3	15		1	1	
Health sciences	70	1	7	6	5	8	1	2	1	1
Pharmacology	71	1	3	4	2	10	1	3	6	
Dentistry	91			1		6		1	1	
Veterinary sciences	61		27	3	2	1	1		5	
Agricultural sciences	57	1	33	3	1		1	1	4	
Multidisciplinary***	61	9	3	2	7	3	2	11	1	3
Psychology	85	1		3	5	4	1	1	1	
Economics	90		3		1		1		5	
Political sciences	89	1	2		6		1		1	
Educational sciences	94		1		3	3			1	
Sociology	87	2	4	2	4		1		1	
Other social sciences	84	1	1	1	4	1	2	2	4	
All disciplines	**71**	**4**	**5**	**3**	**3**	**7**	**1**	**3**	**2**	**1**

* Based on fractional counting of research papers. Rounded figures (excl. cases accounting for less than 0.5%).
** Institutional subsectors:
a Universities, interuniv. research institutes, research schools, academic hospitals, higher vocational institutes.
b Research institutes funded and run by the *Royal Netherlands Academy of Arts and Sciences* (KNAW) or by the *Netherlands Organization for Scientific Research* (NWO)
c Government research institutions.
d Large applied research institutes and large technological institutes (TNO, DLO, GTIs).
e Other public research institutes.
f Non-academic hospitals.
g Other public institutes not primarily devoted to conducting research.
h The five large R&D-intensive multinationals (*Philips*, *Shell*, *Unilever*, *Akzo Nobel* and *DSM*).
i Other private enterprises, private research organizations and R&D laboratories.
j Dutch branch of an international (research conducting) public organization.
*** ISI subject category Multidisciplinary sciences, which covers the large general journals with a broad multidisciplinary scope (e.g. *Nature* and *Science*).

Source: CWTS, data: Science Citation Index, Social Sciences Citation Index.

The large research laboratories of the five large R&D-intensive multinationals (see above) account for 50% of the research papers by the business sector.

Table 18 lists the relative citation impact scores of the entire university sector across scientific disciplines, and a breakdown of the overall impact across the 13 universities. The university sector as a whole performs well above the worldwide average in most disciplines. Only a few disciplines such as Political sciences have a relatively low international scientific impact (i.e. a score below 1). The data indicate significant differences between the universities and paint a university sector that is quite heterogeneous in terms of citation performance. For instance, the excellent performance in Physics (see Table 16) can now be ascribed to the University of Groningen, the Free University of Amsterdam, and the University of Leiden. Some universities can boast on citation impact scores which are way above worldwide average and much higher than the average of the entire Dutch university sector. These extremely high impact scores, such as in the case of the Technical University of Eindhoven in the field of Chemistry, indicate relatively high levels of international visibility, a mark of scientific quality and international prestige. Other universities show disciplinary citation scores way below the average performance of Dutch universities – but still above worldwide average.

It is worth noting that many of the citation impact scores of the universities, and the associated (inter)national standing, have changed significantly in the past decade, reflecting the natural dynamics of research systems in general, and to some extent the organizational changes that have taken place in the Dutch university system during the last 15 years (see section 3.1).

Other public sector research institutions account for a substantial share of basic research in the Netherlands, particularly in the Medical sciences and the Natural sciences. Many of the research papers have high citation scores that exceed the university performance. The large research labs of the five large R&D-intensive multinationals also produce many highly cited research papers in the Engineering science and Natural sciences. In contrast, international research papers of the large contract research institutions, like TNO, and those produced by the smaller research-performing firms, show relatively low impact scores compared to the performance of the other institutional sectors. This is most likely a result of their focus on applied research of a more local or domestic scope.

Table 18: Citation impact of Dutch universities by discipline, 1992-96.

	Mean citation impact Dutch universities*	Deviation from mean citation impact**,***												
		RUL	UU	RUG	UvA	VUA	KUN	EUR	KUB	UM	LUW	TUD	TUE	UT
Biology and biochemistry	*1.06*	0	0	0	0	0	-	0		- -	0	-		
Chemistry	*1.24*	-	0	0	0	+	0				+	0	++	++
Physics	*1.35*	+	-	++	0	++	0					-	0	- -
Astronomy and astrophysics	*1.11*	0	0	0	0									
Earth and environmental sci.	*1.40*	0	0	++	0	0					+	-		
Math. and computer sciences	*1.12*	0	++	0	0	-	++	0				0	- -	- -
Electrical engineering	*1.24*		0		0							0	0	0
Materials science	*1.12*	+	0	-	0							0	0	0
Chemical engineering	*1.48*			- -	-							0	++	0
Mechanical engineering	*1.10*											-	++	0
Civil engineering	*1.25*					++					0	0		
Other engineering sciences	*1.22*	+	0	0	0	- -	0	-		- -	++	0	- -	0
General medicine	*1.06*	0	0	0	+	0	0	0		0	0			
Clinical medicine	*1.30*	0	0	0	+	0	0	+		0	++			
Health sciences	*1.14*	-	0	-	-	-	-	+		0	++			
Pharmacology	*0.97*	0	0	0	0	+	-	++		0				
Dentistry	*1.22*		- -	0		+	0							
Veterinary sciences	*1.39*		0								+			
Agricultural sciences	*1.55*		-								0			
Multidisciplinary**	*1.54*	0	- -	- -	++	++		++						
Psychology	*1.06*	0	0	+	0	0	-	0	-	0				
Economics	*0.97*			-	0	0		+	+	0				
Political sciences	*0.83*	0	-	0	++	0		-						
Educational sciences	*1.16*	0	0		-	- -	-			++				0
Sociology	*1.07*		- -	++	+		++							
Other social sciences	*1.10*	++	-	0	-	0	0	0	-					

* Mean citation impact relative to worldwide citation average (=1).
** Relative citation scores for those universities that produced at least 100 papers, or accounted for at least 10% of the total university output, in the discipline in 1992-96.
*** Universities:

1. Large general universities: Leiden (RUL), Utrecht (UU), Groningen (RUG), Amsterdam (UvA), Free Univ. Amsterdam (VUA), Nijmegen (KUN)
2. Smaller general universities: Rotterdam (EUR), Brabant (KUB), Maastricht (UM).
3. Specialized universities: Agricultural Univ. Wageningen (LUW), Technical Univ. Delft (TUD), Technical Univ. Eindhoven (TUE), Technical Univ. Twente (UT).

Symbols:
++ more than 0.30 above average of all Dutch universities in the discipline
\+ between 0.15 and 0.30 above average
0 average
\- between 0.15 and 0.30 below average
-- more than 0.30 below average

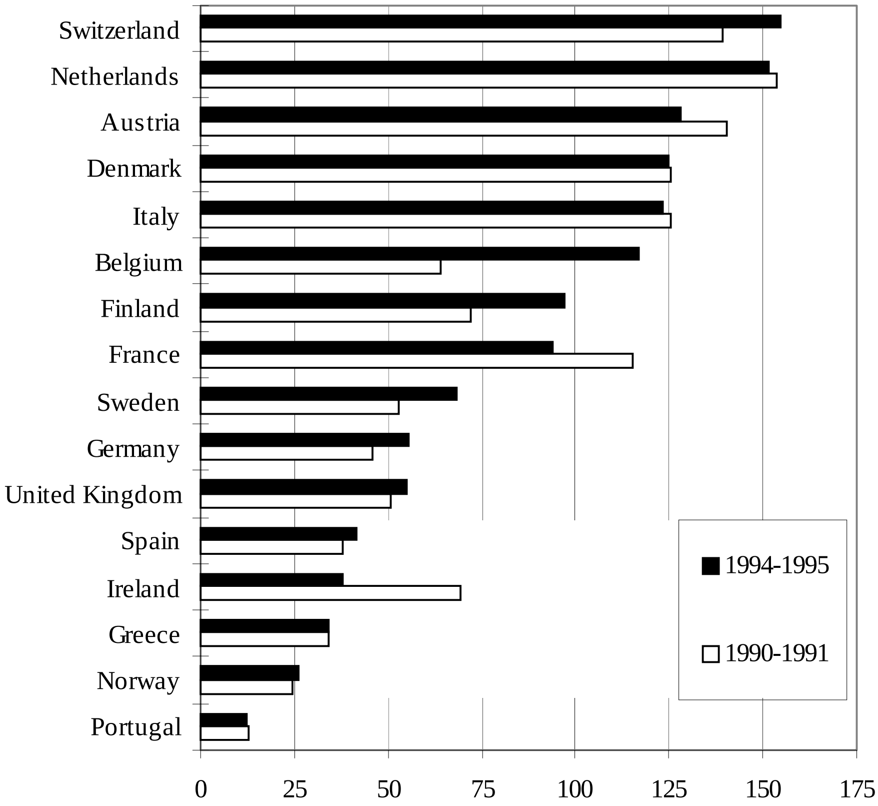
Source: CWTS, data: Science Citation Index, Social Sciences Citation Index.

4.5 Technological performance and specialization

A high patenting level dominated by the large R&D-intensive multinationals

Patents can be used both as an indicator of the technological output and a country's relative technological specialization. The Netherlands accounts for slightly more than 2% of the patents filed at the European Patent Office, which is an average contribution amongst the Western European countries. However, the performance is much better on a per capita basis, where the Netherlands ranks second after Switzerland in terms of the number of patents per R&D-worker in the private sector (see Figure 19).

Figure 19: Technological productivity of Western European countries: relative patent output per capita, 1991-92 versus 1995-96.*



* Productivity index: average number of European patents in 1990-91 and 1994-95 per R&D workers active in the private sector in 1989-90 and 1993-94 respectively. Scores of countries relative to the unweighted average score of selected countries. Mean productivity score for selected countries is equal to 100 in each period.
Source: CWTS, data: EPO.

The relatively large patent output, and the associated technological specialization, of the Netherlands is determined to a very significant degree by the patenting strategies of the five large R&D-intensive Dutch multinationals (Philips, Shell, Unilever, Akzo Nobel, DSM) and the industrial sectors in which they operate. As a result of their foreign activities, as much as one-third of Dutch patents originate from R&D that was performed abroad. Philips, the multinational enterprise in the electronics sector, is a key contributor to the Dutch patent profile.

Table 20 displays the patent specialization of the Netherlands relative to the other Western European nations. Dutch specialization centers mainly on the following three large industrial-technological sectors, each of which is characterized by substantial levels of patenting activity: (1) food and agricultural technology; (2) electronics and electronic components (including electrical machinery, image transmission, information storage, and telecommunications); (3) chemistry - polymer chemistry, organic chemistry and petrochemistry. The specialization is strongest in the agricultural sector and food technology sector, and in electronics and electrical machinery. There are comparatively few European patents by Dutch firms in the chemical sector given its economic importance for the Netherlands. Civil engineering technologies are also an important part of Dutch patented technology.

The Dutch specialization profile within the European patenting system has remained relatively unchanged over the last decade. Notable exceptions are the increased levels of specialization in three areas: (1) Civil engineering, building materials and mining, (2) Biomedical technology, (3) Data processing.

Table 20: Patent specialization profile of Western European countries by technological area, 1994-1995.*, **

	NLD	AUT	BEL	CHE	DEU	DNK	ESP	FIN	FRA	GBR	IRL	ITA	NOR	SWE
Agriculture, nutrition, beverages , tobacco	++	-	0	+	0	++	+	0	0	+	+	+	++	0
Image transmission	+	-	0	-	- -		-	+	0	0		- -	0	
Handling, conveyor equipment, robots	+	+	+	+	+	+	+	+	0	0	+	+	+	+
Civil engineering, building materials, mining	+	+	0	+	+	0	+	0	0	0	-	+	++	0
Information storage	+	-	- -	- -	- -		- -	- -	-	- -		0	0	
Telecommunications	+	-	0	-	-	-	-	++	0	0	+	-	-	+
Lasers	0	- -		-	-		-		+	+		-		-
Process engineering, separation, mixing	0	0	0	0	+	0	-	0	0	0	0	0	+	+
Electric power, nuclear technology	0	+	0	0	0	+	-	0	+	0	-	+	- -	+
Instruments, controls	0	-	- -	0	0	+	+	0	0	+	+	0	0	+
Biomedical engineering	0	-	-	0	-	0	0	0	-	0	++	0	-	++
Electrical machinery	0	-	-	0	0	-	0	-	0	0	+	0	- -	-
Data processing	0	-	-	- -	- -	-	- -	-	-	0	0	-	- -	-
Polymer chemistry	0	-	+	-	0	- -	-	-	-	-		0	- -	- -
Metrology, sensors	0	0	-	+	0	0	-	+	0	+	0	-	+	+
Mechanical engineering, machinery, armament	0	+	- -	0	+	0	0	0	+	0	-	0	0	+
Manufacturing and application of polymers	0	0	+	0	+	-	-	- -	-	-	0	0	- -	- -
Optical equipment	-	- -	++	-	-	- -	- -	- -	-	0	- -	-		- -
Electronics and electronic components	-	- -	-	- -	-	- -		- -	-	-	+	0	- -	-
Transport, traffic	-	0	-	-	+	-	0	-	+	0		0	+	0
Paper, printing	-	0	+	0	0	-	-	+	-	-	0	-	- -	0
Bio- and genetic engineering, pharmacy	-	0	0	-	-	+	+	-	+	+	0	-	+	0
Material processing, machine tools	-	+	-	+	+	-	0	0	-	-	0	+	+	+
Inorganic chemistry, glass, explosives	-	-	0	-	0	+	-	+	+	0		0	+	-
Organic chemistry, petrochemistry	-	-	+	0	0	+	+	- -	0	+	-	-	-	- -
Textiles, apparel, leisure, textile machinery	-	+	+	+	0	0	+	-	+	0		+		-
Coating, crystal growth	-	0	0	-	0	- -	-	-	-	-	-	-	-	-
Engines, turbines, pumps	-	0	- -	+	+	+	-	0	0	0		0	- -	0

* The Revealed Patent Advantage (RPA)-index: relative number of patents of a country in an area, divided by the number of patents in that area relative to total number of patents across all countries and areas. Standardization: RPA*=(RPA-1)/(RPA+1).

Symbols: ++ Very high patenting activity 0.5≤RPA*≤1; + High patenting activity 0.1≤RPA*<0.5; 0 Average patenting activity -0.1<RPA*<0.1
- Low patenting activity -0.5<RPA*≤-0.1; - - Very low patenting activity -0.5≤RPA*≤ -1; .No patenting activity

** Patents according to inventor country and priority year. Technological fields sorted by decreasing RPA*-value for the Netherlands.

Source: CWTS, data: EPO.

List of abbreviations

AHCI	Arts & Humanities Citation Index
AUT	Austria
BEL	Belgium
CBS	Statistics Netherlands
CHE	Switzerland
CWTS	Centre for Science and Technology Studies
DEU	Germany
DLO	Netherlands Organization for Agricultural Research
DNK	Denmark
ECN	Netherlands Energy Research Foundation
EPO	European Patent Office
ESP	Spain
EU	European Union
EUR	Erasmus University Rotterdam
FIN	Finland
FRA	France
fte	Full time equivalent
GD	Delft Geotechnics
GDP	Gross Domestic Product
GRC	Greece
GTI	Large Technological Institutes
IRL	Ireland
ISI	Institute for Scientific Information
ITA	Italy
JPN	Japan
KNAW	Royal Netherlands Academy of Arts and Sciences
KUB	Tilburg University
KUN	University of Nijmegen
LUW	Wageningen Agricultural University
MARIN	Maritime Research Institute Netherlands
MERIT	Maastricht Economic Research Institute on Innovation and Technology
NLD	The Netherlands
NLR	National Aerospace Laboratory
NOR	Norway
NOWT	Netherlands Observatory on Science and Technology
NWO	Netherlands Organization for Scientific Research
OECD	Organisation for Economic Co-operation and Development
PRT	Portugal
RUG	University of Groningen
RUL	Leiden University
R&D	Research and Development
S&T	Science and Technology
SCI	Science Citation Index
SSCI	Social Sciences Citation Index
SWE	Sweden
TNO	Netherlands Organization for Applied Scientific Research
TUD	Delft University of Technology
TUE	Eindhoven University of Technology
VSNU	Association of Universities in the Netherlands
UK	United Kingdom
UM	Maastricht University
US	United States
UT	University of Twente
UU	Utrecht University
UvA	Universiteit van Amsterdam
VU	Vrije Universiteit Amsterdam
WL	Delft Hydraulics